SALUKI ENGINEERING COMPANY POLICY AND PROCEDURES MANUAL:

Senior Engineering Design Textbook for ECE 495a,b and ME 495a,b

By
Kay Purcell
Irving Margon, Jr.
Alan Weston
Michael Blankenship
Frances Harackiewicz

Southern Illinois University at Carbondale
Department of Electrical and Computer Engineering and Department of Mechanical Engineering
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CHAPTER 1 - WHAT ENGINEERS DO AND WHERE THEY DO IT

Most engineering students arrive at senior status in their university with little comprehension of what they will do during their career. The purpose of this chapter is to give a picture of engineering as it is practiced and of the various structures under which engineering is performed.

The first thing needs to be put into focus is the place of engineering in today's business community. Where does an engineer work? What does an engineer do?

1.1. WHERE DO ENGINEERS WORK?

Engineers work in privately owned companies and for governmental agencies. Privately owned companies have from one individual to tens of thousand employees. The three basic types of structures are: sole proprietorships, partnerships and corporations. Engineers also work for national, state and city agencies.

1.1.1. ENGINEERS IN THE PRIVATELY OWNED COMPANY

1.1.1.1. The Sole Proprietorship

The one-person company, or SOLE PROPRIETORSHIP is not for beginners. The reason a single individual can sell services is that he or she has vast experience and couples this with highly specialized knowledge which makes a CONSULTANT service salable. Examples are engineers who can design and install robots, architects, engineers who can install assembly lines or engineers who can design electronic systems which interface accounting, inventory control, and operational planning, as well as predicting profitability and analyzing the effect on profit of making one or more changes in a product line.

1.1.1.2. The Partnership

The next larger unit of business is a PARTNERSHIP. This is common for architects or civil engineers who operate in the public works area of design. For example: design of bridges or roads, town planning and development. It is also common for structural engineers or electrical engineers who do building oriented power and lighting design, or produce specialized software. Business which provide consultants are often partnerships.

Partners and Consultants limit their activities to design, specification, and, for larger firms, supervision of construction or even project management. Their scope of activities is limited not by their technical ability, but by their ability and willingness to assume liability. Ability to assume liability is a function of assets owned and capital available.

1.1.2. ENGINEERS IN THE CORPORATION

The largest and most common type of engineering group is the CORPORATION. A corporation is a legal entity that is responsible only to the limit of its assets.

A few corporations, like Bechtel, which is the largest privately owned engineering company in the world, have less than 50 owners and are known as CLOSED. That means that they do not have to publicly publish their annual financial results.

Most corporations are OPEN, public companies. Their stock, which is what the ownership certificates are called, is available for purchase through one or more of the stock exchanges of the world. As public companies, they must not only publish their financial records but also include a K-10 report in their annual report. This is a United States Government requirement to protect the owners, or stockholders.

The K-10 lists all law suits and problem areas that the company has. It then gives the probable effect of the expected resolution of each on the companies financial stability and status. A public company is required to have an outside audit of its books each year. And it is the outside auditor's job to vouch for the accuracy of the K-10 report.

When an engineer has to pick a supplier, or choose an engineering company to use or buy from, or even select a company to go to work for, the engineer should look at their last available annual report and read the K-10 section carefully before making a decision.

How big are engineering companies or engineering groups within operating companies? The magazine *Engineering News Record* (ENR) publishes lists of the biggest contractors by types of work each year. The two biggest in their 1989 listing were Fluor Corp. of California as a diversified open corporation, and Bechtel as a diversified closed corporation with work loads in progress of over $10 billion and $8 billion, respectively. Fluor's work was about 85 percent in the USA. Bechtel had 50 percent of its work in more then 30 overseas countries.

Staffing levels in the biggest engineering companies exceed 20,000 engineers. This does not include field staff on construction projects except those seconded from the home office. Field staff of craft supervision level and lower levels are usually hired locally for the duration of the job only.

There are corporations whose sole function is engineering, or engineering and construction, or just construction. Many engineering companies are parts of a corporation where synergism is created by their availability. Universal Oil Products (UOP), for example, created Procon in 1940, so that they could offer to build the units that they were licensing to clients. This had the further advantage that they did not have to expose their patented design to third parties. UOP stood behind Procon for over 20 years to guarantee its performance.

The corporate structure provides financial protection to the engineering company, but not the client. Engineering companies which do enter into cost risk contracts either have long years of experience and track records of performance which inspire trust in clients, or are branches of corporations which both have tangible assets and will stand behind the engineering company with their assets. Clients can protect themselves, to some extent, by bonding the performance of the engineering company to 100 percent of the project cost. This means that if the engineering company fails to complete the project, the bonding company will hire someone else to complete the work at no additional cost to the client.

Many engineering corporations also limit their risk by limiting their activities to engineering only. These tend to be specialized in one field of expertise. For example, in England, the firm of Ewbanks is specialized in power plant design. They do all of the basic plant designs for the ECGD, the governmental agency that owns and operates all of the power plants. When they finish a design definition, the ECGD goes out for bids to other engineering firms who will commit to doing the detailed engineering, the procurement of all of the equipment and the construction. Helmuth, Obata, and Kassabaum (HOK), the American consultant mentioned above specializes in all sorts of buildings from high-rises and hospitals to prisons, but they limit their activity to design, supervision and project management.

1.1.2.1. The Engineering, Procurement, and Construction Engineering Corporation

It is a big jump from the consultant, partnership or limited scope engineering corporation to one that is capable of and prepared to accept full responsibility for not only engineering but also the cost of procurement and construction, thus EPC. Companies with this capability and risk accepting willingness first arose in the US just before World War II, when a consortium agreed to build Hoover Dam near Las Vegas for a fixed price and on a fixed schedule. The confidence of the group was based on their experience and their newly developed project management concept.

Two factors occurred at the same time to account for the emergence of the EPC engineering company. First, project costs began to exceed $100 million, and corporate management started to look for lump sum bids so they would be able to talk to their banks about a firm quoted cost and also a firm scheduled completion, so the date when the facility would begin to generate income and pay back the loan would also be known.

Second, a number of large American engineering companies developed project cost control systems and scheduling systems and project performance techniques which let engineering, procurement and construction overlap to shorten schedules and reduce cost. This made it possible for them to make offers that were attractive to the clients and most welcome to the lenders who were used to waiting to the end of a project to find out the cost. Needless to say, profit margins were also generous.

The resources available to the project manager in an EPC company are extremely broad. Not only is there a general engineering department, but planning, scheduling and cost specialists as well as a construction team are at his beckon call. The drawings on the next three pages show the structure of the engineering department, how the project team is made up from the engineering department groups and the various functions that will be carried out by the task force and its support groups. The wide scope of activities that can be assembled as needed shows how developed the project management concept has become and the flexibility that can be achieved to fit almost any project scope.

This flexibility is a great factor in the American project concept's dominance of engineering projects throughout the world. Since most foreign companies are very rigidly structured, they were not, and in most cases still are not, capable of forming an effective project team within their engineering companies.

The willingness of the EPC engineering company to undertake even large projects on a fixed price basis gives prospective owners the possibility to delegate full responsibility to a single company. However, that company had to have both financial and staff credibility. Between 1935 and 1965, all of the firms which developed this capability in the world were American.

1.1.2.1.1. The Historical Decline of American EPC Contractors, 1960 to 1990

Beginning in the 1960's, the training and joint venture contract exposure that the American EPC firms had been providing in many foreign countries began to create a level of competence in such countries as Germany, England, France, Italy, and Japan. Engineering companies in those countries began to undertake their own independent EPC contracts, hiring American supervision in most cases to succeed.

Two other factors entered to eliminate US dominance in the worldwide project design and construction field. One was the need for new sources of project finance. Countries like France, England, Italy and Japan offered Governmental finance through their own engineering companies on the proviso that the financed equipment and engineering be done in their country. Techniq in France, Snamprogetti in Italy, and Japan Gasoline Company–all either owned by the government or sponsored on preferential terms by the government–became key factors in the international engineering field.

The second factor that brought Korea, Taiwan, Greece and others into the field was an Arabic reaction to American legislation and perceived pro-Israeli bias. In the mid 1970's the Arab countries, who where sponsoring multi-billion dollar projects with their soaring oil moneys, decided that nothing would be accepted on any project which was shipped on a ship that did, or had ever done, business in Israel. They wrote a clause in contracts requiring the engineer to guarantee that ships used had not put into Israeli ports. The ACLU took the case to the courts, who ruled that it was not legal for any American company to agree to a contract that contained such a clause. So there was a shortage of bidders. For the first time, the Koreans were allowed to bid on projects in countries such as Saudi Arabia. Their first bid was less than one-half of the next nearest bid on a water desalination plant; and they executed the contract efficiently.

US companies went from the forefront to a position of frustration. Since 1980, only three major contracts have come to US companies. A $20 billion management contract to build a new town and refinery/petrochemical complex in Jubail in Saudi Arabia and a similar contract for a second similar project in Yanbu, Saudi Arabia, plus the management contract for the Saudi's King Faisal University project which was valued at $5 billion. Bechtel, R M Parsons and HOK were the contractors–chosen because they still had they principal administrative personnel and control techniques necessary for such vast projects.

1.1.2.1.2. Changes in the US EPC Contractors since 1980

In the late 1970's as oil prices soared, American EPC contractors greatly increased their staffing, anticipating the construction of many multi-billion dollar plants in the US to make natural gas or synthesis gas to make petroleum from coal.

With the decline in crude oil prices, all but one plant was abandoned. And with the downturn in prices worldwide, many Arab and other OPEC country projects were abandoned. With the dearth in big projects in the world, big changes have occurred in the EPC contractor picture in the US. Some of the biggest down-staffed drastically. Numbers reported include drops from 44,000 in 1980 to 19,000 today, for one of the biggest contractors plus drops from over 30,000 to under 15,000 for at least four others. And many others became involved in mergers. Procon, Kellogg and Rust were absorbed into Signal, which in turn merged with Allied that had several of its own engineering groups, and finally regurgitated a group of assets that included Kellogg into a company called Henley.

Lummus and Crest were swallowed by Combustion Engineering which in turn was swallowed. Stone and Webster was absorbed into Raytheon.

Until 1980, the big conglomerate chemical companies such as Dupont, Dow, Monsanto and, overseas, Phillips and ICI as well as the big oil companies all had extensive engineering groups of their own. Their research departments developed new products like Nylon or Orlon. To keep their secrets intact Dow and Dupont even had their own construction staffs.

Today, much of this expensive protection has been abandoned. Monsanto, for example, has almost eliminated its in-house project staff. All of the engineers in the project group have been distributed to operating units or been released. Any project of over $2 million is done with outside engineering help. Pre 1980, projects of up to $20 million were all done in-house. An arrangement with Bechtel, one of the biggest American EPC contractors, provides the project capability and delegates to Bechtel the problem of keeping staff employed between projects. Bechtel has a similar arrangement with Chevron.

But the big oil and chemical companies still put together internal task forces to do feasibility studies like we are doing in this course by drawing from operating units who will use the new facility. The task force then takes on the project responsibility of supervising the engineering firm that will design and build the project and may even have the operator training and start-up responsibility. Many operating companies call on retired engineers to return to handle their contractor liaison for new projects without having to add to their permanent staff.

But all is not gloom and doom. As the 1990's begin, an increasing amount of engineering work is being done, whether by engineering companies or owner's engineering departments. And some companies like Dupont maintain their wall of secrecy. When Dupont bought Conoco, they had the Conoco engineering center in Ponca City, Oklahoma, increase its staff from 2,600 to over 4,000 to do more work in-house.

1.1.2.2. How Corporate Engineering Departments Are Organized and Operate

Engineering departments are organized to best utilize the strengths of the management that run them. Every engineering group has a chief engineer. Individual discipline groups each are headed by a principal engineer, although job titles may vary from company to company. The chemical engineers do not always report to the chief engineer—an example of "the structure that fits the strength of the individuals" rule. Chief engineers are usually civil or mechanical by training, as they have a broad feel for many elements of a project, and are exposed to the whole engineering process by their interface with other engineers. Engineers interface not only with engineering but also with procurement and construction during a project. Chapter Five covers the procurement interface, and Chapter Ten covers construction.

In most engineering disciplines, there is a hierarchy from the principal engineer to senior and junior engineers to two levels of non-degreed personnel, called designers and draftsmen. Most engineering departments also have estimating, planning, cost control, as well as quality control groups; but these may report along different lines, depending on the talents of top management. The project engineering group includes project managers and project engineers. In some companies, it reports to a director of projects, who may or may not be in the engineering group.

The lines of reporting frequently are tied to the dollar value of the project. In a S500,000 project, the biggest individual purchase order probably will not exceed $25,000. A project manager may have authority to approve that size order. But, on a billion dollar project, the largest purchases may exceed $10 million and require a vice president or even board of director's approval. And the responsible vice president is the project director in some companies on big projects.

When a project team is put together, it creates a strain and divided loyalties within a company. The team members are frequently relocated to a task force area to improve communication. But each discipline engineer reports to his department head, as well as the project manager. This dual reporting structure is referred to as matrix organization.

It is an important function of a project manager to keep on good terms with all department heads so that his project will be well served and get the best staff assigned. It is not uncommon for department heads to have weeks when requests for staff exceed warm bodies. S/he must then meet with the project managers and reach an agreement on who will have work delayed, see if any project will pay for overtime, or discuss the possibility of hiring temporary help who may not be as efficient

1.1.2.2.1. Corporate Management Structure

Corporations are organized in many ways to best accomplish their goals, but they have a certain number of features in common. To begin with, they have a board of directors, or BOD, and a CHIEF EXECUTIVE OFFICER, or CEO.

The CEO runs the company, sets policy and is responsible for developing 5- and 10-year forward plans. The CEO decides what the business of the company shall be, and how it should grow or change its direction.

The CEO selects the BOD from senior executive staff and from OUTSIDE companies. The outside directors are selected to help the company achieve its goals. They may represent political clout, or customers, sometimes key suppliers, and even industries or unions. They may also be selected to improve the public image of the company.

The Board does not take a very active roll in running the company. They may have committees to decide on acquisitions or mergers. Principally, they provide assurance to the stockholders that their company is being run in an optimal manner. They can take action, in rare instances, to remove the CEO. They convene quarterly, in most companies.

Principal stockholders control places on the board of directors by means of their financial clout. Some raiders, like Carl Ikhan, begin their activity by buying large blocks of stock shares. It usually takes only about 30 percent ownership to control a large corporation. This is done by obtaining proxy rights to vote small stockholders shares at the annual meeting when corporate decisions are made.

When one is a small stockholder, they receive, before each annual meeting, an invitation to attend the meeting. They also receive the audited financial statement of the company, the quarterly financial updates and annual report, and, hopefully, quarterly dividend checks which represent distribution of a part of the profits to the shareholders.

They also receive a statement of items the CEO wants to have voted on at the annual board meeting by the entire stockholder group and a proxy card, giving them the right to-vote for or against each item on the CEO's agenda. The CEO assumes almost no small stockholder will come to the annual meeting. To maintain control of the company, the CEO asks each shareholder to give the CEO the right to vote the shareholder's stock for the sharholder. This right is called a "proxy"–the right to vote another person's stock. It is how the CEO stays in power.

When an unfriendly takeover is attempted, the group not in power has to ask for the proxy by newspaper advertising. They also sometimes offer to buy all of the outstanding stock of the other stockholders. When they own more stock, or have more proxies than the CEO, they can take over the company.

1.1.2.2.2. Corporate Staff Structure

Most executives have no more than six lieutenants who report to them. This is true of the CEO as well. Most corporations are organized by function; in some corporations there is a geographic division that may be above the functional one. For example, Exxon operates drilling and production, refining and marketing facilities in every continent and most countries of the world. They have national companies and organizations which, in turn, report to regional control management groups, which then report to the managing company in New York City.

In some companies, which are referred to as diversified, there is a division by products. Dupont, for example, has its petrochemical business. But it also owns Continental Oil Company, Consolidation Coal, plus several product companies, such as its carpet manufacturing, which are also operated separately. General Motors has separate divisions for Buick and Cadillac and Pontiac and Oldsmobile as well as Chevrolet. Each has its own functional staff.

In some companies, such as Allied Signal and DuPont, some functions, such as research, are consolidated for all divisions. In others, such as General Motors, where divisions operate as if they were separate companies, each does its own design and research. But the results of the research, such as a 16-valve fuel-injected engine, may be used by all of the divisions.

1.1.2.2.3.Corporate Functional Groups

The number and makeup of functional groups depends on the complexity and goals of the company. If a company does only engineering, it may have civil, electrical and mechanical design groups. These may be independent or grouped into a general engineering group which has a chief engineer who coordinates the work of the groups and assigns staff to projects.

Project engineering and project management may be a separate group. So may planning and scheduling and construction management or supervision. Economic studies, estimating, and cost control are also possible separate groups.

Quality control is another specialty. This may be a separate group or consist of delegated individuals from each discipline.

Draftspersons and designers may be attached to each engineering discipline or be a separate group whose members are assigned by the chief engineer to each project. These are usually non-degreed persons with experience and skill to translate the engineers' designs into working drawings and specifications.

To complement the engineering group, planning and scheduling, cost estimating and cost control, procurement and marketing groups are needed. These are seldom within the engineering department;

however, in some engineering companies the planning and scheduling group report to the construction manager or the chief engineer.

Big engineering companies have a lot of technical mail to control. On each project there may be correspondence with manufacturers and suppliers of vessels, pumps, digital components, instruments, air conditionings, etc. Final design, for example, may require choosing suppliers and getting so-called "certified prints" from them. These are drawings that exactly locate bolt holes, nozzle locations and orientation for finalizing piping design, and give weights so the civil engineers can design foundations.

A technical paper handling group is needed to accomplish mailing the right packages to the right supplier with the right copies to the designated engineers and managers in the design and owning companies and seeing, by telephone expediting, that all approvals are giving promptly. This group also must keep the paper for each project within the boundaries of the projects, and set up and keep all necessary files of outgoing and incoming drawings, specifications, correspondence, permits, etc. They must also obtain and retain the necessary copies of all documents that will go into the final operating manuals for the client.

Finally, there are the staff groups such as lawyers, accountants, personnel managers, traffic managers, insurance specialists, and perhaps training, safety and security specialists.

Frequently the grouping of these many, diverse talents is dependent upon the experience of the management individuals. Functional groups may be varied as management people come and go and as projects require. Many companies do things other than engineering. In these companies the engineering group, or groups, fit into one or more functional departments.

In the refinery functional groups of a major USA oil company, for example, in the mid 1960's there were engineers in the following groups:

- A central pool of several thousand engineers located in a refining center. This group specified all new projects, made an economic analysis of each, and made a BOD presentation to ask for an appropriation of funds to proceed with the project. It also served as a training facility for all newly hired engineers. It provided specialists to operating facilities with operating problems or to study expansion or revamp of facilities.
- Operating engineering groups in twelve US refineries, five petrochemical facilities in the USA and abroad, and in a refinery in England. These local groups did specifications and designs for local projects valued up to $1 million each year and also had operational management responsibility over the operating staff.
- A small group in the economic analysis section of the president's office who evaluated forward planning costs and probable economic benefits. They also verified the economic aspects of various divisional forward plans and made recommendations to the president on the relative value of various proposals to accomplishment of the 5- and 10-year forward plans.
- A small group who ran an analog planning program to determine what crude oils to buy, where to route them through the pipelines to which refinery, and what products to make in each refinery to meet sales requirements and maximize profits. The program also permitted the engineers to convey to each facility manager each month what feedstock would be delivered in what amount, and how to program the refinery to maximize profit.

- A group that looked at upgrading operating facilities, assessed the cost of so doing and implemented approved plans. Among the approved projects there was one which is still ongoing in third generation activity, this was to install digital instrumentation, wherever feasible.
- Two project planning and management groups–one in Europe and one in the USA

All engineering managers in every group were responsible for keeping a 12-month forward forecast of the cost of operating their department and the staff they would require. They also had to contribute to 5- and 10-year planning updates each year. So that there was no panic each year at the time plans had to be send to management for consolidation into a total company plan, it was required that the plans be updated monthly so that a twelve-month forecast was always available for management review.

In total, there were perhaps 8,000 engineers and support staff in the refining division of the company. Similar numbers of engineers were employed in other operating divisions, such as, oil exploration and drilling, pipelines, transportation and terminal storage, and in location, design and management of service stations.

1.1.2.3.EMPLOYERS WHO DO MORE THAN JUST ENGINEER

When procurement, construction, manufacturing and sales are added to the above design responsibilities we find several new types of employers. The first two are the suppliers and manufacturers.

1.1.2.3.1.Suppliers and Manufacturers

The suppliers provide the equipment and materials which go into construction and manufacturing. This means that many of them, such as pump or instrument suppliers, are also manufacturers of components which make up a production line or constructed project. Principal material suppliers provide sand, gravel and cement for civil structures; steel and steel shapes for columns, beams and rebar, steel alloys; copper and aluminum for wire and motors; plastics for pipe and glass. Penn Aluminum International, Inc. is such a supplier.

Manufacturers make finished products. Usually these are sold to the public. But in many products there is an intermediate store or agent who sells on behalf of the manufacturer.

Suppliers, manufacturers, stores, and agents all employ engineers to design systems, make proposals, assist in sales or be the prime salesman, install components or supervise installation, help in start up and operation and advise or provide maintenance services.

1.1.2.3.2.Constructors

The third group of employers are the construction, maintenance, and operations companies. These are frequently associated with the engineers, suppliers, or manufacturers. One example, becoming more common, is the company especially created to operate a facility. Solid waste disposal plants are almost all so operated. The city of Miami, Florida, for example, has hired a French firm to operate its facility. Many government owned plants such as the nuclear fuel concentration plants are also operated by contractors. Even the in-ground missile silos are maintained by contractors. Companies such as Martin Marietta, Dupont, Union Carbide, Ogden Martin, and Blount all have subsidiary companies or divisions dedicated to such operation. In some cases, such as the solid waste plants, the formation of such a company, with seed capital for the construction in the amount of twenty percent of the plant cost, is a necessary part of the selling effort to get the contract to build and operate the plant.

Construction companies may be established with minimum engineering support. Civil construction companies in particular, who specialize in earth moving, road building, and earth dam building fall into this category. Their efforts are supervised by engineers in the government agency employing them or the design contractor.

Most construction of large projects is done by integrated engineering companies or engineering divisions of companies such as Dupont. An integrated engineering company performs EPC services; that is, engineering, procurement, and construction.

Some engineers do not like confined office routine. They are best suited to construction activities. Construction engineers work not only in the field, supervising and directing construction, but also in the home office providing input into planning, scheduling, and estimating the cost and duration of construction. The home office engineers also look at construction problems such as heavy lifts and see that necessary construction equipment and transport for equipment to the site are included in the estimate.

The construction engineers are also responsible for contracting for the site camp, including small tools, such as welding sets, other equipment and transport; arranging for utility connections; arranging labor union contracts; hiring site construction labor personnel and/or subcontractors; and securing necessary permits.

1.1.2.3.3. Maintenance and Turnaround Contractors

Maintenance and turnaround are two specialized facets of construction which employ significant numbers of engineers. Big chemical, paper making, oil refining, steel making, and similar process plants run continuously, twenty four hours per day. But they do not run forever without shutting down for repairs or maintenance. They have scheduled shutdowns, called turnarounds, in which complex maintenance is performed. Operating cycles may be long or short.

Paper making has about a 30 day cycle of operation. Yarn weaving plants also have short run cycles. These are set by the severity of the operations which requires that exact tension in the paper or yarn material being manufactured is maintained or a break will occur. When that happens all material in process must be cleaned out of the machinery before a new run can begin.

Power plants and oil refineries try to run two years between shutdowns. Their shutdown frequency is established by government regulations that require all boiler plants to be inspected every two years. The refinery, for energy conservation purposes, has numerous heat recovery devices; and the government classes these as boilers from a safety point of view. Since plants only make money when they are running, the scheduling of vast amounts of repair and replacement activity in the shortest time has become a specialized engineering activity which is computer planned and controlled because of its complexity. Operating and maintenance engineers also have lists of repairs and replacements which can be done when unplanned shutdowns occur. Many of these require long term planning to get company approval to spend the money and then to order the components and have them in place for quick insertion at any time.

1.1.3. ENGINEERS IN NATIONAL, STATE AND CITY AGENCIES

The functions of engineers working for federal, state or city agencies are somewhat different than those in private industry. Their functions are custodial and supervisory rather than hands on design and operation. They prepare specifications and contracts as well as administer them. They also have to estimate the costs of new projects, lobby for appropriation of funds, which may involve appearing before legislative committees, and go through the competitive bidding route to select a contractor to do the approved work

The engineering departments of the federal government are found in almost every cabinet department.

1.1.3.1. Department of Defense - DOD

Defense is responsible for manufacture of all ordinance–weapons and delivery systems–as well as establishment and maintenance of all military installations worldwide. They are the principal US government employer of engineers and engineering companies.

Defense is also responsible, as directed by Congress and the president, for development of new weapons systems and hardware. As such they sponsor vast amounts of research. The DOD operates through competitively awarded contracts.

There are over 50 national laboratories, in addition to privately contracted research groups, which contribute to these defense development research programs.

Engineers working for the Department of Defense prepare bidding documents, assess the proposals and make recommendations for award. They may participate in negotiation of the award as engineering specialists assisting the contracting officers. They are also responsible for administering the contracts. They are frequently located in the offices of the contractors to monitor the work in progress and to give prompt approvals to decisions they are authorized to make.

They also have the responsibility to see that progress, which is the basis of contract payment, is as represented by the contractor. They also must try to eliminate contractor's requests for extra moneys which in the past have created celebrated and infamous over runs. They also must try to keep work on schedule by seeing that contractors have adequate expert staff and that planned time is expended fruitfully.

They must observe security practices employed by the contractor and do their best to see that required security levels are maintained. This includes not only monitoring work practices but employment practices.

1.1.3.2. Other Principal US Government Employers of Engineers

The Department of Energy (DOE), Environmental Protection Agency (EPA), National Aeronautics and Space Agency (NASA), National Science Foundation (NSF) and Nuclear Regulatory Commission (NRC) are other principal employers of engineers and engineering companies.

Each of these groups, as well as all other cabinet departments–Agriculture, Education, Health and Human Services, and Transportation–are required to put a part of their annual budgets into research and development. They all publish wish lists of projects or ideas for which they will sponsor research.

Some are intended for small businesses and are advertised by the Small Business Administration (SBA) quarterly for DOD and less often for the other groups with smaller budgets.

All projects are advertised for bidding in the Economic Digest, a Department of Commerce publication. Requests may vary from new software to a new supersonic airplane or space station design. In NASA's case, they even ask for firms to modify space technology so it can be used on earth.

Engineering functions in all governmental departments are as described above for the Department of Defense. However, in some agencies such as EPA and the Health Department, there is a broad public monitoring responsibility that includes writing laws and enforcing them.

1.1.3.3. State and Local Engineering Employment

Each state has its regulatory agencies to enforce US and state laws for the EPA and Health and other agencies. The state may also participate in administration of US military bases, as well as national guard establishments.

But the principal functions of state and local engineers are to get the many design and construction projects defined, funded, contracted and built on time and within budget. Roads, bridges, dams, inspection stations, rest stops on freeways, and public buildings which include schools are principal cost items. The control of zoning for building is a key activity in larger cities.

Utility system control; design, installation and maintenance of such facilities as flood control, sewers and sewage treatment plants; auto, foot and railroad bridges and crossings; sidewalks and traffic control are other principal state and local engineering responsibilities

1.1.3.4. Public Corporations

From time to time, frequently when public emergencies such as drought or flood have occurred, the US government has established public corporations to undertake vast engineering activities that are regional in scope.

The Tennessee Valley Authority (TVA) and Missouri Valley Authority (MVA) are two such agencies. Although their original thrust was to eliminate or greatly reduce peaks of flood and drought, they have become not only dam builders and principal power producers but also substantial research agencies who have moved far afield from their original enabling legislative intent.

The TVA, for example, has major research establishments at Muscle Shoals in Alabama and Oak Ridge in Tennessee. Their areas of research include fertilizers and production of alcohol from all naturally occurring crops from corn to trees. They accept private as well as public funding for these activities.

The TVA has also built recreational lakes in Kentucky and a new canal to allow Ohio river traffic to go to Mobile, Alabama instead of New Orleans. The advantage of Mobile is somewhat deeper water.

Engineers working for TVA or MVA or similar governmental agencies perform functions much the same as other governmental engineering employees. TVA and MVA al so have research staffs.

1.1.3.5. The US Army Corps of Engineers

This discussion of employers would be incomplete without a mention of the Corps of Engineers. This group operates all of the canal locks throughout the United States. It also takes a lead roll in planning new waterway installations from locks to bridges to harbors to canals. It has a principal responsibility for stabilizing wetlands along the eastern coast of the United States and for maintaining national inland wetlands like the swamps in Florida.

Overseas, the Corps has been the engineering arm of the Saudi Arabian government since World War II. It has been responsible for design and construction of cities such as Yanbu and Jubail, each with major petroleum based industrial complexes. Both of these projects cost $20 billion. Other typical large projects include the $5 billion King Faisal University.

1.2. WHAT DO ENGINEERS DO?

The above discussion of where engineers work introduced some of the things engineers do in a functional sense. Now let us look at engineering specialties as career paths.

1.2.1. THE FIRST JOB

No matter where an engineer goes to work, the first few weeks on the job will be spent in indoctrination. That is, learning what the new company does, what the engineering group, or groups do, and how the company gets its engineering needs satisfied.

Almost every engineering request to the engineering department is so complex that it must be addressed by a team of engineers of many disciplines.

The new employee will find that the engineering department has a structure. There is a chief engineer and departmental heads for each engineering discipline. Newly employed engineers are assigned to work for the chief engineer of their discipline be it mechanical, electrical, or civil.

There are usually many specialized groups in the general engineering department in addition to the principal engineering groups. Most of these have been mentioned above. All engineers will interface with most of the other groups. Some engineers, in fact, decide to specialize in one of the activities such as planning and scheduling, estimating, or cost control for their career.

In order to learn what one's own department does and how they do it, young engineers will usually be given brief departmental task assignments. These will let the management assess the capability of the engineer both technically and in terms of ability to think for themselves and write up the results of the work. Typical chores would include updating standards, documenting design work already completed, or analyzing a problem that was troubling one of the project groups in the department.

These tasks show the young engineer how the other groups in the department can help the engineer or how the engineer can give them assistance. They then comes assignment to a project. When they are on a project, they will find that they now have two bosses–their department manager and their project manager.

One part of the indoctrination will be to read the company's DESIGN STANDARDS AND PROCEDURES. These include: company developed short cuts in design such as nomographs; a full explanation of the company's complete reporting forms and how to use them; engineering specifications based on good industry design practices for all applications where industry-wide standards do not apply; corporate rules of conduct; quality control procedures and guidelines; corporate reporting requirements; personnel policies; and other instructions, documents, and guidelines necessary to insure that the finished engineering and construction work of the company meets or exceeds industry established, and recognized minimum, design and construction standards and specifications. These standards protect both the company and the public.

1.2.2. THE VARIETY OF ENGINEERING SPECIALTIES

There are over 2 million engineers working in the United States in 1989. Most of them fall under the headings of chemical, civil, mechanical and electrical engineers.

In 1983 the National Science Board estimated that there were:

Discipline	Number (1000's)	Percent
Mechanical	250	16.9
Electrical	280	18.9
Civil	200	13.5
Chemical	80	5.4
Aero/Astro	50	3.4
Others(l)	620	41.9
TOTAL	1,480	100.0

(1) Included in this group are industrial engineers. Large production industries like cigarette manufacture and automobile manufacture are typical employers. As a group, there were about 163,000 industrial engineers.

Industrial engineers are principally electrical and mechanical engineering and technology graduates who specialize in robotics and who set up and improve the performance of production lines and facilities. They also work on quality control and improvement.

They were not included as an engineering group in the above table because some of their activities. These activities are not only varied, including many sub-specialties such as time-and-motion study, but also include some activities that the professional engineering licensing boards do not consider of an engineering level. Additionally, some universities give technology degrees, which have lower mathematics and engineering caliber course requirements.

There is a fine line between the two types of degrees insofar as industry and licensing boards are concerned. Some states require additional courses or time on the job for technology graduates to get a license.

The "other" grouping in the table gives you an idea of how many kinds of specialties there must be. Many of the specialties have their own learned or honorable societies, even if they do not have the stature of the societies of the principal disciplines. For example: Nuclear engineering, plastics engineering, and ceramic engineering are offshoots of chemical engineering. Aeronautical engineering and marine engineering are off shoots of mechanical engineering. Instrumentation engineering and biomedical engineering are off shoots of electrical engineering. In addition, hydrological engineering, environmental engineering, and engineering mechanics are off shoots of civil engineering.

No matter what discipline an engineer majored in during college, job opportunities may lead into one or more specialized career paths. Here are some of the engineering specialties, most of which have been mentioned above, that can be career paths in themselves.

1.2.2.1. Engineering Design

Most young engineers start out as engineers doing engineering design. This may include: design of mechanical components or systems; design of chips or electronic or electrical systems; design of structures, foundations, roads; in short, design of relatively well defined parts of a project scope.

A design engineer, gaining in experience, will advance into design of systems; become a group leader on a project or within the department; then become a department head; and finally, with additional experience, advance to become chief engineer or engineering vice president.

1.2.2.2. Management

As the young engineer moves up the corporate power ladder, types of activities change and responsibilities grow. The engineer does less and less actual design him/herself, but begins to check and comment upon the design of subordinates. The assistant group leader begins to plan group or departmental work assignments and to schedule work on a project. The group leader plans and schedules for the department for many projects being performed simultaneously with differing deadlines. Forecasting labor requirements for projects of the department and budgeting the work and resource requirements of the department come into the responsibility area with advance to department head. As departmental manager, the engineer also will begin to get into corporate planning activity.

An engineer with a broad focus may advance to senior management with responsibility for more than one discipline. As engineering manager or vice-president, added responsibilities will include: departmental annual and forward planning for staffing, budgeting and scheduling; attending endless meetings; making presentations, which may be on behalf of your entire company, to quarterly assemblies of bankers, who may be lending your company money on projects, and stockbrokers who handle your companies stock; participating in sales activities; perhaps making your company's presentation to get funding or acceptance as the engineers for a big project.

The engineering manager has to fight for departmental space and budgets; capital equipment, like new computers; inclusion of department projects in the corporate forward plan, added staffing or staff training programs, etc. Managers have no regular workweek. They usually have to travel a lot–frequently on weekends and at night–and then go right to work the next day.

Managers have a profit objective for their group. Their bonus will depend not only on their performance but also on the group performance. Some managers make bonuses that equal their annual salary. Some managers are fired for not meeting objectives.

To move above engineering responsibility an engineer will have demonstrated many collateral talents:

- Ability to get along with the top management and be a selfless team player
- Ability to have literate reports come from your group
- Ability to budget and manage people
- Ability to verbalize effectively and glibly in the most adverse circumstances
- Ability to perform socially in all corporate settings, including dressing well and exhibiting impeccable grooming

An engineer's spouse will have to prove acceptable to the spouses of top management. They will have to dress well and have well-bred manners. Both spouses and engineers will have to be well educated, well spoken with no provincial accent, and be, well read and up to date on current affairs.

Depending on the global scope of your company's activities, this may mean that both engineer and spouse will have to have the ability to defend your country's policies and to explain your company's position on such policies without offending anyone. It may also require ability to speak one or more foreign languages, to know and understand the politics of several foreign countries, and to know the position in these countries of the people with whom you are asked to interface. Most companies that require their engineers to go abroad or have knowledge of management activities will send them, and their spouses in the case of language, to Berlitz or to get a crash MBA course in the areas where they will need expertise.

Should an engineer aspire to the role of CEO or president, he or she must be prepared to sacrifice private life for the company, which must always come first. They will be on call seven days a week. Seldom will meals be spent at home or with the family. Very extensive travel is common. In addition, and hardest of all for most, is the need to have no friends within the company in the sense that only latest performance is a criterion for action and decisions–not friendship.

1.2.2.3. Project Engineering and Project Management

An engineer with several years of experience can move into project engineering. Project engineers coordinate the work of all the discipline engineers on a project. They also have to cope with project planning, scheduling, cost forecasting and all management aspects of the project. These functions include insuring that adequate staff is available in the office and on the site, seeing that union matters are always under control, liaising with the client to be sure that they are happy and making decisions promptly when required for the project, seeing that supplies and equipment are ordered on schedule and that deliveries remain on schedule, and seeing that all extra work requests from the client are in writing, well defined in terms of both dollar and schedule affects, and signed as approved by the client's representative as soon as possible.

If an engineer likes project engineering, he or she can aspire to move up to project management, which involves having responsibility for all design, all schedule compliance and all expenditure of project funds. Expert project managers are among the most highly paid executives in industry. Managing a $20 billion project gives the project manager more fiscal responsibility than the governments of all but a few countries.

1.2.2.4. Marketing and Selling

Many young engineers will start assisting salesmen early in their careers in the capacity of technical advisors. If the engineer has a proclivity for sales, he or she may soon be handling both the sales and technical advice functions. Some companies that sell highly technical equipment, such as electronic parts, robots, or mechanical equipment that must be carefully matched to the use, have to have engineers as salespersons.

The difference between selling and marketing is scope and responsibility. The marketing manager has to plan the sales approach and sell it to management. This includes defining personnel and financial requirements, sales targets and sales goals, predicted profitability and forward growth and profitability estimating. The salesperson is a cog in the marketing manager's plan. The marketing manager also has to administer the plan and manage the sales personnel.

Marketing is one of the best routes into management. Top management participates in the development of and must approve all marketing plans. Consequently the marketing manager will become known to the top managers relatively early in his or her career. If he or she meets or exceeds profit goals and demonstrates ability to motivate salespersons, they are an obvious candidate for advancement; much more obvious than the engineering manager whose group merely contributes to the team effort is.

1.2.2.5. Estimating

All engineering work is estimated and budgeted before it is begun. The ability to estimate does not require that the estimator be an engineer, but the fact is that many excellent estimators begin their careers as design engineers. Estimators have good exposure to management because they sit in many meetings with them, but few estimators advance to management status. Estimating is an important function in every engineering company. Being a good estimator assures good job security and a relatively low-pressure career with a good amount of variety of experience. The estimators have their own learned society and meetings.

1.2.2.6. Planning and Scheduling

All engineering work, project and departmental, must be planned and scheduled. Usually departmental heads do departmental planning. Project planning and scheduling is a highly skilled activity that takes a specialist. As with estimating, it is not absolutely necessary that a planner be an engineer, but most of the good ones are engineers who have had both design and construction experience.

Planning and scheduling is a key predecessor event for making an accurate estimate. Planners get good exposure to management as they sit in many high-level meetings at which budgets and project and construction plans are finalized. Like estimating, planning and scheduling tends to be a career rather than a path into top management. Some planners are good enough to become consultants with their own business. The planners and schedulers also have their own learned society.

1.2.2.7. Operating Engineering

Operators work in process plants or manufacturing plants. The difference between process and manufacturing plants is this:

A manufacturing plant takes components and assembles them into a finished product. Automobiles, cigarettes, and carpets are examples of manufacturing plants. They have complex assembly lines and forming operations. The engineers who work in these industries as operators run the plant. There are also design engineers in manufacturing plants who design new products, design the machinery to go into the assembly lines to make the products, revise and update instrumentation, and design robots to work on the assembly lines.

A process plant takes in raw materials and alters them physically and/or chemically into finished products or intermediate products for manufacturing plants, e.g., paper manufacture from wood; alcohol manufacture from grain or sugar or grapes; and gasoline and diesel manufacture from crude petroleum are examples of process plants. Power plants and co-generation plants are also process plants. A co-generation plant produces both steam and power from some combustible material such as coal, oil, gas, or municipal solid waste.

There are both design engineers and operating engineers in process and manufacturing plants. Design engineers on the staff in process or manufacturing plants work 8 to 4:30, five days a week. The operators work on a three-shift basis, seven days a week. Shifts in some plants rotate so that operators may work unsocial hours. Some plants have operators work ten days on and four days off. Operating engineers work shifts just like the operators.

Operating engineers may advance to shift supervisors and plant supervisors. The spirit of operation is freer than in design. There are fewer individual pressures. The operating engineer impinges mostly on operators who work for him or her and are in lower status categories. Operating engineers do not have as many deadlines and such close supervision as design engineers. They also are less likely to advance into the topmost echelon of company management, although becoming plant operations manager places them in the plant management group council. When an operations engineer does move up it is to be responsible for more than one operating plant. In some corporate structures, the top operations manager or vice president is in the top management echelon of the company. Operating engineers have their own learned society.

1.2.2.8. Maintenance Engineering

Maintenance engineers have several functions. They establish procedures to keep the machinery and equipment in a plant running on a day to day basis. They plan for major alterations and maintenance on scheduled plant shutdowns.

The scheduled shutdown, or turnaround as it is called in some industries, is an intensive activity period of roughly 30 days duration. During the turnaround the plant is not making any money, so the turnaround is carefully scheduled and preplanned on a critical path schedule. The maintenance engineer must either prepare this schedule and do the pre-shutdown work or hire firms who specialize in this work. Maintenance engineers have their own learned society.

1.2.2.9. Construction Engineering

Construction is an excellent career for engineers who cannot stand the constraints of office life. The construction engineer gets to do a bit of everything: planning, scheduling, supervising craft labor, interfacing with unions, worrying about buying and setting up construction facilities, and getting construction utilities and equipment and small tools.

The construction engineer has to insure that the construction team works together, provide for health and accident emergencies, and interface closely with the project manager and construction manager as well as the design engineers whose efforts must be interpreted for the construction team by the construction engineer. Near the end of major construction work, the design engineers from the design office are frequently assigned temporarily to the field to check out the installation and the instrumentation.

The construction engineer has to work with the procurement staff to check that all equipment is purchased, manufactured, and delivered to site in good condition and on schedule. S/he has to fight with the insurance company about damage. S/he has to interface with the client’s engineer (unless s/he is the client's construction engineer), and as the job nears completion see that all of the testing is done and witnessed, that surplus materials are sold, that all approvals are obtained from the client, that the site is cleaned up and the construction camp dismantled and removed.

In short, construction engineering is very healthy and very varied. Lots of fresh air and mud, rain, sleet and snow; but a relatively low-key little-pressure job as long as everything goes well. Strikes, construction accidents, slippage of the schedule, and budget overruns do create enough interest to keep the engineer mentally stimulated.

Construction engineers get to live for six months to six years in lots of different construction locations; some fun some boring. They may not always be able, or want, to take their family. Schooling for children may be a problem, although on remote construction sites the wives of the staff run schools—sometimes teaching in several languages.

There is a psychological insecurity factor for many families caused by continually moving around. Family life is difficult. But pay and bonuses for a job done on schedule and within budget are good, and vacations between jobs can balance some of the strains of family life. In construction oriented engineering companies, construction engineers can progress to construction management and into top management. Construction engineers have a learned society too.

1.2.2.10. Industrial Research

A Ph.D. degree is the entry card for a career in research that occupies perhaps 5 percent of all engineers. Research can be very mentally rewarding. Almost no researchers move into top management, but the pay is good and there is almost no pressure associated with the job. Researchers do not have their own society, but are very active within their own discipline societies. Fame and peer recognition are rewards for researchers. In addition, within the constraints of ethics, a researcher may aspire to a senior career in consultancy at high wages.

1.2.2.11. Teaching – Academic Research

A Ph.D. degree is also the open sesame for a teaching career at the university level. Teaching at university level requires a significant amount of research during the first five to ten years of your career. Almost no engineer, with a Ph.D., would aspire to teach at a lower level than in a university. The "tenure" system in universities affords a degree of job security that can no longer be experienced in industry.

In addition to the possibilities for intellectual and peer satisfaction, the university professor can advance through department chair to dean to vice-president and even college or university president. If the engineer goes this route, then he or she must acquire many of the fiscal, planning, interpersonal, management, and social talents described above under management.

1.3. HOW DO ENGINEERS GET THAT FIRST JOB?

1.3.1.THE RESUME

Through out their careers engineers will use a resume. Initially it will help obtain that first job. Thereafter the company will include the resumes of the key personnel in proposals to get work. A resume will also be used when an engineer desires to change jobs. In each case the engineer should tailor the resume to suit the purpose it is to serve. Resumes are either included in a proposal or accompanied by an application form or a cover letter; they are never submitted alone unless it is in response to a specific request. The purpose of a resume that is used to obtain a job is to get an interview.

Inattention to spelling and grammar in your resume give your prospective employer the feeling that you are stupid, have muddled thinking, are uneducated, are not professional; you are also likely to be misunderstood and to call into question the value of your worth.

In the proposal for this course, the engineers will include their resumes. Since the staff (faculty) know that the engineers will have limited experience, the resume each engineer includes should be a copy of one that will be used to obtain a first job; it will be evaluated on that basis.

1.3.1.1. **STRATEGY:** The Sales & Marketing Game

The resume is a great tool. There are really no rules, no definitive procedures that dictate how you prepare your resume. The choice is yours. The opportunity is there to sell your achievements creatively and aggressively, to effectively position yourself above the competing applicants, and get in the door for an interview. Just remember, the purpose of your resume is to get the interview, not to tell your life history.

Suppose that you designed an innovative new product line. Your are ready to begin selling the product, so you develop marketing plans, sales literature and other campaigns that highlight the features and benefits of the product. In essence, what makes it so great.

The concept is the same when you prepare a resume – highlight the features and the benefits. The format to get the hiring officer’s attention is not set in stone. Any number of examples are presented in a multitude of publications and web sites. You will have to tailor the resume and even the format to the particular position that you are trying to get.

1.3.1.2. **CONTENT:** Capture Attention & Win

Please note this is a recommended format that may or may not be appropriate to your particular circumstances. Remember, there are no rules to resume writing. Prepare a resume that will sell your talents, technical qualifications, career history, and achievements.

1.3.1.2.1.The Value-Offered Statement

Most people's resumes include only one kind of information: historical data that tells an employer who you are, where you came from, and what you did. It may also list skills that may or may not be transferable to a new job. None of this information tells an employer WHAT YOU CAN DO FOR HIM. The resume leaves it up to the employers to figure that out for theirselves. That's no way to market yourself. But that's all the information 99% of resumes contain. That is why most resumes get no response from an employer.

It is an old marketing adage that says, “Give the customer a sample of your product before you expect him to buy from you.” That gets the prospective customer hooked. It gives him or her a reason to want more. It also accomplishes the critical goal of PROVING to your customer how good your product is.

Do the same with your resume. Give the prospective employer a free sample of what you can do for HIM (or her). It will help get the employer's attention, and it will distinguish you as a job hunter whose goal is to DO THE JOB for the employer, rather than just to GET A JOB for yourself. How do you put a free sample of the benefits you offer an employer into your resume?

First, you have to clearly understand what makes your work and abilities valuable to companies in your field. Do not just think about your skills. Think about how you have used your skills to help an employer succeed and be more profitable. However, do not put only that on your resume. That is just more historical stuff. Just because you helped your last employer is no proof that you can help ME. You need to package the information in a way that says to a prospective employer: This is what I can do for YOU.

To do that, you need to understand what an employer's needs are. That means understanding the problems and challenges his company faces. Do some research. Most companies in an industry face the same general problems. You can learn about these by reading industry publications and talking with key people in the field. You find these folks by reading the articles they write or articles that are written about them. Call them up or call employees of your target company. Talk to the professional associations that the company belongs to. Dig. You will be surprised at what you will learn. Use that information to figure out how YOU can use YOUR skills to help solve the problems your prospective employer is facing.

Now go back to your past accomplishments. What skills did you use? Make a list of those skills, to help you think about them. How did each accomplishment help your company become more successful or profitable? It does not have to be a huge difference that you made, but it has to be a difference. Now take those skills and ask yourself, how would I apply them to solve the problems and meet the challenges of the companies I want to work for?

Create a new area in your resume. Call it VALUE OFFERED instead of CAREER OBJECTIVES. Put it at the beginning of your resume, under your name where you would normally put your objectives. In two sentences (no more than three or four lines on the resume), state the value you are offering. Be specific. If you have to do a separate resume for each company that you approach, so be it.

Here are some examples of good VALUE OFFERED statements:

"I can reduce your operations costs by negotiating better deals with your freight vendors and streamlining your shipping department."

"I can increase your revenues and profitability by teaching consultative selling techniques to your sales staff, and by establishing relationships with key opinion-makers in your target market."

"I can increase your profitability by bringing programming projects in on time and under cost. I can do this by using special techniques to help your design team work more closely with your end users."

These are examples of poor VALUE OFFERED statements:

"Hardworking, capable operations expert who can help you streamline your operations and save money." (But HOW?)

"Strong sales and marketing experience with exceptional communication skills to benefit your bottom line." (But what EXACTLY will you DO for my company?)

"I bring great value to any company because I am very good at working with people." (Too general, doesn't address a specific problem or goal of the employer.)

Get the idea? It takes a lot of work to develop this kind of statement. You have to learn a lot about the company you are pursuing. It also helps to know exactly what kind of specific help that a particular manager needs (this might be your current employer, if you are looking for an internal promotion or job change). **Be specific and avoid glowing generalities, which are generally regarded as Madison Avenue fluff and leave a negative impression.**

You could spend your time doing the necessary research, and deciding what EXACT value you will offer a company, or you can spend it licking stamps, mailing hundreds of resumes to companies you understand very little about, and waiting by the phone.

Put a sample of your value into your resume. It is the jewel a hiring manager looks for.

1.3.1.2.2. Engineering Experience

Unless an entry level engineer has had an internship or significant military technical experience, the experience section should be placed after the Education section because the experience, while significant, will generally not be directly related to the job that is being sought. If your work experience is not engineering related, re-name this section Work Experience.

So, you want a job? Let's just suppose ... I've run an advertisement for a computer programmer, a systems analyst, a chemical engineer or a Chief Information Officer. And now, only one week later, I have 429 resumes on my desk and at least 100 phone messages from interested applicants. It would be easier to just do the job myself (if I knew how!) than to try to work my way through this pile. So, I spend the next week sifting through resumes that all say the same thing. Programmers tell me they write code, systems analysts tell me they design new systems and applications, chemical engineers write that they develop processes for chemical manufacture and CIOs tell me that they direct the corporate information management organizations.

Looking at what I think is resume #388, something is different! This resume says something. It highlights projects, achievements, special task forces, and a host of other interesting and distinctive activities. I want to meet this applicant!

Now, is that applicant you? It certainly can be if you learn the tricks and techniques to effectively market yourself through your resume.

Yes, of course, you need to include the "typical" resume information - work experience, educational background, technical qualifications, and professional affiliations. Equally important is the emphasis you place on selling your career successes – special projects, new systems development, productivity improvements, quality improvements, reductions in operating expenses, and more. The list goes on and on. A few examples include:

- Directed the development and implementation of a new corporate Information Management System to replace obsolete technology. Managed project from initial conceptualization and

systems specification through the entire programming, configuration planning, installation and technical training cycle.
- Redesigned internal product scheduling procedures and reduced net days per project by 32.
- Redesigned engineering processes and expedited daily production by 18%.
- Identified cost overrides in contracting data processing fees, re-negotiated vendor agreements, and saved over $2.3 million annually.
- Wrote and implemented a series of customized programs (e.g., accounting, inventory control, purchasing, order entry) to support UNIX-based operations for a multi-million dollar global distributor.

By including this type of specific information, you are "teasing" the prospective employer. It is important that you provide detailed information to substantiate not only your qualifications but also your ability to contribute to the corporation and effectuate positive change. In today's economy, everyone is suffering - from the large corporate giants of yesterday to the small, high-tech companies. Money is tight, competition is fierce and economics are forcing massive change.

Companies need expertise and the ability to produce. Your job is to use your resume as an effective sales tool that will demonstrate your knowledge, achievements, and capabilities. As your prospective employer, "tell" me not only what you have done, tell me how well. Be careful, however, about "overkill". Achievements must also be within the realm of reality **and** **documentable**!

Include job titles, employers, locations and dates of employment in addition to a short, yet comprehensive summary of responsibilities with special emphasis on project highlights and achievements.

1.3.1.2.3. Education

This section will normally be first in a resume for an entry level job. Include college degrees, seminars, workshops, conferences, and any other professional development activities. Be sure to include distinguished academic achievements, honors, and awards. College activities may or may not be appropriate based largely upon dates of graduation and amount of professional experience.

If you financed (including student loans you took out) a significant portion of your education, include a statement like: “Financed 75% of college education.” If your grade point average (GPA) is not as high as you might like, this may well provide a reason.

Include the best GPA you can: overall, engineering, major (e.g., electrical engineering), last two years, etc. When you include your GPA, include the base (4.0), e.g. GPA: 3.1/4.0. Some schools use a 5.0 base, and 3.1, for example, does not look so impressive on that scale.

Include relevant elective courses only if you need them to fill the page; use significant design projects instead. You do not need to include the required courses because every one with your degree will have had a similar course.

Avoid including lists of courses taken, and include relevant elective courses only if you need them to fill the page. If your work experience is insignificant and you have no engineering experience (not an unusual case for new college graduates), include a list of your significant design projects, including your senior design project. List any relevant projects that you worked on for pay or as a volunteer outside of school. If your worked on any relevant projects for your own amusement, list them also especially if you have any evidence that they worked.

1.3.1.2.4. Computer Skills

When you list your computer skills, be sure to get the terminology correct. For instance, do not refer to operating systems and applications packages as computer languages; to do so will belie your expertise—not good if computing skills are required for the job you seek. If you list "assembly language," be sure also to list which one(s), e.g., "assembly languages: Intel 8086, Motorola 68000."

1.3.1.2.5. Personal

By law you do not give information related to gender, age, height, weight, race, or national origin. Some other personal information is permissible and will possibly help you get hired if it is appropriate for you. This information includes your US citizenship status, the date you are available to begin work, your willingness to relocate, and your willingness to travel.

You should list your membership in professional societies and your community involvement.

If you play golf reasonably well, list it first on this list; since most people in middle and upper management play golf, this activity will indicate that you are promotable, and it will almost certainly be required when you get to represent your company at professional conferences or meetings with clients. Bridge, sailing, and tennis are also good. The hiring officers are looking for people who work well with others and scrutinize your hobbies with this in mind. Softball, basketball, and other team sports, especially those that are sponsored by the company, are especially good to mention.

Do not list scuba diving, skydiving, hang gliding, bungee jumping, or any sport considered dangerous unless it is directly job related. A possible employer does not want to spend a ton of money training you and then have you go kill yourself in a sporting accident. It is not a good idea to list any hobbies, such as dart throwing, billiards, or pool, that are only done in a bar, especially if you are looking for a job in the "Bible belt." Omission is not lying. Tell the truth if you are asked. Do not volunteer it!

1.3.1.2.6. Other considerations

1.3.1.2.6.1. Name, Address(es), Phone Number(s), and email address

Your name should be centered at the top of the page. If your present more that one address (current or school and permanent), **give the date before which the current address is to be used and the date after which the permanent address is to be used** rather that labeling "Current" and "Permanent." If your resume gets separated from your cover letter and lays around for who knows how long, it is not likely that the hiring officer will call you; some one who did not present a guessing game for the correct number will be called.

1.3.1.2.6.2. Foreign Sounding Names

If you have a foreign sounding name, put your citizenship/visa status immediately under your name. This is especially important if you are a US citizen or permanent resident. You do not want to be overlooked because that is preferred or required for the job you want. Remember when there are 200 applicants and one job, the hiring officer is looking for reasons to throw your application in the reject pile – do not give him one.

1.3.1.2.6.3. Languages

If you are fluent in more than one language, say so and list all. International trade is becoming more and more important.

1.3.1.2.6.4. Length of Resume

An entry-level resume is generally limited to one page. Faced with a stack of 200 resumes, the hiring officer will probably have decided to give you an interview or a rejection letter before the end of the first page is read, much less the second page. Remember, the purpose of a resume is to get you to the interview, not to tell your life story..

1.3.1.3. **VISUAL PRESENTATION:** THE "MAKE IT LOOK GOOD" GAME

Yes, visual presentation matters. In order to sell yourself as a professional, you must "look" like a professional. With the advent of word processing, desktop publishing and laser printers, there is no excuse for a non-professional presentation. Here are a few helpful hints:

- Use bold and italics to highlight specific items on your resume.
- Right hand justify the text for a "cleaner" appearance.
- Use high quality paper (24 lb., 25% cotton). White photocopies very well and is traditional. Ivory, light blue, and light gray are distinctive and attractive, yet conservative. If you have a question, make a photo copy; if the copy looks streaked and dirty, the paper is not acceptable: photo copies of your resume may well be circulated to different departments at the same time.
- Use matching stationery and envelopes for your cover letters.
- Proofread and double proofread. Errors are unacceptable.
- Leave lots of white space. Readability is as important as content. If no one reads the resume, it does not matter what you have said or how well you have said it.
- Stay away from long paragraphs of more than 6-7 sentences. Break paragraphs with blank lines in between and/or use bullets to enhance reading ease.

The one versus two page dilemma is a constant point of concern. Years ago, the "Resume God" said "Let your resume be one page." At it was law. But times have changed, the competition is fierce, and you must make every attempt to aggressively "sell” your qualifications. If two pages is required, so be it. You will find that the response to your job search campaign will be directly dependent upon how well you have marketed your qualifications and achievements; not on number of pages. Keep in mind that the purpose of the resume is to get you to the interview, not tell your life history.

The Truth About Resumes

Most college students utter an audible grunt the first time the "resume reality" hits them: "Uugghhh. I gotta do that resume thing." The tendency is to wait until the last minute, then crank out the basics just so you can go on to the next step. But if you properly understand what the resume is and where it fits into the entry level hiring process, you will see that it requires a great deal more thought and preparation than just "cranking it out."

Many hiring managers will contend that they take as little as three seconds to review a resume. What they really mean is that the minimum amount of time is three seconds. Successful resumes will be reviewed much longer. The key is to capture and hold an audience long enough to accomplish your specific purpose. And that purpose is to get to the next step in the process–the interview. But don't ever believe that a resume alone will get an interview. Or a job. The truth about resumes is that they are quite limited. The resume will not find the interview for you. The resume will not find the job for you. The resume is not your job search. But it can provide you with the starting point for your job search. If you cannot sell yourself on paper, you probably will not be able to sell yourself in person.

From the perspective of the hiring company, your resume is your initial marketing brochure. Period. Nothing more and nothing less. Once you start looking at the resume from a marketing perspective, you will be on your way to a more effective resume. It cannot "make the sale" any more than a marketing brochure can sell you a car–there still has to be the test drive, a look under the hood, a chance to kick the tires, etc. However, if the marketing brochure is effective, you have already been pre-sold on the car before you arrive in the showroom. Same for resumes.

Your resume is a professional reflection of you as the potential product. Professional resume, professional product. Sloppy resume, sloppy product. Take the time to develop your resume as the very best reflection of you. It is essential that the importance of the particular sections of your resume be carefully scrutinized. In evaluation by hiring specialists, these aspects are listed in importance:

1. qualifications
2. key words and phrases
3. accomplishments
4. assess the quality of the written document

1.3.1.4. **ELECTRONIC MEDIA:** THE KEY WORD RESUME

When Fred Flintstone was "downsized" by his job at the stone quarry and he found he no longer had a job, he probably met with the placement department and they referred him to the local resume writer. Together they produced an appropriate document utilizing the finest of stone carving tools and the highest quality granite available. Fred then made the rounds leaving resume slabs for corporate consideration.

Now that the electronic age is with us, the appearance of the printing press, the typewriter, electric typewriter and word processor have each heralded a new era for resume production. The icon of the newest era is the computer. The computer with all its related electronic technology and on-line networks allows for instantaneous production and distribution of resumes on a global basis. Frederick J. Flintstone IV can now produce a resume at will and transmit it electronically to computer on-line databases where it can be searched immediately and continuously. The entire process can be completed in a matter of minutes or hours. The resumes may contain photos of the job seeker or a video clip of the job seeker performing in one way or another. Creativity of presenting your “cover letter” and resume will certainly improve your chances at getting that interview.

The standard resume, no matter how effectively designed, executed or presented, is no longer adequate to meet the demands of electronic/computer scanning. Computer scanning and database management of resumes are necessitating a significant re-engineering of the concept and process of using resumes in job hunting endeavors.

Once a scanned resume is uploaded into a database, it can then be searched by anyone who has access to the database. One such database is the Worldwide Resume/Talent Bank database located in the Career Center forum area on the America On-line computer network service. This 20,000-resume database can be accessed by America On-line members at no cost beyond their membership fee and the usual on-line charges. This particular database is also accessed via the On-line Career Center on the Internet for a viewing audience of 43 million. Prodigy subscribers now also have access to the Worldwide Resume/Talent Bank on the Internet.

Other resume databases have been developed by a myriad of associations, groups, and companies. They vary widely in size, content, accessibility and cost. Their primary commonality is that they are all searched in one way or another by computers.

On the far end of the spectrum are resume management systems. These systems scan resumes into databases, search the databases on command, and rank the resumes according to the number of resulting "hits" they receive. At times such searches utilize multiple (10-20) criteria. Major corporations and recruitment firms usually utilize such resume management systems. The reliance upon resume management systems, coupled with the downsizing of human resource departments in many corporations, has resulted in a situation whereby many resumes are never seen by human eyes once they enter the electronic systems!

The lesson here, therefore, is to make the resume as computer/scanner friendly as possible so that its life in a database will be extended and its likelihood of producing "hits" is enhanced. Note that the Key Word resume must contain an adequate description of the job seeker's characteristics and industry specific experience presented in Key Word terms in order to accommodate the electronic/computer search process. These are the words and phrases that employers and recruiters use to search the databases for "hits"!

Also observe that the following guidelines are followed in order to enhance the processing of Key Word resumes through the electronic system:

- Left justify the entire document; avoid right justification and full justification.
- Utilize a sans serif font in size 10-14; avoid anything smaller.
- Use spaces; void tabs.
- Use new line (Shift-Enter in Word); avoid hard returns whenever possible.
- Use only normal text; avoid italic text, script, underlining, graphics, bold and shading.
- Use blank lines for delimiting; avoid horizontal and vertical bars.
- Recast to eliminate parenthetical material; avoid parentheses and brackets.
- Use regular mail or e-mail; avoid faxed copies, which become fuzzy.

As Joyce Lain Kennedy recommends in her *Electronic Resume Revolution*, "The name of the game for OCR software is distinctive edges to each character." Key Word resumes should be clean, neat, and detailed. Remember, they are designed to be scanned, to be computer friendly, to produce "hits," not necessarily for visual appearance or to be read by humans. The more of the above suggestions that are incorporated into the processing, the better the chances of the resume moving through the entire computer scanned system without corruption.

1.3.1.4.1. Success on the Information Superhighway!

One of these writers (MEB) suggests, therefore, that successful job seekers will prepare two versions of their resumes. The traditional market driven resumes will continue to be designed to be read by "real people" in "20 seconds or less" and will follow the various formats presented by untold numbers of resume writers and resume writing programs. The Key Word resume, however, should be developed, added to the successful job seeker's arsenal and utilized in any situation where computer scanning might possibly be involved.

Most employers are changing the way they use and retrieve information. Electronic scanning into databases using the Information Superhighway is the "Way of the future." Join Frederick J.

Flintstone IV and travel into the future now by presenting your Key Word Resume to potentially millions of employers locally, nationally, and globally.

While most resumes arrive in a standard #10 envelope and are relegated to mass review and filing, a resume on disk arrives in a non-standard sized diskette mailer. It is guaranteed to receive special attention when being passed through the internal mail process. For those seeking employment, this diskette mystique can work very nicely to your advantage. When used to present your resume, it can turn an otherwise plain and drab piece of paper into a truly irresistible personal presentation.

The resume on disk is successful because it is unique. If you have the technical talent to create your own version of the resume on disk, do it. Do not worry that "no one else is doing it that way." It is your opportunity to stand out and be noticed in your field. And not just for technical fields–nearly all hiring managers have a PC on their desk. In a few years, this technique may be more commonplace. But for now, you will truly be a standout.

1.3.1.4.2. The Very Best Way To Create Your Resume

Most resume books tell you that, as the first step, you should "take a piece of paper and begin listing all your positive attributes" or something to that effect. Why? I thought you wanted to write a resume? If you want someone to produce an exhaustive list of all your positive attributes, go ask your mother; moms are great at that. This practice in "positive attribute development" futility might be okay for little Johnny who is about to graduate from high school and wants to figure out what he wants to do with his life, but, hey, are we not college grads? Why do we not take that quantum leap and just start putting together the actual information on disk in resume format where it can be used?

Successful resumes generate information as they are created. Think about it. Do you ever write a term paper from scratch? Not usually (unless you are using a typewriter–any typists still out there?). You use either a template file with all the information and codes already set up (like the standard format for the bibliography section that comes at the end of every term paper), or you reuse the basic information from a previous paper (that is why you handed in your Psych paper with last October's date on it).

The same principle applies to resumes. The very best way to create your resume is on-line, real-time on the screen, right in front of you, capturing information as you go. But note: do not waste your time using one of the commercial resume software packages. Reason? First, they artificially force you into their format, which may or may not be correct and most definitely cannot be fine-tuned to your specific needs. Second, they are not portable; i.e., the output file can only be modified with that package. So the next time you want to update your resume, you either have to locate (or buy) the same package or you are out of luck. You are better off working with a standard word processing package (such as WordPerfect, Word, or Ami Pro) and creating your own. Or work with the resume writing feature of the Job Hunt software (have you sent in for your copy yet?) to customize your own.

A note of caution: don't have your resume done by a "professional resume service." It may seem like the easy out, but all the resume service does is take your data and crunch it into a cookie cutter format (and then often seek to charge you $50 to 100 above the quoted price for copies on pretty paper). Do not pay someone else to write your resume. Tom Clancy may be able to write a better novel, but you can out-write even Tom Clancy when it comes to your personal resume. Do it yourself!!

1.3.1.4.3. Key Words

In order to satisfy the idiosyncrasies of the scanning process, a new resume style, utilizing "Key Words," has developed. The term “Key Words” refer to those words or phrases that are used for searches of databases for resumes that match. This match is called a "hit" and occurs when one or more resumes are selected as matching the various criteria (Key Words) used in the search. Key Words tend to be more of the noun or noun phrase type (Total Quality Management, UNIX, Bio-Chemist) as opposed to power action verbs often found in traditional resumes (Developed, Coordinated, Empowered, Organized).

"Key Word resumes are the integral ingredient of the job seeking process." James C. Gonyea, author of *The On-line Job Search Companion* released by McGraw-Hill in November 1994, goes on to say, "Key Words are the billboards that you can place on the Information Superhighway to draw the attention of employers to your employment availability."

Another way to look at Key Word phrases is to think in terms of job duties. Detailing your job duties may require a modified mind set for those of you accustomed to traditional resume writing. However, the words and phrases that detail your job duties are the phrases--the Key Words-- that provide your resumes with "hits".

Additional hints on using keywords from CareerJournal.com are below:

1. Use the job posting to your advantage.

The advertisement for the position you're interested in is an excellent place to find keywords, says Jay Block, an executive career coach in West Palm Beach, Fla., and co-author of "2500 Keywords To Get You Hired" (McGraw-Hill, 2002). If the ad says candidates need to have a bachelor's degree, "bachelor's degree" had better show up somewhere in your resume.

Mr. Block also recommends that job hunters look at ads for similar jobs at other companies. He says that each industry has its own jargon, and becoming familiar with a wide range of ads will help you see which keywords are showing up in ads over and over again.

2. **Some keywords are golden.**

“Although many keywords are industry specific,” Mr. Block says, “certain phrases are important to almost all companies. They include ‘communication skills,’ ‘problem-solving,’ ‘team work,’ ‘leadership,’ ‘resource optimization,’ and ‘image and reputation management.’"

"Business development" might be one of the most important of all,” he says.

"I've interviewed many, many companies that will tell me, 'Everybody from the floor sweeper to the national sales manager had better be involved in business development in some way,' " says Mr. Block.

3. Use words that demonstrate your value.

“The problem with many resumes is that they read like biographies,” says Mr. Block. “Companies don't really care about your life story, they want to know if hiring you will be valuable to them,” he says. That is where keywords come in.

"Keywords are words that have got to show one can produce results," he says.

Mr. Block recommends that job hunters present key phrases like "driving gross" or "increased efficiency" in a prominent way, so that they stand out when the resume gets past the computer and is viewed by human eyes. He says that a prospective employer wants to be able to determine within 10 seconds what value you bring to the table.

Leo Gillespie, a hotel operator in West Palm Beach who has consulted with Mr. Block, says he now thinks of the top of the first page of his resume as a billboard, painted with keywords designed to draw attention.

"You need to highlight the work skills that qualify you specifically for the job that you're targeting," he says. Mr. Gillespie is applying for a position in which he will compete with hundreds of other applicants, but he's confident the right keywords, backed by 20 years' experience in the hospitality business, will earn his resume the attention it deserves.

4. Action verbs still matter.

The keywords that will get you noticed by a computer search are usually nouns, but the verbs you use are still important, says Jim Lanzalotto, vice president of strategy and marketing at Yoh Services LLC, a professional staffing firm in Philadelphia.

"You need to communicate the things that you do in a positive, active way," he says. Using strong phrases like "led a team" or "built a team" instead of "worked with a team" can make a subtle but important distinction to a recruiter.

Mr. Gillespie is one job hunter who has embraced using active verbs. His resume includes phrases such as "igniting revenues" and "motivating and leading a dynamic staff."

5. Don't go overboard.

As important as keywords are for getting noticed, littering your resume with buzzwords that don't accurately reflect your work experience may work against you, says Mr. Lanzalotto.

"Too often, what happens, candidates will muck up a resume by just putting keywords in it, whether they have the skill sets or not," he says. This trick might get you noticed initially by a computer scanning a resume database, but an experienced recruiter will see through it.

Chuck Schaldenbrand, co-owner of RESUMate Inc. in Saline, Mich., which designs professional recruiting software, compared using bogus resume keywords to putting superfluous words on a Web site in order to get it ranked highly by a search engine.

"If you create your Web site for the purpose of a Google ranking, but you destroy the readability of your site, you've shot yourself in the foot," he says.

6. Go with a text file.

The keywords you use in your resume won't help if the resume you submit can't be read by scanning software.

Short of submitting a hardcopy resume on an usual color of paper, there's not much a job hunter can do to foil a resume scanner, says Mr. Schaldenbrand. However, when job hunters are asked to submit a resume electronically, they often have a choice of whether to submit a text file or an HTML file.

Mr. Schaldenbrand says HTML files can be formatted to look more aesthetically pleasing, but he recommends a text format.

"HTML is easier to read, but the truth is recruiters who use database software request resumes in text form, because databases do better with text than they do with HTML," he says.

< http://www.careerjournal.com/jobhunting/resumes/20060605-flesher.html?cjpos=home_whatsnew_major>

1.3.2.COVER LETTER

There are two schools of thought with regard to cover letters. Presented here are two viewpoints. It is left up to you to determine which analysis is correct for your search for the first job of your career. Regardless of whichever way you choose inattention to spelling and grammar in your cover letter give your prospective employer the feeling that you are stupid, have muddled thinking, are uneducated, are not professional; you are also likely to be misunderstood and to call into question the value of your worth.

1.3.2.1. Transmittal Letter vs. Application Letter

Cover letter is one of a myriad of terms used as part of "careers jargon" when talking and writing about job search skills and techniques, which are really misnomers. One example is could more accurately be called a transmittal letter. Many graduates simply send a 5 or 6 line form letter with every resume. This letter essentially says, “Here is my resume. I want a job." Cover letter is still widely used for what is really the application letter. If you ask a new graduate what an application letter is, they suggest that more thought must go into its content and more must be said about how they match up with the job than they usually put into a cover letter.

It is extremely important that applicants understand the importance of the cover letter and realize that, next to an application form, it is this documentation that provides the potential employer with the first impression of the applicant. In these tight economic times, many employers are using the application letter as their point of screening out as they know that some applicants have their resume professionally typed and in some cases even written by professional consultants. The employer relies on the application letter to provide them with an insight into the "real" person, because, surprisingly, most applicants seem to still feel competent and comfortable with writing their own letter. This may also change once they begin to realize its significance as a selection tool.

An application letter should contain evidence that the applicant has taken the time to do some research into the organization they wish to work for and the position advertised. The next step is to show how their qualifications, skills and personal qualities match with those which the successful applicant would need to possess, that is, what the applicant can do for the organization. Such marketing encourages the recruiter to turn over the page and look more closely at the applicant's resume to fill in more details.

Remember that the recruiter is looking for a reason to reject your application. Rejection is easier for them than looking for reasons to accept it. If the letter is poorly written, does not contain enough information, does not adequately address the selection criteria (if there are any), or just states that the resume is attached, it is an easy decision for the recruiter to put it in the reject pile. Job seekers must realize that the application letter is the first step in the recruiting process not the end result; if they do not get past this step they may not get the chance to "tell the employer more at the interview."

Hiring executives confirmed that cover letters (even handwritten, if a must) were essential. Letters are expected for all positions. Of particular note during the cover letter conversation was the reference to salary requirements. What do hiring executives think when salary requirements are requested in an advertisement, but are not provided in the cover letter? Unanimously, they agreed that if the candidate appeared qualified for the position, they would offer the opportunity for an interview, despite the fact that salary requirements were not included.

This is a critical point. Often it is difficult to determine what a specific position will pay. Although you may be interested, you are concerned that your recent salary may be too high or too low for consideration for the advertised position. We now know that it is either acceptable to either (1) not include the salary requirement or (2) state the salary requirements are negotiable.

1.3.2.2. The Truth About Cover Letters!

If you are in pursuit of an outstanding entry-level position, you need to know the truth about cover letters. Contrary to some of the more fashionable books on job search, no one ever got a job because of a spiffy (or "perfect") cover letter. Cover letters are extremely limited in value, even when used properly.

So take everything you've ever heard, read, or seen about cover letters and throw it out! That's right, 99.44% of the information about cover letters is useless. Why? Three reasons.

First, most people assume that the cover letter is actually read before the resume. Wrong. Just ask anyone who reviews resumes–they go straight to the resume (if it is read at all) and only look at the cover letter if they are still interested. In one writer's (MEB) review of over 20,000 resumes, he has probably read only 4,000 cover letters, and that was done only after finding strong interest in the resume. It is actually rather amusing to watch hiring managers reading their mail. The cover letter and resume are pulled from the envelope, the cover letter is immediately placed behind the resume, and the resume is reviewed. Usually scanned first, then read. And you know there is interest if they finally make their way back to the cover letter.

Second, most people assume that the cover letter should be about you. Wrong again. It should be about the company, which is your prospect and your target. Your resume will tell them the basics that they need to know about you (if it is well written).

Third, and most important, many college students end up using the cover letter/resume mass mailing as a crutch to fool themselves into believing they are actually doing something to further their job search. In reality, all they are doing is generating rejection letters. Mass mailing of your cover letter and resume does not work in today's job market. Generic cover letters generate generic rejection letters.

Understand that at the entry level a resume and cover letter on their own do little good. Larger companies have established college recruiting programs that serve as the focal point of entry level hiring. Therefore, most entry-level resumes are ignored. Most medium and small companies do not have the resources to train entry-level hires, so the entry-level resume will again be ignored. The best you can hope for in a blind mailing campaign is that you will be filed away in hopes of being miraculously resurrected at some future date. Very unlikely.

So when should you use a cover letter? Only as part of a limited, targeted campaign to reach potential employers. Take the time to research and understand a company before committing yourself on paper as their potential next employee. If you have no idea what a company does, do not just send your resume and cover letter in blind hope of making a potential match. If you're not willing to invest the time and energy to find out whether a match is possible, why do you expect the hiring manager to do so?

When a cover letter is used, it should be specific and personal. It should be clean, clear laser copy, yet not mass generated. Each letter should refer to a specific person at a specific company and provide a specific next step of action that you will be taking. Do not expect the employer to make the first step. If you wait for them to call you, your odds of contact decrease dramatically. It typically requires a pro-active response on your part to move the process forward to the next level. The "Squeaky Wheel Theory" is alive and well in the employment field. If you respond to me, I shall respond to you. If not, you will likely find yourself buried underneath reams of other resumes. Be the one who stands out.

Remember, you need to make any mailing specific and follow-up on each letter personally by phone. Sound like a lot of work? Not when you consider the payback. The initial investment per letter is certainly greater than a mail merge mass mailing, yet the benefits are far greater. Mass mailings often generate zero results, while a targeted mailing and follow-up program can generate ten to fifteen percent, or more, in interview production success.

The cover letter should have three paragraphs. The first should state the position you are applying for and your special qualifications. Note: That did not say that you wish to apply, but that you are applying! Say something to the effect that "As an mechanical engineering graduate with an interest in …, I am applying for you position as …." Alternatively, you could word it as "Please accept my application the position as …." The second paragraph should provide evidence that supports your qualification. The last paragraph should indicate your desire to meet with them to discuss what you can do for their company and indicate that you will follow up with a phone call in a given time frame.

Currently authorities recommend a single word complementary closing, such as Sincerely, Cordially, or Regards.

1.3.3. THE INTERVIEW

Resumes are written with the expectation of the job interview. Looked on as both exciting and foreboding, the job interview, either by telephone or personal contact, creates a feeling of intimidation that is difficult to control. Questions are always in the back of your mind as to: Will I say the right thing? Am I properly dressed? Will I appear credible for this job? This section gives you a few guidelines to follow that might help in that interview.

RELAX! Take a deep breath. The interview just does not go one way. Although the interviewer is evaluating you and your credentials to join his/her company, you are also interviewing to determine if you like the company and feel as if you would belong there and be able towork as an effective member. Do not lose sight of the fact that they are as much the interviewee as the interviewer.

Now, onto the specifics for interviewing success. There are three critical ground rules for job interviews. You must:

1. respond to the objectives and needs of both you and your interviewer. Not one or the other.
2. listen intently to the interviewer.
3. retain control of yourself throughout the interview.

1.3.3.1. Preparing for the Interview

1.3.3.1.1. Background

You need to know as much about the company as you can find out. This includes what it does or makes, where its plants, offices, and branches are located, whether or not it has international connections, etc. You can find out by reading company brochures, their annual report, and anything else you can find. The university placement office will have company brochures on many companies. Stockbroker offices usually have company annual reports. Read anything you can find about the company. With this information, you will be able to answer questions in a way that shows that you will fit into their operation.

1.3.3.1.2. Appearance

Unless you have been told what to wear to an interview, or know both the company and the people who will be interviewing you very well, it is better to err on the side of conservatism and formality. Next to banking engineering is one of the most conservative of professions. Specifically this means a suit, tie, and polished shoes for men; skirted suit, conservative jewelry, and polished shoes for women.
Men may wear either slip-on or lace-up shoes in the same color as their belt. Women should wear pumps with a 1½ to 2 inch heel and neutral hose; if they wear colored hose, shoes, hose, and bottom of the skirt should all be the same color. Companies interviewing engineers for entry-level positions know that students are poor. If you already have a suit that still fits properly, you do not need to buy another one. On the other hand, if you are purchasing a suit, choose one in the blue or gray range. Two button suits are generally worn with the top button buttoned when you are standing. For men a stripped tie is always correct. Women should avoid low necklines, short skirts, and excessive makeup that would detract from their professional qualifications.

You and your clothes should be neat and clean; your clothes pressed. Men should have a fresh standard haircut; women should have clean hair which looks combed and is either short or arranged so that it is held back off the face. Beards and mustaches should be either shaved or very neatly trimmed. Look at the pictures of the CEOs of the Fortune 500 companies: you will not see many beards or mustaches. Women are expected to wear a touch of perfume; a splash of cologne is all right for men; however, the aroma should not enter the room before you do for either sex. You can establish your
uniqueness through conversation, demeanor, and response to interview questions.

If you are having an in-plant interview (as differentiated from an on-campus interview), look at what the people are wearing in the area where you will be working. That way you can get an idea of what is considered appropriate for that company, and you will be prepared if you accept a job with them, or you can be prepared to reject the job if you do not want to dress that way. Remember you are looking them over also.

1.3.3.2. The Interview Itself

1.3.3.2.1. Punctuality

Do not arrive on time, arrive early. No matter how sympathetic your interviewer may be to the fact that there was an accident on the highway, it is virtually impossible to overcome a negative first impression.

1.3.3.2.2. The First 30 Seconds

Many believe that 60% of the results of the interview are determined in the first 30 seconds. In the first 30 seconds the interviewer observes your appearance, the way you walk and carry yourself, and your handshake. Your approach should be confident and friendly. Your hand shake should be firm, avoiding both the dead-fish and the bone-crusher. Make eye contact and smile.

1.3.3.2.3. The Interview Process

Job interviews can be a trap. Your objective is to get a job; the interviewer's objective is solve a problem (namely, find the best qualified candidate). Immediately, there is a complete diversity of objectives. You must get across to that interviewer that you understand their problems and can solve them. In order to achieve this objective, you must not only tell your interviewer your qualifications, but outline how they directly relate to the company at hand and the company's specific needs. Don't just hear what your interviewer is saying, listen to what they are saying. Then, when the time arrives to answer questions, you will understand the specific needs and objectives of the interviewer and the company. With this understanding, you can frame your answers to directly respond to identified needs.

Remember that the interviewer is interviewing you, take you lead from the interviewer. However, if you have some talents or experience which you want to highlight, be sure to work a reference to them into the answer to the first question which requires more than a yes or no answer. Always give a positive response to questions. If asked questions such as what are your weak points, not only name something fairly minor but also follow up with what you are doing to improve. Substitute strengths for weaknesses. Do not tell your interviewer that you have no experience with a specific accounting software program. Instead, tell them that your experience with accounting software includes AccPac, Lotus, and One Write, each of which you were easily able to learn and quickly attained proficiency. Transition the negative into a positive.

Attitude and demeanor are as important as your response to questions. Be professional and focused, yet friendly and personable. Remember, you need to fit into the workplace. No one wants to hire an individual with no personality, regardless of the qualifications. Be enthusiastic. People love to hire individuals excited about their company. Be professional, yet demonstrate your interest and energy.

Be brief, but thorough in your communication style. Long-winded, endless responses to questions are not the answer. You will lose the interest of the interviewer and can get "lost" in your response.

In each and every interview situation, there are common questions that will be asked. Don't wait until the interview to decide your response. Be prepared and think through your answers before you arrive. Some of these questions include:

1. Tell me about yourself.
2. What are your salary expectations?

3. How did you like your last job and why did you leave?
4. How did you get along with your former boss and co-workers?
5. If you had the last 10 years of your life to live over again, what would you do differently?
6. What are your career goals for the next 5 years? The next 10 years?
7. What are some of your strengths? Some of your weaknesses?
8. Aren't you a little young (old) for this position?
9. What is your personal life situation?
10. If we make an offer, how long do you plan to stay with the company?
11. Are you interested in promotional opportunities?
12. How do you work with others? Are you a leader ... a follower?
13. What is your ideal position and career path?
14. Why should we hire you for this job?
15. Is there anything you would like to say to close the interview?

The interviewer is not permitted to ask if you are married, if you have children, what your religion is, or what your age is.

Remember, the only purpose of the first job interview is to get the second interview. That's it! You are not permitted to ask about salary, vacation, benefits, or anything else that sounds self-serving. Remember, it is at the second (and subsequent) interviews that you will attempt to "close" the sale. It is at that time that questions will be more specific, you will have the opportunity to speak with numerous individuals throughout the company, and you will be given the chance to ask your questions. Let the interview process proceed at the normal pace. Do not rush it along. Being overly anxious does not work.

You may ask about how your performance will be evaluated and what type of training you will receive.

Remember, listening, confidence, and quality of presentation are the keys to successful interviewing.

1.3.3.3. Following up after the Interview

Be sure to send a thank you letter for the interview. If you are still interested in working for the company, say so. If you have taken another job, tell them so they will not waste time considering you: at some time in the future you may wish to work for them or they may become clients of your company.

Should you be unable to keep an interview appointment for any reason, cancel the appointment as soon as possible; if it is too late for them to be able to schedule someone else in your place or you have been unavoidably detained at the time of the interview, be sure to send a letter of apology immediately.

Remember good manners are important.

CHAPTER 2 – THE ART OF TEAMWORK AND PROJECT-MANAGEMENT TOOLS

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CHAPTER 2 – THE ART OF TEAMWORK AND PROJECT-MANAGEMENT TOOLS

2.1. WHAT IS TEAMWORK?

The art of teamwork is the art of establishing successful working relationships with whoever is assigned to your team. It has nothing to do with liking people, approving of someone else's life style, or sharing social activities. It has everything to do with interpersonal skills necessary to enable everyone on the team to contribute 110% of their capabilities. Yes, greater than 100%: In the case of successful teams, the whole is greater than the sum of the parts. Teamwork is getting your work done when sharing responsibility. Teamwork is taking individual responsibility without authority. The generally held belief is that we are each responsible for doing only our own part. We are not supposed to take individual responsibility for the whole project's being successful. That's not fair! Fair or not, that is reality. That is the only way to have a successful team experience. First, each individual needs to recognize that the only person he or she can change is himself or herself. In other words, teamwork is an individual responsibility.

2.1.1. TEAMWORK IS AN INDIVIDUAL SKILL

During the past twenty years, teamwork has become more important in the workplace, and researchers began studying what makes for successful teams. Christopher M Avery (2001) has organized and summarized the most useful of the findings. Jim Collins (2001) has done a study of companies that have transitioned from being good companies to great companies. The characteristics of the executives in the executive teams of the good to great companies bear a striking resemblance to the observations Avery has made about successful teams. In successful teams, each and every member exhibits certain basic values, attitudes, and behaviors; in short, they:

- Use all their personal abilities to affect their entire team's success
- Know that being in a good team is not random; it is a function of one's relationship behavior
- Understand that good relationships evolve from adhering to the norms and expectations of the group and having clear goals
- Take personal responsibility for the quality of the team's relationships
- Recognize that their behavior shapes the team at least as much as the team affects them
- Acknowledge that *not* attending to team performance is a choice to put themselves at the mercy of chance
- Accept responsibility for their bad relationships and poor results, asking, "How did I create this for myself? How will I respond to change it?" and avoid blaming others, external influences, or bad luck
- Assign responsibility for good relationships and good results to others, external influences, or good luck
- Recognize that your contribution can be anything of value to the other team members, such as special talents, special information, network contacts, etc., and demonstrate generosity with what you have as a normal way of operating
- Understand, live, and work the purpose of the project, being alert for people who
    - Can help them learn what they need to learn
    - Can help them achieve the purpose
    - Can be served by the purpose
- Channel ego needs away from self and into the team
- Are very ambitious for the team, not themselves
- Exhibit unswerving resolve to produce the best possible long-term results.

In successful teams, team members regularly describe one another with words such as disciplined, rigorous, dogged, determined, diligent, precise, fastidious, systematic, methodical, demanding, consistent, focused, accountable, and responsible. Take teamwork seriously, learn the skills, and be prepared to take a place on successful teams when you leave SEC.

2.1.2.TEAM FORMATION: CHOOSING A PROJECT

Entry-level engineers rarely have the opportunity to influence either which project team they get or who their teammates will be. SEC allows its engineers to influence either or both. All the engineers working for SEC will be assigned to teams of at least 4, but not more than 6, members. SEC will present the engineers with a menu of projects from which to choose, and the project request form will have a place to designate persons with whom they would like to work. Engineers should consider two issues: (1) the direction they would like their career to take and (2) the degree of commitment they have toward the project for this class.

2.1.2.1.*Technical Area*

Engineers who know in which technical area they would like to work would do well to select a project a project that will highlight the skills they hope to use on their first job. A project of this type will look good on a resume and give the engineer something to talk about during job interviews. There will also be opportunity to improve the depth of knowledge in the area of interest beyond what is normally taught in courses. This will give the engineer an edge in being selected for a job in this particular area.

If experience on the project reinforces interest in the area, the engineer will know the area is a good fit and can proceed with a job search with increased confidence. Sometimes more in depth experience in an area reveals a misfit between the engineer's talents and interests and the technical area. In this case, the engineer can be thankful that this was learned within the context of a course rather than having wasted one or two years of his or her career.

2.1.2.2.*Commitment to the Project*

Section 1.1 indicated that a successful project requires all the team members to be completely committed to the success of the project. Who is the most influential person on the team? The leader? The sharpest technically? The one with the most outgoing personality? The one who talks the loudest? Nope! The most influential person on the team is the one with the *least* commitment to the success of the project. Why? Because that person will de-energize the others down to that minimum level of commitment. It is the same principle as that of the weakest link: the weakest link in the chain determines the strength of the chain. Lazy, unmotivated people cannot be motivated; motivation has to come from within. The project has to tap into motivation that already exists. See section 3.1 for more about motivations.

In discussing good to great companies, Collins (2001), whose focus is on high commitment, high performance successful teams, puts it this way: "It is important to get the right people on the bus, and the wrong people off the bus." He goes on to say that people are not a company's most important asset; the *right* people are. His position is that companies should not burden high performance teams with non-performers. Real world great companies do not try to turn lazy workers into hard workers. Instead, they create a corporate culture where either the lazy workers voluntarily jump off the bus or the others on the team throw them off. He cites a Wall Street Journal story of steel workers at Nucor chasing a nonperforming team member off the plant property with a piece of angle iron.

Avery maintains that commitment to the project is a better determiner of the success of the project than the technical expertise of the team members. There, of course, must be a certain minimum of technical competence; but given that, teams with total commitment that lack specific expertise will improvise, persist, and ultimately triumph. Teams with star players are less likely to succeed than teams with unknowns and total commitment to team success.

Collins uses sports analogies. In what universe is it even conceivable that the United States could fail to reach the semifinals of something called the World Baseball Classic? Not only fail to win, but could field a team that included Roger Clemens, Derek Jeter, Alex Rodriguez, and Johnny Damon and then lose games to Mexico, South Korea, and - wait for it - Canada? Yet it happened this year - 2006.

By contrast, the 1980 hockey team that beat the Soviets at the Lake Placid Olympics was built explicitly on anti-dream-team principles. Coach Herb Brooks, who died in 2003, based his picks on personal chemistry. In the story's movie version, "Miracle," Brooks' assistant looks at the roster and objects that many of the country's greatest college players were left out (professionals were not eligible to play then). To which Brooks responds with this essential anti-dream-team philosophy: "I'm not lookin' for the best players, Craig. I'm lookin' for the right players."

That's the philosophy that powers teams such as basketball's Detroit Pistons and especially football's New England Patriots. The Pats have won three Super Bowls in the past five years with few stars and a quarterback, Tom Brady, who was the 199th pick. The Washington Redskins, by contrast, have bought star after star--and floundered.

The reality is that there are many levels of motivation, commitment, and desire for project success among the employees of SEC. SEC has a culture of not firing its non-performers; if fact, the non-performers are allowed to work for SEC extra terms until their skills meet minimum standards. Commitment levels range from those determined to have the best project that SEC has ever had in its forty plus years of existence to those who believe D is for Degree and who will be more than happy to take home a D. Compensation at SEC, i.e., grade for ECE 495a,b and ME 495a,b, is proportional to the results the team produces and the quality of the documentation of those results. (See Concessions to Academe in Chapter 7).

From the point of view of satisfaction with the project results, what is important is that all the teammates have the same opinion about what constitutes an acceptable level of commitment to the project. For instance, if everyone wants to have the best ever project, all will be making decisions based on what is best for the project, and in all probability, they will have an over-the-top superior project regardless of the technical and non-technical problems encountered. If, on the other hand, everyone on the team thinks D is for Degree, all will be making decisions that will insure that each member takes home a grade of at least D, but more effort than that will not be expected, nor probably given. While the instructors and faculty technical advisors are likely to consider the latter team a failure, the team members themselves will likely consider the whole experience a success: they achieved their goals and graduated.

What happens when there is a mismatch between the commitments of the team members? The team members with higher commitment to the project will be spending time and energy attempting to motivate the non-performers. The non-performers will be spending time and energy quarreling, making excuses, and hiding from their more ambitious teammates. In short, the team will spend much time and energy in non-productive sound, fury, and general wheel spinning instead of making progress on the project.

In summary, for maximum satisfaction with the senior design project, it is less important what an engineer's commitment to the project is than that all the teammates have the same degree of commitment. When potential teammates (teammates) talk to each other before (after) team formation, it is vitally important to have an atmosphere, or culture, where each person is permitted to be brutally honest regardless of their degree of commitment. (See section 3.1 for further discussion.) People from different cultures react differently to brutal honesty in discussions.

2.2. **INTERPERSONAL RELATIONSHIPS AND CULTURAL NORMS**

Sarah Lanier (2000) has suggested that you can come pretty close to predicting how people will react in a given environment if you know where they are from. Lanier gives two classifications: hot climate vs. cold climate and low context vs. high context. This section will present some of the cultural differences you are likely to encounter among people who get assigned to your team.

2.2.1. COLD CLIMATE VS. HOT CLIMATE CULTURES

The cold-climate culture develops in industrialized areas in geographic regions that are cold or are populated by people who have emigrated from such areas, e.g., northern US, Canada, northern Europe, the white population of South Africa, and Israel. The hot-climate culture develops in regions where the climate is hot or in rural areas, e.g., southern US, most Latin countries, the Mediterranean countries, most Asian countries, and the indigenous people of Alaska. The primary basis for interaction in cold-climate people is efficiency; among hot-climate people it is relationship. Cold-climate people are task oriented; hot-climate people are more interested in generating a feel good atmosphere and friendly environment. Cold-climate people will neglect feelings in order to get the task done; hot-climate people will protect the relationships even if the task is delayed. Cold-climate people respect others' time and attempt to be as efficient as possible; they become annoyed by the chitchat and small talk of hot-climate people. Hot climate people respect others' feelings and attempt to be as polite as possible; they assume others think like they do and are easily offended by the brusqueness of the cold-climate people.

As a result of these different cultural traits and expectations, communication between individuals from these different cultures is often difficult and carried out at cross-purposes. In a cold-climate culture the purpose of communication is to exchange information, and, therefore, direct speech is valued. You say what you mean and you mean what you say. In a hot-climate culture the purpose of communication is to establish relationships. You say what the other person expects to hear and you make your wishes and opinions known only indirectly. For example, suppose that Sally has a new haircut that gives a new definition to ugly. When Sally asks Joe, who is from a hot-climate culture, what he thinks of her new hair cut, he is likely to say, "It's real nahse." Translated: "It's real nice." When she asks Henry, who is from a cold-climate culture, he is likely to say something like, "It makes your face look fat." Now Joe would be absolutely horrified at Henry's remark and would chastise Henry for being rude. If Henry asked why, Joe would tell him that it was because he hurt Sally's feelings. Henry would likely reply, "The question was about hair. What do feelings have to do with it?" Henry, on the other hand, would likely think that Joe had lied, especially when his parting remark to Sally was something like, "Don't worry about your hair; it will grow back!" So Henry thinks Joe is a liar and Joe thinks Henry is rude. That does not make a very good basis for cooperation and teamwork unless each understands that the other is coming from a different culture and they talk out their differences.

In a cold-climate culture when you want to know something, you ask and you get an answer you can act on. If you ask someone if they want to do something, or will do something, you will find out. If it is not the answer you want, you can negotiate.

In a hot-climate culture if you ask a direct question, you will get the answer that the person thinks you want to hear. You will find out nothing about what the other person likes, wants, or is willing to do by asking directly. Giving such an answer when it is perceived as not being what you want to hear is just not done; it is considered rude. In order to find out the wishes or abilities of people from hot-climate cultures, it is necessary to ask indirectly or to have a third person ask what the person wants to do or thinks he or she can actually do. For instance, if you are visiting in a hot-climate culture and you want to know where the museum is, you do not ask the first person you see. If you do, you will get an answer, but it may or may not have anything to do with where the museum really is. The person you ask does not want to disappoint you by telling you that he does not know, so he makes up an answer. The answer given is considered polite, not a lie. If you really want to know where the museum is, you find a third person and ask him or her to ask the other person where the museum is and tell you what he said. That way you will either find out where the museum is or find out that he does not know; you will not end up with a wrong answer. Since "everybody" knows that this is the proper way to respond, people from cold-climate cultures are assumed to know that also. This style of communication results in making teamwork assignments difficult and time consuming to negotiate. The project manager of teams with most people from hot-climate cultures would do well to have most of the assignments worked out indirectly before the meeting where the assignments are officially made; this will avoid having a team member agree to do something that he or she has no idea how to do or even how to start.

2.2.2.HIGH CONTEXT VS. LOW CONTEXT CULTURES

High context cultures tend to be very old and relatively isolated. They are very formal and have many rules of behavior. Examples are Switzerland and northeast US. In these cultures there is a very strong sense of what is appropriate and acceptable in dress, speech, and actions. Children are carefully taught the proper behavior starting even before they can talk or walk. People from these cultures assume that their norms are the norms for everybody and that all people every where understand them just the same way that they do. When they are confronted with people from different cultures or from low context cultures, they tend to be offended by behavior that does not conform to what they consider natural. Importance is given to conforming to the group expectation of what is proper and appropriate.

Low context cultures develop in multicultural areas and large cities. When people from many cultures are thrown together and forced to interact with each other, they gradually let go of their preconceived ideas of what is proper and appropriate. They also come to give up the expectation that the dress, speech, and behavior of people from different cultures will be the same as theirs. When confronted with people from high context cultures, they tend to regard them as pompous or stuck-up. Importance is given to individuality, comfort, and convenience.

2.2.3.VALUE THE TASK, VALUE THE PEOPLE

Historically engineering has been a cold climate activity where a premium is placed on honesty, efficiency and careful attention to the brutal truth and cold, hard facts with no consideration being given to the feelings of the people involved. In addition, engineering was often a solo activity. People from cold climates definitely had an advantage in the workplace. In the past twenty years or so engineering has gradually changed. Projects have gotten larger and more complex. Organization has shifted from individuals doing engineering to individuals doing engineering as a part of a team. When working in a team environment, attention to relationships is critical. Skills that support the values of people from warm climates have become necessary to the success of the project. It is necessary to value both the project and the people on the team. It is still necessary that decisions be based on the truth of the situation and the brutal facts of reality, not wishful thinking. It is also necessary that team members be able to argue and debate – sometimes violently – in pursuit of the best answers for the project. The team, however, needs to carry on this debate in an environment that respects each of the team members and their opinions so that at the conclusion each team member can fully support the resulting decision.

For a successful project, every team member must be 100% committed to making decisions that benefit the project results; some of those decisions concern the way each team member relates to the other members on the team; hence, there is a need for teamwork tools.

In our increasingly diverse work environments, Carl Selinger's (2004) updated version of the Golden Rule is appropriate: "Do unto others as *they* would have done unto *them*."[1] [Emphasis his.] As he suggest, if you do not know what they prefer, ask them.

2.3. **TEAMWORK TOOLS**

The members of successful teams exhibit behaviors that include:

- Treating others courteously
- Treating others respectfully, whether or not you like their ideas, words, or actions
- Giving everyone an opportunity to contribute to all discussions
- Being dependable and reliable
- Pulling your own weight in organization, technical work, and busy work
- Contributing anything you can to help the team be successful
- Receiving and giving useful feedback focused on the project issues, not personalities.

These behaviors do not always occur in the normal course of business. People are not born knowing how to relate to one another in the context of a team that is charged with achieving a specific result. Over the last twenty years or so, certain skills and tool have emerged that can facilitate a productive environment. These include what team members need to know about each other, team norms and expectations, and how to carry on a debate on the issues without blaming each other.

2.3.1. WHAT TEAM MEMBERS NEED TO KNOW ABOUT EACH OTHER

Individuals from diverse backgrounds make up engineering teams. Many times, they do not even know each other before they land on the same team. This means that the team members come together with different experiences and different expectations, as well as different technical and other skills. During the first meetings together, team members should share these experiences, expectations, and resources with one another.

After reading section 2, the team members should discuss whether it reflects their own personal background and experiences. This will give each team member both an understanding of where each of the others is coming from and a clue to why they act or react the way they do. With understanding comes the ability relate more productively.

[1] Sellinger (2004) pg 80. Read the entire Chapter 8 for more tips on understanding others.

The successful-team requirement that each member must be 100% committed to the purpose of the team means that each team member must be passionate about the project. Passion cannot be created, stimulated, or motivated; it must be discovered. Each team member needs to share with the others, "What's in it for me? Why am I passionate about this project?" The passion does not have to be for the mechanics of the project; it can be anything related to the project for instance, the technical aspects, to the end result, to the end use of the system, to who the results of the project will help, whatever. This discussion should continue until all the interests are aligned behind the project. Remember that the team member with the *least* investment in the outcome will limit the success of the project. Each team member should discover their own passion; understand the passion of the other team members. This understanding will help the team make better decisions, where "better" is defined as leading to a more successful project outcome.

The successful-team requirement that each member takes responsibility for the success of the entire project requires that all of the members contribute whatever skills and resources they have to the project whether it applies to "their" assigned part of the project or to some other part. This means that each member must be alert to the needs of each of the other members and always filter each of the needs through "What do I have – What do I know – Who do I know – that could possibly help fulfill this need?" Then make the resources available to the team. At one of the first meetings all of the members should tell the others what resources s/he has available that the team might use towards meeting the purpose of the project and additional resources revealed as the need for them arises.

In addition to cultural background, personal benefit, and resources, team members need to discuss what they expect from each other in terms of behavior.

2.3.2.TEAM NORMS AND EXPECTATIONS STATEMENT

The team members will discuss expected team behavior until the team reaches a consensus. At this time, they will write up the conclusions in a norms and expectations document, which all team members will sign.

2.3.2.1.*DEFINITIONS*

There are two important, similar, but different concepts: norms and expectations.

2.3.2.1.1.Norms

Norms are expected behaviors that are quantifiable. That is, you can determine quantifiably whether or not a norm has been met. Subjective judgement is not required. The following is a list of examples of norms. Note that this is not a suggested list. Your team should discuss what norms are important to you and create your list to match your needs.

- All team members will be present or accounted for at all team meetings
- All team members will be notified by email at least 24 hours before any meeting time or place change.
- No team member will be more than 5 minutes late for any team meeting.
- All team members will contribute $10 toward team expenses.
- All team members will complete all team assignments on or before their due dates.

Notice that in all cases the team can clearly determine whether or not any team member complied with the norm statement.

2.3.2.1.2.Expectations

Expectations are expected behaviors that are not quantified. These are general guidelines that the team has agreed to abide by. They are either not quantified or are not quantifiable. Subjective judgement is required to determine whether or not they have been met. In most cases these will work acceptably; however, occasionally one or more may have to be quantified and moved to the norms list in order to maintain order and keep up the morale of the team. Again, the following list is just a list of examples, not a list of suggestions.

- Team members will treat each other respectfully
- Team members will be courteous to each other at all times
- Team members will be early for team meetings
- Team members will help one another whenever needed
- Team members will ask for help as soon as they know they need it and not wait until their assignment is late
- Team members will pull their own weight
- Team members will encourage all members to contribute to discussions and will respect all contributions
- Team members will be supportive, not judgmental

Note that compliance with these items requires subjective judgement. If there is a continual problem with one or more of the expectations that you have on your team's list, the team may want to revisit that expectation and reword it so that it becomes a norm.

2.3.2.2.*What if the norms and expectations are violated: When silence is wrong*

Having rules is not of much use if nothing happens when team members violate them. In the best of worlds all of the norms and expectations will be followed by all of the team members all of the time. However, we live in the real world. Mistakes happen; agreements are broken. All team members have the responsibility to speak up when they disagree with the group's direction our purpose. Real team players never go along with something about which they have strong negative feelings. Calling others on broken agreements is critical to building trust, but is difficult to do. However, when team members choose to show their true response to others' irresponsibility, they actually foster true collaboration. This happens because showing the ability to be provoked signals integrity, and integrity builds trust.

While calling others on broken agreements is necessary, it is also necessary to do it in a way that builds relationships rather than strains them. Suggested steps are:

- Acknowledge your own feelings about calling someone on the broken agreement
- Be invited, for example, "Sam, I would like to talk to you about how we are working together. Is this a good time?"
- Explicitly describe the actions that have caused the concern
- Tell how the broken agreement affected you personally: "I felt…," "I interpreted…..." etc.
- Stop talking and listen, prepared to make amends
- Make a new agreement about how similar circumstances will be handled in the future.

The ability to be provoked is part of a communication strategy called tit-for-tat. To play tit-for-tat, start interactions with cooperative behavior. If the other person cooperates, cooperate. If the other person is uncooperative, show that you are provocable. Point out their uncooperative behavior; let them know that you hold them responsible for their behavior and that they can have it either way: cooperative or uncooperative. Then match their moves. Game theory has shown that this is the best way to reach a win-win relationship quickly. Your strategy is to cooperate first, not to defect first, but not to tolerate defections. Getting even is not a move in tit-for-tat, when the other party's defection is matched it should be with equal or *lesser* force. You do *not* want the incident to escalate to a war. While responding with greater force is useful in deterring bullies, it is not useful for establishing cooperative, trusting relationships with teammates.

When you are the one to make a mistake or break an agreement, damage control is your responsibility. Suggested steps for cleaning up broken agreements are:

- Acknowledge that you broke the agreement
- Express regret for having broken the agreement
- Ask the other person what you can do to correct the situation
- Recommit to the relationship.

Cleaning up broken agreements is vital to maintaining a productive working relationship.

A norms and expectations agreement is incomplete without some statement of what will happen when a violation occurs. Generally, there should be an escalating sequence of steps with increasing frequency of violation. Remember that the purpose of the corrective actions is to encourage the reluctant team member to become a team player that contributes fully and positively; the purpose is NOT to punish derelict members. The idea is to bring about reconciliation, not divorce. The following list contains examples of possible corrective actions:

- Private verbal warning by the member who noticed the violation
- Official verbal warning by all the other team members
- Written warning signed by all the other team members
- A meeting with one or more of the course instructors or the technical advisor to discuss the problem
- A written report to all of the course instructors and the faculty technical advisor explaining the problem

Note that specifications may state that any of the steps may occur one or more times before escalating to the next level of severity.

When a problem occurs and the team brings it to the attention of the course instructor, the team should be prepared to show the course instructor their approved norms and expectations statement and document the steps that they have taken. Some of the possible consequences of not being able to establish successful working relationships with others include one or more team members receiving a course grade one letter lower than they otherwise would have.

2.3.2.3. *The SEC team norms and expectations statement*

One of the first things the team will do as a team is to come up with a norms and expectations statement. Each team will submit a copy of their norms and expectations statement on the Friday of the week after the week when they receive their request for proposals. This statement is to have three sections:

- Norms – quantified behavioral guidelines
- Expectations – non-quantified behavioral guidelines
- Corrective actions

All members will sign this document before submitting it to the course instructor. The course instructor will evaluate it based on clarity and workability. Comments may be offered and sometimes a team may be asked to redo or re-think part of the document. All teams are required to have a norms and expectations statement on file with the course instructor.

After initial approval, each team should review and update this document at least once a month – more often if behavior and participation become a problem. The teams are not required to submit updated copies of this document, but they should have the latest version available for inspection. This is a living document; nothing is cast in concrete; it may be revised at any time by team consensus.

2.3.3.ARGUMENT WITHOUT BLAME

On can never be sure that an engineering decision is a good one until it has been compared to other possible decisions – many other possible decisions. Engineering development does not proceed in a straight line from concept to solution; there will be many blind alleys, false starts, and just plain mistakes. Each of these circumstances presents an opportunity for acrimony to enter the relationships among the team members. If the project is to be successful, this must not happen even though the discussion is vigorous – perhaps even violent – about issues relating to *the project*, not fellow teammates. Some proven strategies for accomplishing this are discussed below.

Lead discussions of what to do with a focus on the results to be achieved. Avoid building a potential solution into the problem statement. For a trivial example:
Bad: What kind of hammer do we need to hit the nail with?
Better: How can I get enough force on the nail head to drive the nail into the board?
Notice how the first option leads to no solution if there is no hammer of any type available. When a team finds itself in the position of seeing no solution, they should try rewording the question by eliminating anything that is not absolutely necessary as a part of the desired results.

Autopsy failures and problematic occurrences with questions, not accusations. Ask: What should we do? What happened? Why did it happen? What do we need to do to prevent this in the future? What to we need to do now? Answers should be in terms of the project elements with no mention of who did what. Blame is not helpful, is not productive, and will move the team farther from the project purpose rather than closer to the best solution. If a team has a plan that did not work; it has a plan that did not work – not a reason to blame the plan makers. The successful team will take this as an opportunity to learn why it did not work and to do it better next time. Blame is not important; "Where do we go from here?" is.

Talk to each other, engaging in vigorous debate, but use language that respects the opinions, and view points of all team members. Use feedback rather than criticism. "Constructive" criticism is still criticism. It blocks understanding. The difference is in word choice and attitude. Criticism comes from a stance that says, "I have superior knowledge, and I am going to straighten you out"; feedback comes from a stance that says, "I would like to share with you how I think or feel about that." In order to give feedback, eliminate from your vocabulary "right" and "wrong." Replace them with "that works for me" and "that doesn't work for me." Criticism usually includes phrases like "You are (favorite judgment here)" or "This is (favorite judgment here)." Feedback usually includes phrases like "When you (specific action here), I (compassionately revealed response here." For example, compare:

- "Mary, I'm sorry to have to tell you this even though it is for you own good. Your proposal is lousy. It will have to be completely rewritten if you want any chance of winning the bid."
- "Mary, in my experience this proposal is not going to produce the results you want. Let's talk about it and determine what it might take to get the bid."

The team needs to understand that the project will proceed in an iterative fashion, cycling many times through questions to debate to decision to action to analysis and back to questions. The team should retain the faith that they will prevail regardless of the difficulties, and the team should confront the most brutal facts of the current reality when determining their next course of action. Understanding will drive the discussion, not bravado. Every problem has at least one solution; your team's job is to find an optimal one.

When team members have aligned their interests, when a commitment to the project exists, and when resources are shared in an environment of valuing both the task and the people, then the right people are on the bus and the wrong people are off the bus. If the right people are on the bus, there will not be any need to manage the people, and the team can put all their effort and energy into getting the right people into the right seats and managing the project.

2.4.**PROJECT MANAGEMENT TOOLS**

Over the years, companies have developed ways to help their employees work together in successful teams. Three of these tools are (1) responsibility, approval, support and information charts, (2) action item lists, and (3) professional team meetings.

2.4.1.RESPONSIBILITY, APPROVAL, SUPPORT, INFORMATION CHART

If a project is big enough to be assigned to a team, each of the team members will have his/her own area(s) of responsibility. Anything for which everyone is responsible, no one is responsible. Getting the right people into the right seats involves assigning the various responsibilities to the various members, and the team needs to document this division of responsibility. The name of the document that SEC uses is the responsibility, approval, support, information chart, or RASI chart for short.

This chart is a matrix with the initials of the team members, the faculty technical advisor, and the industrial consultant (if there is one) along the top. The various areas of responsibility are listed vertically on the left side. Under exactly ONE team member's initials there will appear an R. That's called the big R, and that team member is responsible for that area. Other team members who have expertise in that area or who have subsystems that interface with that area will have S's in their columns for that activity. If that activity requires decisions that need to be approved, the individuals who need to give approval will have A's. Approval of the faculty technical advisor or industrial consultant is usually required for spending money, for instance. Individuals who need to be informed of any decisions made in that area, or need to provide information that impact that area.

Like the Norms and Expectations Statement, this document is a living document. It will reflect the current assignment status, and the team will modify it as changes in assignment occur. Your team will prepare two of these documents. The first one will be a practice document for this semester's assignments. There will be technical assignments for parts of the literature review, and there will be documentation assignments for the proposal preparation. You will submit this document the third Friday after you receive your request for proposals.

In the proposal you turn in there will be another RASI chart. This one will be for the technical subsystems for next semester's work. The teams will review RASI chart in the proposals during the first week of the second semester with the faculty technical advisors. Team will make revisions in the subsystem definitions and assignments if necessary. You will resubmit this document with your progress report. This time it will also contain the documentation assignments for the Design Report.

2.4.2. ACTION ITEM LISTS

The RASI chart details project responsibilities and the timeline in the proposal shows the overall intended progress. However, if a project is large enough to require a team to do the work, the work cannot be done in one heroic effort. Guided by the timeline and the RASI chart, the team will work out specific detailed responsibilities for each member each week. This will be a list of activities, or actions, that are very specific and can be accomplished in one week. Subdivide large activities taking longer than one week into smaller pieces. Each engineer will accomplish at least one thing each week toward the completion of the project.

This list of assignments is called your Action Item List. The team will keep it in Excel, or some other spreadsheet program. The team will update it each week. A copy of the current version will be posted to the team's space in Web CT every Friday between 8 am and 3 pm.

The format of the action item list is as follows. There will be a header that will contain:

- the name of the project,
- the SEC Reference number,
- names of the team members,
- for each team member, the number of hours s/he worked on the project during the past week,
- designation of the project manager, and
- **the date of the last update**. This is the item most often forgotten.

The list itself will have 8 columns: activity number, activity, person responsible, date assigned, date due, new due date, status, and comments. The activity numbers start with one and are in sequential order as the activities are entered. The activity column lists an activity; i.e., it has a <u>verb</u> in it. The person responsible is just that: a <u>single</u> person. Except for team meetings, field trips, and the like, "all" is not acceptable. For activities that all will contribute to, list one person to be responsible for collecting the information, or list each separately. The due date column is the original due date established when the item was assigned. The new due date column is to be used only if the activity falls behind, and a new due date is needed. The status is the percent complete. Newly assigned items are left blank, previously assigned items that have not been started yet are 0%; completed items are 100%; for delayed that have been started, make a numeric estimate. Use the comments column to explain delays, cancellations, transfers to other team members, etc.

When the team posts this list each Friday, use the Hide feature to hide ancient history and speculative future events. Leave visible all activities that you close (complete) since the last Friday that the team posted the list and all open activities that are due in the next two weeks. Evaluation criteria include compliance with the requested format, equitable distribution of technical and non-technical work elements, and appropriateness of assignments. Timeliness and regularity of completing assignments will influence individual performance evaluation.

2.4.3. PROFESSIONAL MEETINGS

Discussions and decisions relating to technical and procedural issues facing the team occur in professional meetings. The presence and use of an agenda distinguishes a professional meeting from a social gathering. Teams can make decisions three ways: by authority, by vote, and by consensus. Making decisions unilaterally by the authority of one person is only justifiable in two cases: when there is an emergency requiring a quick decision and when the consequences of the decision affect no one else except the decision maker. In any other case, this is a very ineffective method. In groups as small as engineering teams, the use of Robert's Rules of Order and formal votes to determine what to do are not usually necessary, or even a good idea. If there are 4 team members and the vote 3 to 1 to do something, 25% of your team feels alienated. This is too expensive in terms of reduced productivity. The best course of action is to discuss the topic until you can come up with a solution that you can all agree to; that is, use decision by consensus. Agendas and decisions by consensus are critical to productive, efficient, professional team meetings.

2.4.3.1. *Agendas*

When the members of a team come together to discuss the project, it is in the context of the professional meeting. In a professional meeting, one person is in charge, directs the discussion, keeps the focus on the project, and uses a written agenda to guide the meeting. Usually the person in charge is the project manager, but that is not necessary. Some teams effectively pass the duty of chairing the meetings around so that each person gets a turn. Most meetings also have someone designated to take minutes and read them back for approval at the next meeting. For SEC projects, teams are small enough and meetings frequent enough that formal minutes are not usually necessary or helpful. However, at least one person should write down the important decisions in his/her design notebook; and everyone should write down those decisions that directly impact his/her own work.

Effective team meetings require planning. A meeting of team members without an agenda is just a social gathering, not a team meeting. Before each team meeting, someone needs to be responsible for making a list of items related to the project progress for the team to discuss. Each team member is to have a copy of this list before the meeting. A hand written and photo copied agenda is ok. This is a working document, not a report for Client.

If the meeting is with the faculty technical advisor or industrial consultant, usually the first item is to give the floor to the consultant and advisor, in that order. After that, consider the agenda; add, remove, or modify items, and approve the agenda. Using you working copy of your Action Item List, review work done since the last meeting. Determine what the next steps in the project should be. And lastly formalize who will do what and update the Action Item List and verify when and where the next meeting will be.

Discussions will stay on topic. That is, they will center on agenda items. When the discussion starts to veer off course, it is the responsibility of the person chairing the meeting to bring it back to the agenda items.

Saluki Engineering Company expects all teams to have a formal team meeting with an agenda during the scheduled class time on every Thursday from the time the teams are formed until the semester's report is submitted. This means each team member will have his/her own design notebook with him/her, and each team member will have a copy of the agenda for the day's meeting. NO EXCEPTIONS.

The key to having a successful team that accomplishes more than could be expected of the individuals separately is to stay focused on the project and to use the project management tools that industry has developed for controlling progress: Norms and Expectations Statement, RASI charts, Action Item Lists, meeting agendas, and a commitment to decision by consensus.

2.4.3.2. *Decisions by Consensus*

"Consent" and "consensus" have the same root. Decision by consensus is a decision where 100% of the team consents to move forward together. Consensus maintains group energy and direction;

consensus avoids alienating any of the team members and lowering commitment. Low commitment is more infectious than high commitment.

Teams make technical and procedural decisions with the least amount of interpersonal conflict when there are many options to choose among. The first step is to generate as many options as possible. Then the similar options are grouped together and a list made of the consolidated options. After the team generates the options, there are a number of schemes for ranking them and making decisions. Most of these are named after their inventors, like the Pugh Chart, and nearly all of them involve some sort of decision matrix with the options on one axis and the important criteria on the other. All of the team members rank each of the options on each of the criteria, then compare scores. The ranking can be either qualitative or numeric. Weights sometimes accompany numeric rankings, giving some criteria more importance than other criteria. Numeric scores can be summed to give a total score with either high score or low score winning. Qualitative rankings, e.g., high-medium-low or better-same-worse, can be used to choose the highest ranking option and then modify it by using parts of the other options that relate to the criteria where the highest ranked option is weakest. Through elimination of the weakest options and iteratively applying the matrix to the remaining, possibly modified, options a winner will eventually emerge. Then it is time for a sanity check.

The sanity check will insure that the team agrees and is ready to move forward. The team conducts a sanity check by polling each of the team members and having each of them rank their agreement with the decision according to some scale such as the one suggested by Avery (2001):

1. Unqualified yes. Move forward.
2. Perfectly acceptable. Move forward.
3. I can live with the decision of the team. Move forward.
4. I trust the team and will no block this decision, but I need to register my disagreement. Move forward.
5. I think more work is needed before deciding. Do not move forward.
6. I do not agree and feel the need to stand in the way of adopting this decision. Do not move forward.

During the sanity check, each team member has veto power as the team will not move forward until there is 100% agreement to do so.

When there is a difference of opinion on a team, it is time for the leader to step in and silence the majority, giving the minority an opportunity to speak. Avoiding right-versus-wrong type arguments, ask the minority, "How can we change this plan so that it works for you?" The dissenters then have the responsibility to move the team forward and help modify the plan so that it works for everybody. Keep using language like "That works for me" or "That doesn't work for me" and "What could move us forward together?" After a plan is agreed upon, take a pole having the team members rank their level of agreement as described above.

After a team decides a course of action, team members it is time for team members to volunteer for assignments to carry out the decision. Volunteering for assignments generally results in better follow through and fewer slipped due dates. Sometimes negotiation is necessary in order to get all the pieces assigned. During the process the team members need to be aware of the cultural differences described by Lanier (2001). Selinger (2004) also discusses this in the context of other negotiating skills in Chapter 10.

Arming themselves with teamwork tools and project management tools, teams are in a good position to move forward to success, how ever the team has defined success.

2.4.4.HOW TO TELL IF A TEAM IS ON THE PATH TO SUCCESS

Successful teams have a symbiotic relationship between desire for preservation and willingness to change. They preserve their core values and core purpose, but are willing to change specific cultural and operational practices as well as specific goals and strategies. With this stance, the team guards that which gives each of the team members their passion for the project and the stated purpose of the project. This stance also provides the flexibility to deal with the brutal facts of reality while charting a path to the desired results. The table below summarizes the differences between the behaviors of successful teams and those on the path to failure.

Behavior leading to success	**Behavior leading to failure**
Small disciplined steps leading up to success	Attempt a giant leap to a miracle
Confront brutal facts when defining next steps	Embrace big plans without reference to facts
Consistently stay focused on core values and core purpose	Latch onto anything that looks good
First build disciplined people	Jump into action without discipline or coordination
Use appropriate technology to achieve the purpose of the project	Run about grasping at any attractive technology
Spend little energy trying to motivate people; motive the people from the results	Have no results; spend a lot of energy trying to motivate people
Let the results do the talking	Promise more in the future to compensate for lack of results
Maintain consistency over time; each action builds on the previous actions	Demonstrate inconsistency with lots of false starts and no follow thorough

In summary, successful teams will demonstrate the art of teamwork by effectively using teamwork tools to ensure that the initial high degree of motivation and passion for the project is maintained and will effectively use project management tools to control progress and manage the project.

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CHAPTER 3 – ENGINEERING DESIGN

3.1. INTRODUCTION TO THE ENGINEERING DESIGN PROCESS

Engineering design is related to, and based on, science and engineering science. Engineering design deals with the same subject matter as science and engineering science. However, the motivation, goals, and processes are quite different.

3.1.1. SCIENCE

Scientists study generalized problems related to natural phenomena. They seek general principles applicable to all of a species or similar elements of matter.

The key step is induction in which a theory or principle is inferred from an initial set of observations or measurements. An attempt is then made to verify the theory by a series of trial and error experiments.

Generally, there are no absolutes in science. Theories are only probably true. Scientific knowledge exists in all gradations from that for which there is a large body of evidence to that which rests on slight evidence but is regarded as possibly true.

Obtaining new information is considered sufficient justification - the characteristics of a butterfly or a rare plant may be studied without necessarily considering its utility to man as a food or other product.

Areas of science include physics, chemistry, life sciences, and earth sciences.

3.1.2. ENGINEERING SCIENCE

Engineering science has its roots in mathematics and the basic sciences but carries knowledge further toward application.

Studies are made in order to obtain information related to problems that could arise in engineering. As a result of decisions that formerly rested solely on experience, judgment and qualitative understanding have become largely matters of mathematical analysis and quantitative computation.

Mathematical models of reality are made which always require some assumptions, e.g. no friction, weightless, etc. Physical tests are then run to verify the mathematical model. Alternately, test data can be plotted followed by an attempt to arrive at an equation or formula that gives values consistent with the plotted points.

The engineering sciences include fluid mechanics, solid mechanics, thermodynamics, and the electrical sciences.

The methods are similar to those of the basic sciences but the results desired are not as fundamental.

3.1.3. ENGINEERING DESIGN

The function of the engineer is to design. Design is the process of devising a system, component, or process to meet some human need. While the engineer makes use of mathematics and the knowledge obtained by those in science and the engineering sciences, practical considerations are of equal importance if the design is to be successful.

Basic to engineering practice are the following considerations:
1.Available materials and their relative costs, qualities, and advantages.
2.The most effective use of labor and equipment.
3.A realistic analysis of economic, social, and ethical values.
4.Present and possible future needs and wants.

Only in engineering are there assumptions or standards which involve elaborately considered value judgments requiring comparisons between the demands of safety, cost, desirability, reliability, efficiency, convenience, esthetics, etc. However, no single engineer would have the background to make all of these judgments so reliance must be placed on codes or specifications.

Typically, a committee of experts studies and recommends realistic bounds and constants as standards which are then approved or rejected by a larger group familiar with the area. This prior social agreement on basic assumptions resulting in codes and specifications is a major factor behind the success of engineering practitioners. However, codes do not cover all situations and the engineer is still responsible to see that the code is not followed blindly if it results in an unsafe situation.

Basically, codes are primarily concerned with the protection of the public, i.e. safety. Thus other factors such as esthetics, economics, social considerations are still left up to the engineer.

3.1.4.THE ENGINEERING DESIGN PROCESS

Engineering design can be summarized as a five-step process:

1. Recognizing needs and specifying objectives (Planning)
    - Economic justification.
    - Social effects.
    - No single "correct" answer.
    - Engineers should assert personal as well as professional opinions.
    - Engineers provide accurate projected estimates of cost.

2. Preliminary design of alternate solutions
    - Probably most important step in insuring success of the final system.
    - Approximate values calculated.
    - Understanding of construction procedures is essential.

3. Evaluation of alternatives
    - Usually proceeds at same time as preliminary design.
    - Frequently a number of alternatives of equal merit.
    - Competitive bidding sometimes adds difficulties.

4. Final design and analysis
    - Computer used if structure is complex.
    - Final properties of each subsystem and connection are determined.
    - Draftsmen prepare drawings of entire system.
    - Fabricating firm prepares detail drawings.
    - Drawings are supplemented by written specifications.

5. Implementation

- Final and most visible phase.
- Control by design engineer varies.
- Revisions are sometimes necessary.

3.1.5.SEC PROJECTS AND THE DESIGN PROCESS

SEC design-build projects, which result in a report accompanied by a working model, usually proceed through Step 3 above. Design is an iterative process, and it is usually necessary to visit the steps more than once. Teams that proceed through the first pass of Step 3 can get specialized components ordered before leaving for break after the submission of the proposal; doing so will reduce procurement delays.

SEC design-study projects, which do not result in a working model, usually proceed through at least the first pass of Step 2 above.

All SEC projects complete Step 4 above during the second phase of the project, i.e. the second semester. During this time they will capital cost and schedule necessary for Client to complete Step 5 if they choose to do so.

During the course of an engineering design project, the project engineers document their progress and have it reviewed by knowledgeable peers. As American society is becoming more litigious, it is becoming more important for engineering companies to be able to establish that their engineers followed good engineering practice in the design of their products. Also, brains are not all distributed to one company. It is not unusual for more than one person to have the same or a similar idea concurrently, so who (which company) gets the patent is often in dispute. With these two scenarios becoming more common, it is absolutely necessary that a company be able to produce documentation in a court of law that will establish what the engineers did and when they did it. In short, engineers must document their work *as they do it.* This documentation takes several forms: the design notebook, design reviews, and working models. There are special considerations for design involving software.

3.2.**THE DESIGN NOTEBOOK**

The engineers' design notebook is one of the chief defenses a company uses in a court of law when they are involved in a liability suit or a patent fight. A company can win or lose millions of dollars based on the documentation of their engineers' work. If you are doing work critical to the company where liability or patent claims are likely, the company will give you a design notebook. You will be required to use it in a way that will protect your company from lawsuit and you from unemployment.

3.2.1.GUIDELINES FOR DESIGN NOTEBOOK CONTENTS

An engineering design notebook is a bound notebook with numbered pages. Not loose-leaf, not spiral bound, but sewn or glued. In this class it may or may not have pre-numbered and removable duplicate pages. On the first page put your name, email address, and phone number (in case you lose it and some kind honest person finds it); then put the names, addresses, email addresses, and phone numbers of your team mates; names, phone numbers, email addresses, and office hours of your faculty technical advisor(s) and industrial consultant, if any. The second page should be an index of the contents of your notebook; you will build this as you work in your notebook.

This notebook will contain a chronological record of everything related to the project; every thought, idea, scribble, preliminary sketch, or calculation; everything. You do not own any scrap paper; if your work is not in your notebook, you did not do it. Do not leave gaps and white space. Fill up the pages. Sign and date each page as you fill it up. Keep a record of how much time you spent on an activity *in your notebook*. Refer to previous pages by page number.

When you discover a mistake, draw a single line through the wrong part. If it is a large area or a whole page, put a big X on the wrong area. Add a note explaining why the work is wrong. Do not obliterate the work or make it unreadable. Very often what your thought was wrong turns out to have been right after all; sometimes what is wrong in one case is right for another. You do not want to have to repeat work.

When you read something related to your project, put a brief summary and full documentation (author, title, publication, date, etc.) in your notebook even if you have a photocopy of the material in your project file. Document telephone conversations in your notebook: Name of person, name of company, phone number, date, time, and topic of discussion. Similarly, document interviews in your notebook. Also record any decisions made during team meetings that will impact your part of the design work. If you are the project manager, you may want to record all decisions made at the team meetings and assignments of the other team members.

Record the work in your design notebook in standard engineering format. That is, there is to be a problem statement with labeled diagram, a list of what you know, a list of what you are attempting to design, and the steps you take to get from what you know to what you need.

When you go into the lab to perform tests on components or on a subsystem you have built or on your project as a whole, you are to document what you did in the laboratory just as you did your lab experiments in your previous courses. Experimental documentation includes: a statement of what you hope to accomplish, a list of materials and components, a sketch of the experimental setup, a table of the values you expect to measure and the actual measurements, an estimate of the accuracy and precision of the data you record, sample calculations for any calculations you make on the data, and a statement of analysis of the results and the conclusions you make. The experimental setup, data summary, and conclusions will appear in your design report, so make your records carefully.

Engineering design begins with a clear statement of what you are attempting to accomplish. It includes a record of your data-gathering phase, and continues with the application of mathematics and scientific principles to effect a solution option for your subsystem. When you consider more than one option for a solution, detail all of them in your notebook as far as you pursued them. When you make a decision among several options, record your reasons for choosing as you did.

You are to have your design notebook with you for every class session, team meeting, and design review. (You will not need your design notebooks on days when there are oral presentations in class.) Design notebooks are not optional.

3.2.2.DESIGN NOTEBOOK EVALUATION

Design notebooks will be evaluated on the following criteria:

- Organization – organization will be chronological.
- Format – pages are full, signed, and dated; they contain information on the time spent on each activity

- Problem statements
- Original design work preliminary sketches – labeled and accompanied by explanations
- Calculations – presented in standard engineering format: problem statement, orderly progression to the solution, and answer with units, clearly identified, and significance noted
- Lab data and analysis, if relevant to your project
- Bibliographic references
- Telephone/interview log
- Relevant meeting notes
- Options considered and data used for selection criteria, accompanied by explanatory material

Random words, phrases, numbers, and equations are of no use in a court of law. Someone "skilled in the art" must be able to read and understand what you did, and were trying to accomplish.

A good engineering design notebook is one from which, several years after the project is completed, the project can be reconstructed. Critical decisions will be apparent, and the reasons for the actions taken will be backed up by facts and data. It should be possible to show where original entries in the design notebook substantiate every figure, statement, and conclusion of the published report.

3.2.3.DESIGN NOTEBOOK SUMMARY

1. If the pages of the notebook are not pre-numbered, number the right hand pages in the book consecutively beginning with 1 on the first page.
2. Reserve the first page for the contact information of your course instructors, faculty technical advisor(s), client representative(s), and teammates. Your own contact information should be on the cover in case a kind, honest person finds your lost notebook.
3. Do not, under any circumstances remove pages from this book.
4. Keep a record of your daily activities in the book. Make all narrative entries in the book in ink. Neatly lineout any mistakes; do not obliterate them. Detailed calculations and sketches may be in pencil. Record the hours worked each day.
5. Date each entry
6. Notebook entries should include:
    a. Calculations
    b. Graphs, sketches, map, and design drawings
    c. Concepts and hypotheses
    d. Design criteria, requirements, and specifications
    e. Records of experimental work done including the raw data taken
    f. Summaries of design team meetings, field trips, interviews, telephone calls, etc.
7. Notebook entries should not include:
    a. Lecture notes
    b. Verbatim excerpts from reports you submit
    c. Material that is not pertinent to the project
    d. Pamphlets, journal articles, etc. (keep these in the project file and cross-reference them in the notebook)
    e. Any personal or nonprofessional comments
8. All entries should be neat and legible; i.e., in a form that you would be willing to show to a potential employer. Spelling and grammar are thus also significant.

In the event that there is a debate about your course grade, the faculty technical advisor and the course instructor(s) will assess the quality, quantity, and timeliness of the work and the quality of the documentation in your design notebook to settle the dispute.

3.3. **THE PROJECT FILE**

During the course of the project, you will accumulate papers related to your project. These will be everything from copies of articles, pages from teammates' notebooks, computer printouts, vendor data, drawings, correspondence, etc. Give each of these a document number, list it in your design notebook, and then archive it in a file. At the end of the project, you can then determine which items need to go into the Design Report. Keep all of your project-related papers together.

3.4. **DESIGN REVIEWS**

Each project will have at least one and not more than three design reviews. The first design review will come between the beginning of the second week of the second semester and the end of the fourth week of the semester. This is a feasibility design review. This review should occur as soon as you have your subsystems identified and tentatively designed on paper. Note: there are not enough clock hours for all teams to have a design review in the same week. Plan yours early.

The second design review is an interim review. This should occur when the when the subsystems are designed and system integration has begun. This design review looks critically at the subsystem interfaces and overall performance. This Design review should take place between the eighth and tenth weeks of the semester.

Complex projects may require a third design review between or after the two listed above.

The purpose of design reviews is to provide a systematic way of identifying problems with the design, to aid in determining possible courses of action, and to initiate corrective action in problem areas. Design reviews are for your benefit to improve the results of your project.

The design review is a small meeting of experts you have gathered to give you advice on your project. Your team is responsible for selecting people to invite, arranging for the meeting, inviting the guests, and running the meeting.

Whom should you invite? Your industrial consultant, if you have one, will expect to be invited as will your faculty technical advisor and all of the course instructors. However, all of these are more or less closely associated with the project. The purpose of the design review is to get input, help, and suggestions from others who have related expertise, but are not directly involved with the project. OK, so whom to invite? Other faculty members, graduate students, undergraduate students, other people from your industrial consultant's company, your parents and/or their friends if they have the appropriate expertise. The idea is to get a group of people together and let them exchange ideas with you and each other regarding your project. You get to write down all their good ideas to use later.

How do you invite them? The best way is face to face. Explain your project and what you want from them, namely, an hour of their time and their advice. Find out when they are available. Select a time when most of your ~~victims~~, oops, guests can come. Arrange for a place and send an email asking for confirmation of day, time, and place. A couple of days before the meeting make handouts that explain your project, what you have done so far, what you plan to do next, and any problems about which you want advice. Assemble the package together with an agenda and cover letter and deliver it to your guests (or their mailboxes). If you can put the material in an email attachment, you can send email instead. If you put this much effort into inviting people and they have committed to coming, most of them will probably follow through and show up.

You will give oral presentations of your proposal, progress, and design to management. The emphasis those presentations is on what your are doing and why, how much it will cost, how long it will take and how much money Client or Management can make by implementing your design. On the other hand, the emphasis of your design review is the technical aspects of your project. These reviews are less formal than presentations in atmosphere. You wear whatever you usually wear to work (school). You can expect everyone there to understand at least some of the technical aspects of your project. You can actually use equations, circuit diagrams, and engineering drawings. You may hold your design review(s) in whatever room makes the most sense for what you are presenting and how you are presenting it. You may use one of the rooms assigned to the Senior Design course, the lab where you have your equipment set up, one of the conference rooms scheduled through the departmental secretaries, or any other appropriate place.

When you are conducting the meeting, remember that this is a professional meeting. That means you have an agenda and one person is in charge. The person in charge, usually but not necessarily the project manager, keeps the meeting focused on your project. Each member of the team should present the information relevant to his/her subsystem. Presentations should be kept brief and to the point. Elaboration can come in response to guests' questions if necessary. Remember that the purpose is to get ideas and help from the guests, so be sure to allow as much time for them to talk as possible. Be prepared with questions to ask them if they are hesitant to start talking. If they should wander off topic, you need a gentle way to bring them back to your project. Be prepared to ask another question, or present a proposed course of action and invite comments on that. When you run out of questions and they are no longer being helpful, adjourn the meeting. If some want to stay and talk, they may, but those who need to leave can do so gracefully.

Evaluation of design reviews involves answers to these questions:

- ✓ Did you issue appropriate invitations sufficiently early and with handouts?
- ✓ Did you prepare your presentation and questions?
- ✓ Did you take charge of the meeting and conduct it in an orderly manner?
- ✓ Did you get useful help with your project?

A thank you note to those attending who are not your course instructors or faculty technical-advisors is a thoughtful touch. Remember to mention something the individual said that was helpful if he/she made any such contributions; otherwise, thank them for their time and attention.

In Chapter 7 of *Stuff You Don't Learn in Engineering School* (2004) Carl Sellingr explains how to conduct an effective meeting. The design review should reflect the fact that the team has read this chapter.

3.5.**THE WORKING MODEL**

The most effective proof of concept for a design project is a working model. However, not all projects lend themselves to a working model, and not all models actually work. Projects that do not propose to have a working model are designated *design-study* projects. Projects that do propose to have a working model are designated as *design-build* projects. A design-study project will result in a thicker Design Report because all of the design time will be spent generating paper work to document the design.

Many design-study projects that cannot have a working model of the complete design can have a model. They may have either a mock-up (a model that shows what it will look like but is not supposed to be functional) or a working model of one or more subsystems. These models do not have to be full-scale. Nevertheless, they do make a good impression and have good visual impact. They usually influence Client and Management to look more favorably upon the project. If a model of some part of the project, or a mockup can be included, it will enhance the value of project presentation.

Projects resulting from requests for proposals that have a working model as part of the work requested have an obligation to show something that does something, even if it is not a complete prototype as proposed in the proposal. The question, "How are we going to demonstrate this?" should be a primary consideration from the beginning of the design phase. An effective and impressive demonstration is a big factor in having an outstanding project.

There are many reasons why working models are not completely constructed, or even begun. Some of the reasons are legitimate; others indicate poor planning or lack of effort.

Sometimes a team cannot construct the working model because there are critical components or tools that were promised, but for one reason or another are, or become, unavailable. As soon as this becomes the obvious situation, the team needs to act to change what the proposed results will be. Depending on the time in the semester and the nature of the project, the team should redirect the project in one of a number of different ways, for example:

- Extend the scope and convert to a design-study project
- Construct only a part of the complete project
- Change the project to design and construct something different
- Design and construct a substitute for the missing part and reduce the scope of the original project.

In the case of a partial construction, the team needs to carefully plan how to demonstrate that the part that is constructed actually works. Any solution similar to these is acceptable and usually does not result in any penalty.

Teams with design-build projects generally run into trouble either (1) when they look at the evaluation criteria and see that the working model is only worth about ten percent of the Design Report grade, or (2) when they fall victim to the "Of course, it will work: I designed it" attitude. Why is the performance of the working model only worth approximately ten percent? If the project turns out to have some complexities unforeseen by the team, the faculty technical advisor, or the course instructors, it would not be fair to penalize the team that has worked diligently to solve a very complex problem.

In the two cases above, the trouble arises when insufficient effort has gone into the attempted problem solution. Remember, if the working model is only ten percent, what is the other ninety percent? Spending twenty-four hours per day in the lab during the last two weeks of the semester does not constitute adequate effort. OK, you cannot get your model to work. What would make the Design Report an outstanding report? It will be an outstanding report if it is a report of what you *did* do. It will show good engineering practice of selecting a solution from among options, implementing the solution, describing the tests and results of the implementation, selecting another course of action from among available options, describing the tests and results, … through many iterations of changes and attempted improvements. In research it is just as important to know what does not work as it is t know what does work.

Remember, if your working model works perfectly it is still worth only ten percent of your Design Report. The other ninety percent is professional quality documentation. Without outstanding documentation, the most perfect working model is only an expensive toy. Engineers are not employed to make toys; they are employed to produce designs that can be manufactured and sold. The difference is the documentation.

3.6.SOFTWARE IN ENGINEERING DESIGN

> "There are two ways of constructing a software design; one way is to make it so simple that there are obviously no deficiencies, and the other way is to make it so complicated that there are no obvious deficiencies. The first method is far more difficult."
> - C. A. R. Hoare

Engineers can use software to create, analyze, or improve an engineering design. It can also be the result of the design process. In either case, documentation of the design process can be problematical. Currently a court of law expects documentation that is evidence to be a piece of paper. Files created on a computer during the course of engineering design tend to be voluminous when printed out on paper.

3.6.1.SOFTWARE AS A DESIGN TOOL

The purpose of documenting ongoing engineering design work is to be able to establish what you did and when you did it. The problem with computer generated files is the ease with which dates can be changed. Therefore, dates on computer files and computer-generated output will not stand up in a court of law. In order to have irrefutable legal evidence many companies will have engineers print out their files regularly, sign and date each page, and have their signatures witnessed.

The management of Saluki Engineering Company expects engineers to document the use of software design tools in their design notebooks. Engineers should print out any significant results, whether positive or negative, and place them in their project files.

3.6.2.SOFTWARE AS A DESIGN PRODUCT

When the resulting product, that is, working model, is a software package, design documentation becomes even more problematic. Engineers will do initial input and output planning, data storage planning, and algorithm development in their design notebooks. However, engineering management recognizes that engineers will do most of the actual engineering design as they type into a computer. Again, some companies require daily printouts, signed, dated, and witnessed.

The management of Saluki Engineering Company wants the engineers to put into their project files a copy of every major development step and major revision of every implementation tested. In addition, a copy of every test data set and resulting output.

The design report should show the test results for competing implementations; although the final product will contain only the revision that leads to the bast overall project. Note that the best implementation of any particular sub-function may or may not be included in the best overall version. The Design report should document all the test results and justify the version chosen for the final product.

CHAPTER 4 – ETHICS: MICROETHICS AND MACROETHICS

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CHAPTER 4 – ETHICS: MICROETHICS AND MACROETHICS

4.1. ETHICS IN MODERN ENGINEERING

Ethics can be defined as the use of skills and resources with the intention of doing good. As professionals, engineers have been concerned with ethical conduct and the reputation of the profession. Engineers attempt to improve the lot of society by making improvements that others will pay for. This interest in ethics has taken the form of concern about the conduct of individual engineers and inner workings of the engineering professions. This domain of ethics could now be termed *microethics*.

It has now become clear that the future of engineers depends on professional and social responsibility being more in tune with technical achievements. History and sociology are becoming more important as the focus of society shifts from performance alone to risk assessment, sustainable development, and product reliability. If engineers are to have an influential role in the future, they are going to have to take care that their solutions contribute to a sustainable world that provides a safe, secure, and healthy life for all people as well as being technically viable, economically feasible, and environmentally and socially sustainable. This is a shift toward what might be called *macroethics*.

4.2. MICROETHICS

Microethics has been incorporated into engineering education for many years now. The emphasis has been on the importance of responsible individual behavior as embodied in the codes of ethics of the various professional societies. Class coverage has taken the form of what-if discussions and case studies of engineering disasters. These have been covered in various ways including in individual classes as the occasion arises as well as in courses dedicated to the discussion of ethics. Every student should have encountered the code of ethics from an appropriate society at some time during his or her academic career. The primary purpose of these discussions is to create awareness so that the entry level engineer will go in being aware that these types of situations occur. Forewarned is forearmed. The conscientious student will think through these situations and not only be more likely to recognize a questionable situation when it arises, but have some sort of a game plan on how he or she would handle it. The situations likely to be encountered most frequently are not going to be glaringly black or white; they will be in the gray area somewhere. For instance: underestimating costs in planning studies in order to generate future consulting contracts; overlooking construction flaws or surveying errors in order to maintain good relations with the contractor or avoid embarrassing other engineers; accepting components that are just slightly out of specifications in order to save time and avoid having to send them back. When ever you have a question about the microethics of a situation, you can always consult with the ethics division of your professional society for help, guidance, and clarification.

4.2.1.INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS CODE OF ETHICS

IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology, its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

Approved by the IEEE Board of Directors
February 2006

4.2.2.SOFTWARE ENGINEERING CODE OF ETHICS

SOFTWARE ENGINEERING CODE OF ETHICS AND PROFESSIONAL PRACTICE

(Version 5.2)

As recommended by the IEEE-CS/ACM Joint Task Force on Software Engineering Ethics and Professional Practices and jointly approved by the ACM and the IEEE-CS as the standard for teaching and practicing software engineering.

Short Version

PREAMBLE

The short version of the code summarizes aspirations at a high level of abstraction. The clauses that are included in the full version give examples and details of how these aspirations change the way we act as software engineering professionals. Without the aspirations, the details can become legalistic and tedious; without the details, the aspirations can become high sounding but empty; together, the aspirations and the details form a cohesive code.

Software engineers shall commit themselves to making the analysis, specification, design, development, testing and maintenance of software a beneficial and respected profession. In accordance with their commitment to the health, safety and welfare of the public, software engineers shall adhere to the following Eight Principles:

1. PUBLIC - Software engineers shall act consistently with the public interest.
2. CLIENT AND EMPLOYER - Software engineers shall act in a manner that is in the best interests of their client or employer and that is consistent with the public interest.
3. PRODUCT - Software engineers shall ensure that their products and related modifications meet the highest professional standards possible.
4. JUDGMENT - Software engineers shall maintain integrity and independence in their professional judgment.
5. MANAGEMENT - Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.
6. PROFESSION - Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.
7. COLLEAGUES - Software engineers shall be fair to and supportive of their colleagues.
8. SELF - Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession.

4.2.3.AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE OF ETHICS

ASME CODE OF ETHICS OF ENGINEERS

The Fundamental Principles

Engineers uphold and advance the integrity, honor, and dignity of the Engineering profession by:

I. using their knowledge and skill for the enhancement of human welfare;

II. being honest and impartial, and serving with fidelity the public, their employers and clients; and

III. striving to increase the competence and prestige of the engineering profession.

The Fundamental Canons

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

2. Engineers shall perform services only in areas of their competence.

3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

6. Engineers shall associate only with reputable persons or organizations.

7. Engineers shall issue public statements only in an objective and truthful manner.

NOTE THAT THE ASME ADDS A STATEMENT OF FIVE TIME THIS LENGTH TITLED "THE ASME CRITERIA FOR INTERPRETATION OF THE CANONS"

Last updated 96/01/22

“THE ASME CRITERIA FOR INTERPRETATION OF THE CANONS” is available on Web CT under Articles as a PDF file.

4.2.4.AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS CODE OF ETHICS

ASHRAE Code of Ethics

As members of a Society

> "organized and operated for the exclusive purpose of advancing the arts and sciences of heating, refrigeration, air conditioning, and ventilation, the allied arts and sciences, and related human factors for the benefit of the general public,"

ASHRAE Bylaws, June 1997

We recognize that honesty, fairness, courtesy, competence and integrity must characterize our conduct.

With the foregoing in mind

> Our efforts shall be directed at all times to the enhancement of the public health, safety and welfare.
> Our services shall be offered only in areas of our competence.
> Our products shall be offered only in areas of their suitability.
> Our public statements shall be issued only in an objective and truthful manner.
> Our endeavors shall carefully avoid conflicts of interest and the appearance of conflicts of interest.
> The confidentiality of clients' and employers' business affairs, proprietary information, and procedures shall be respected.

Approved by the Board of Directors June 22, 1986

Revised Date:
March 15, 2004

4.2.5.NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS CODE OF ETHICS

NSPE Code of Ethics for Engineers

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.

    a. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.

    b. Engineers shall approve only those engineering documents that are in conformity with applicable standards.

    c. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.

    d. Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.

    e. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.

    f. Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.

2. Engineers shall perform services only in the areas of their competence.

    a. Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.

    b. Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.

    c. Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provided that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.

3. Engineers shall issue public statements only in an objective and truthful manner.

    a. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.

    b. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.

    c. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

4. Engineers shall act for each employer or client as faithful agents or trustees.

    a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.

    b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.

    c. Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.

    d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.

    e. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.

5. Engineers shall avoid deceptive acts.

    a. Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers, or past accomplishments.

b. Engineers shall not offer, give, solicit, or receive, either directly or indirectly, any contribution to influence the award of a contract by public authority, or which may be reasonably construed by the public as having the effect or intent of influencing the awarding of a contract. They shall not offer any gift or other valuable consideration in order to secure work. They shall not pay a commission, percentage, or brokerage fee in order to secure work, except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

III. Professional Obligations

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.

    a. Engineers shall acknowledge their errors and shall not distort or alter the facts.

    b. Engineers shall advise their clients or employers when they believe a project will not be successful.

    c. Engineers shall not accept outside employment to the detriment of their regular work or interest. Before accepting any outside engineering employment, they will notify their employers.

    d. Engineers shall not attempt to attract an engineer from another employer by false or misleading pretenses.

    e. Engineers shall not promote their own interest at the expense of the dignity and integrity of the profession.

2. Engineers shall at all times strive to serve the public interest.

    a. Engineers shall seek opportunities to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community.

    b. Engineers shall not complete, sign, or seal plans and/or specifications that are not in conformity with applicable engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.

    c. Engineers shall endeavor to extend public knowledge and appreciation of engineering and its achievements.

    d. Engineers shall strive to adhere to the principles of sustainable development[1] in order to protect the environment for future generations.

3. Engineers shall avoid all conduct or practice that deceives the public.

a. Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact.

b. Consistent with the foregoing, engineers may advertise for recruitment of personnel.

c. Consistent with the foregoing, engineers may prepare articles for the lay or technical press, but such articles shall not imply credit to the author for work performed by others.

4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.

    a. Engineers shall not, without the consent of all interested parties, promote or arrange for new employment or practice in connection with a specific project for which the engineer has gained particular and specialized knowledge.

    b. Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the engineer has gained particular specialized knowledge on behalf of a former client or employer.

5. Engineers shall not be influenced in their professional duties by conflicting interests.

    a. Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.

    b. Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the engineer in connection with work for which the engineer is responsible.

6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.

    a. Engineers shall not request, propose, or accept a commission on a contingent basis under circumstances in which their judgment may be compromised.

    b. Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical considerations.

    c. Engineers shall not, without consent, use equipment, supplies, laboratory, or office facilities of an employer to carry on outside private practice.

7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.

a. Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.

b. Engineers in governmental, industrial, or educational employ are entitled to review and evaluate the work of other engineers when so required by their employment duties.

c. Engineers in sales or industrial employ are entitled to make engineering comparisons of represented products with products of other suppliers.

8. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.

    a. Engineers shall conform with state registration laws in the practice of engineering.

    b. Engineers shall not use association with a nonengineer, a corporation, or partnership as a "cloak" for unethical acts.

9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

    a. Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.

    b. Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the engineer for others without express permission.

    c. Engineers, before undertaking work for others in connection with which the engineer may make improvements, plans, designs, inventions, or other records that may justify copyrights or patents, should enter into a positive agreement regarding ownership.

    d. Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property. The employer should indemnify the engineer for use of the information for any purpose other than the original purpose.

    e. Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars.

Footnote 1 "Sustainable development" is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development.

—*As Revised January 2006*

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount."

Statement by NSPE Executive Committee

In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding."

It is further noted that as made clear in the Supreme Court decision:

1. Engineers and firms may individually refuse to bid for engineering services.
2. Clients are not required to seek bids for engineering services.
3. Federal, state, and local laws governing procedures to procure engineering services are not affected, and remain in full force and effect.
4. State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.
5. State registration board rules of professional conduct, including rules prohibiting competitive bidding for engineering services, are not affected and remain in full force and effect. State registration boards with authority to adopt rules of professional conduct may adopt rules governing procedures to obtain engineering services.
6. As noted by the Supreme Court, "nothing in the judgment prevents NSPE and its members from attempting to influence governmental action . . ."

NOTE: In regard to the question of application of the Code to corporations vis-à-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer, and it is incumbent on members of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.

4.3. **MACROETHICS**

While the conduct of the individual engineer has been of a concern for many years and engineering societies have developed formal codes of ethics, it is only recently that the role of the engineer in broader society has become of concern and importance.

The Accreditation Board for Engineering and Technology (ABET) has included macroethics among the requirements for accreditation in its last revision, Criteria 2000. All schools are now required to demonstrate that their graduates have had courses in social studies relevant to the issues facing society today and that they have applied concerns about these issues to their engineering designs. Currently the principles and applications have not yet been codified, but they will probably be within the working lifetime of the engineers who are in school now.

Observing the consequences of previous years of engineering solutions, society has observed that life cycle considerations are important. The byproducts of the production processes and the remains after the useful life have to be disposed of or reused without making the environment uninhabitable. Some resources are not renewable and cannot be continuously consumed for ever.

The increasing dependence on computers has raised questions about the issues of privacy versus public good and the reliability of computer networks. Robotics, nanotechnology, and genetic engineering are all areas that are raising increasing concerns.

Engineers who want to have a significant career are no longer going to be able to focus exclusively on technical and financial issues, but rather are going to have to consider the implications for society and for the future in all of their engineering projects.

Design reports should address issues such as:

- What can this system be used for in addition to its designed purpose?
- Can this system be modified to harm individuals, companies, governments, or property?
- Can this system be used for or modified to be used for illegal or immoral purposes?
- Can this system have any unintended consequences or side effects that you can now for see?
- How much would it cost to modify the system so that it cannot be used for undesirable purposes?

Students who wish to be considered outstanding, i.e., receive a grade of "A," will demonstrate that they can contribute meaningfully to this discussion as these issues relate to their senior design project. All design reports are expected to contain a statement that considers the implication of the project on society and the future.

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CHAPTER 5 – THE PROPOSAL

5.1.INTRODUCTION TO ENGINEERING PAPERWORK

Entry-level engineers often have difficulty transitioning from academe to the work place because they do not understand the fundamental differences between academic communications and engineering communications. This section will briefly explain the differences; Paretti (2006) gives a more detailed description in an article in *IEEE Transactions on Professional Communication.*

5.1.1.ACADEME VERSUS THE WORKPLACE

In the academic setting the purpose of communication, written and presentations, is to demonstrate the degree to which the student has mastered the material. The audience is a person who is more knowledgeable in the field, knows exactly what the student should be saying, and is evaluating the understanding of the presenter. Professors need information from students that is correct and complete; the organization, style, tone, and visual design are largely irrelevant. Students, especially good students, have become very expert at this type of communication. Unfortunately, when entry-level engineers carry these skills into the workplace, miscommunication occurs because this is the exact opposite of what workplace communication requires.

In the workplace, the communication of information goes from a person who has detailed specific information to decision makers who need that information in order to make informed decisions regarding the future of the company. In other words, the engineer writing the report, making the presentation, is the expert giving information to the decision maker who is probably an engineer from an very different discipline, a lawyer, or an accountant. These decision makers are usually the upper management from you company or the client company to whom the engineer's company is making a proposal or for whom the engineer's company is doing work. These managers are very busy; they do not have time to learn the details of all the engineering disciplines that affect their company's operation. What these managers need is information that is correct, reliable, defendable (in court), and completely, clearly, and concisely delivered in a format that that will allow them to quickly assimilate the information they need. The organization, style, tone, and visual content are as critical as the content for creating understanding and acceptance in the minds of the decision makers.

5.1.2.SALUKI ENGINEEING COMPANY AS A TRANSITION

SEC is run as much like an engineering department in a corporation as is possible within the constraint of its actually being an academic course. This means that the course instructors will view the paperwork and presentations as if instructors were part of upper management of an engineering company. They will be looking for answers to management type questions, and the answers they find in the team's documentation will partially decisions on what they do next regarding that particular project. The instructors have 15 to 25 projects to manage; these projects cover the full range of sub-disciplines in electrical, computer, and mechanical engineering. The instructors, like corporate managers, cannot be an expert in all areas and do not have the details of any one project upper most in mind when a particular document comes in.

When a document arrives, the manager needs to be able to quickly determine (1) Where did it come from, (2) Why do I have it, and (3) What should I do with it when I am finished with it, in addition to being able to quickly assess the technical content. Engineers who do not want communications ignored will take the responsibility of providing that information in a format that is useful to the managers.

From time to time SEC management will give engineers feedback and ask for corrections and resubmission of a document. Entry-level engineers need to understand the fundamental difference between corrections required for academic papers and corrections required by managers. Academic evaluators are looking for technical and grammatical correctness, and most changes required by them are related to these issues. Workplace management will ask for corrections because the information is not in a format that is useful to them, in other words, the changes required will be related to organization, style, tone, and visual content. The typical reaction is, "Why do I have to change it? All the information is there." True, but managers are busy people, they do not have time to study the document in order to discover what they need to know; they need to be able to glean the information that they need quickly. If the document is going out of the company, it needs address the client, supplier, or whomever in a style and tone that will lead to better relationships.

Wearing two hats, SEC management will request document changes that address both correctness issues and style related issues. Management expects engineering teams to understand and make both types of changes. SEC management understands that its engineering staff has never been required to write documents to be evaluated on style as well as content. Management will evaluate only the final version of the required documents. Previous submissions that need corrections should be regarded as opportunities to make mistakes for free: they will affect neither your grade nor your pay check; take every opportunity to learn to do it right now, before it will affect your paycheck!

5.2. **WHAT IS A PROPOSAL?**

A proposal is a reply prepared by an engineering company in response to a request from an operating company to provide services and/or equipment. This text contains two proposal outlines and explanatory discussions.

The first proposal outline is suitable for a cost-plus-fixed-fee price, in-house-services only offer. The work scope is limited to provision of engineering services, plus, when suitable, a working model. This is a very common type of real world proposal request and is good practice towards successful proposal writing; it is also suitable for engineering course work with limited time and money.

The second proposal outline is a checklist for a full commercial proposal. It begins with an explanatory discussion that includes a marketing section. This discussion will show where the proposal fits in the spectrum of corporate activities and how an engineering company plans its engineering department activities, adjusts its staffing levels, and competes with its peers.

5.2.1. WHY AN ENGINEERING PROPOSAL IS REQUESTED

An operating company requests an engineering services proposal when it wants to add a facility or capability to its operations that it cannot accomplish with its own engineering staff. A new facility may be a building or manufacturing plant or a group of equipment that works as a unit. A capability may be automation or modernization of a plant or its control systems or a new product.

The management of most companies has an annual budgeting problem. They have just so much money to spend on modernization, new plant construction to add volume or reduce production costs, and research to add new products. They have designs made, such as SEC will make this term to be able to assess the cost, time to get into production, and, through feasibility studies based on the design data, the profitability of the competing projects.

5.2.2. MAKING THE PROPOSAL LEGALLY VALID

A proposal is a contract document. It binds the engineering company to do the work specified in the time stipulated for the price offered. It must be signed by a company official authorized to commit the company to do work. This usually is a vice president or higher. It is almost never the project manager, unless the proposal is so significant that the project manager is a vice president.

For an engineering contract to be useful and valid:

1. it must be entered into by two "independent parties,"
2. each must get some "consideration" from the contract, and
3. time must be "of the essence."

The identified phrases have special contract meanings as follows:

1. Being an "independent party" means that neither contracting company can belong in whole or in part to the other. You cannot legally contract with yourself.
2. A "consideration" is something of value. In engineering contracts, usually one party gets a design, or a constructed facility, and the other gets money.
3. "Time being of the essence" means that the performing company has a time frame to complete the contract. A contract without time constraints is a bad contract for both parties.

5.2.3. HOW PROPOSALS ARE USED IN INDUSTRY

Many companies add facilities or capabilities using a two-step procedure. As the first step, they ask for a proposal from an engineering company to define the facility or capability. This definition includes the capital cost, a technical definition of what is included in the cost, and a schedule for installing the facility, or capability, from the day approval to proceed is given.

They then talk to their bank and to their accountants and see if they can afford the proposed addition and how they may finance it. They also make calculations to see that the addition will have the desired affect such as increasing capacity, adding a new product to sell, or reducing operating costs. Most important, they can assess the affect of the change on the profitability of the company.

Sometimes a company may have two or three projects they would like to do, but not enough financial capability--profit for reinvestment or credit--to do them all. Then, having the engineering assessments made gives them a way to determine which project is best to do first.

The management of many companies insists on an independent appraisal of a project, even if the staff can make a preliminary assessment. Many banks also require the independent assessment before they will lend money for a project. The engineering assessment plus the financial opinion from an independent accounting firm are frequently referred to as "bankable paper," which indicates how important they are to the business world.

After the first step is completed, the second step is to award the final design, followed by either procurement and construction/installation, or development and manufacture, to the company which did the phase one work, or to another engineering company. The work scope of engineering design courses corresponds to step one of this two-step process. An engineering company or department never submits a "final" report. Every design report contains a stated, or implied, proposal to do more work.

5.2.4.A LETTER OF REQUEST TO PREPARE AN ENGINEERING SERVICES ONLY PROPOSAL

On the next pages, is a typical Letter of Request for Proposals (RFP). It is the sort of request used to get a proposal to perform first phase work from an engineering company. It asks the company to quote a price to provide a technical specification, a capital cost estimate, and a project schedule to construct (install, or manufacture) the facility (addition, or product).

5.2.5.THE PROPOSAL RESPONSE DECISION

When an engineering company gets a letter requesting a proposal, its management, together with its sales or marketing department, must decide whether it is desirable to bid on the project. You will note that the request letter says, "… request has been sent to three engineering companies." This means it is not certain that any one bid will be successful; the odds look like one in three to get the work.

The engineering company must assess its current and future workload to see if the work fits its staff capability and availability. The management must review their success ratio in bidding to the company asking for the bid. Do they have a good success ratio? Or are they merely giving the asking company a price against which to compare the bid of the engineering company they usually award work to? This is known as "keeping them honest." Because they do not pay for the bids, asking for such known losing bids is a semi-unscrupulous practice of many operating companies.

Acceptances of bids are usually made with four key factors in mind:

- the low price,
- the shortest schedule on which the work can reasonably be done,
- the caliber and experience of the personnel offered by the engineering company to do the work, and
- the experience of the engineering company in the type of facility or capability that is under consideration.

It is expensive to bid. The management of an engineering company must keep its success ratio high on bids, or it will spend all its profits making losing bids. Management usually considers one success in four or five bids to do work on a cost plus fee basis as satisfactory.

When a decision is made to bid, a project manager must be assigned to prepare the bid. The manager must assess the personnel and material requirements to bid, must prepare a bidding schedule, listing all of the work elements and showing their sequence and their degree of overlap, and must estimate the cost of preparing the bid and get the budget approved by management.

Saluki Engineering Company
Engineering Resource Center
College of Engineering – Mailcode 6603
Carbondale IL 62901-6603
618-453-7035

Request for Proposals

16 February 1999

Subject: **Proposal for An Electronically Controlled Antenna**

Client: **Engineering Innovations, Inc.**

Project Number: **ECTLANT-56.S99**

Recently electronic locators that broadcast radio frequency signals are used to locate lost Alzheimer's patients, track animals in wild life studies, and other applications where the location of the person or thing being sought is not known. Typically, the seeker goes out with a detecting device and wanders around waving it in all directions until the detector picks up a signal. This is not an optimal arrangement because it wastes time and there is a real possibility the seeker will miss the desired signal. A better plan would be to go out with an antenna system that has three or more antennas controlled electronically. The electronic control can then direct the reception in a continuous 360° sweep. When the antenna picks up a signal, the controller will know the direction of the antenna at the time of the interception. The controller will display this information to the seeker, who will then know the relative direction of the target. Since an electronic controller can sweep the entire 360° relatively quickly, it is more likely that the target will be located quickly. Thus, Engineering Innovations, Inc would like a feasibility study to determine the cost of such a system.

Saluki Engineering Company, hereinafter SEC, has been appointed Architect-Engineer Coordinator for the referenced study on behalf of Engineering Innovations, Inc., hereafter "Client," to make an engineering study of the referenced project.

SEC has divided the work into packages by engineering team capability and will coordinate the overall work. SEC has sent this bid package to three competitive engineering teams, hereinafter Engineer, of equal capability including your team. SEC is hereby requesting a proposal from Engineer for Client's approval to do the defined work. The timeline for this project will be as follows:

April 21, 1999	Proposal draft due in SEC Resource Center (Room A319B) at noon. This proposal will be evaluated for compensation (grade in the course).
April 29, 1999	Proposals may be picked up from course instructors after noon with conditional acceptance and comments from SEC.
April 27, 1999 – May 6, 1999	Oral presentations 11:00-11:50 am in EGR A111
May 10, 1999	Final proposal (2 copies) submitted to SEC by noon. One copy will be forwarded to Client.
August 23, 1999	Work begins.

Your proposal will receive conditional acceptance on April 29, 1999; you may have to make additional changes after Client has reviewed it.

Engineer will present the drawings, specifications, and explanatory text in a final Design Report together with the capital cost estimate and schedule to manufacture the product.

One written and one oral progress report will be required during the design as indicated on the attached schedule. In addition, one or two formal progress review meetings will be required.

The proposal, which you will submit by noon according to the attached schedule, must include:

1. A cover and title page
2. A transmittal letter
3. An abstract of 300 to 500 words
4. A non-disclosure statement
5. A table of contents
6. An introduction that indicates that you understand the study and why it is being undertaken.
7. A literature survey that lays out the following:
   a. what is already known about projects of this type
   b. what the required design procedures are
   c. the relevant content of the applicable codes and standards
   d. the materials and components
   e. a summary of how the reviewed literature relates to this project
8. A and its relationships to the other subsystems, including a site plan or block diagram to visually show how the subsystems are related
9. For each subsystem,
   a. a description of what each subsystem will be or do
   b. a description of how each subsystem relates to the other subsystems, including a site plan or a block diagram to show the relationships,
   c. a list of the elements which will define the subsystem design,
   d. a list of deliverables, including all drawings, tables, lists, write-ups and other elements, that you can now identify as probable parts of the Design Report you will submit at the completion of the project
   e. a list of design activities required to produce the deliverables listed
10. A project organization chart indicating project manager and showing for each nominee: name, principal area of responsibility, and discipline;
11. A Responsibility-Approval-Support-Information (RASI) chart for the project;
12. An action item list that shows detailed action items for the first two weeks and significant action items for weeks thereafter
13. Team timeline indicating significant milestones in either
    a. Excel or Word table format with the team schedule having one line for each member of the team (this line is the total line at the bottom of the individual member's individual schedule),
    b. Microsoft Project timeline with each of the action items from 6 above together with the engineer responsible as indicated in the RASI chart, or
    c. A SureTrack timeline with each of the action items from 6 above together with the engineer responsible as indicated in the RASI chart
14. For design and build projects, a list of all components that you can now anticipate needing and their actual costs

15. An appendix that includes
    a. the resumes for all candidates for the team
    b. a sample of the title block that your team will put on each of the drawings
    c. copies of any communications your team has with other companies.

Any literature that your team requests from vendors during the course of the writing of this proposal, or the work on the project, will be addressed as follows:

A. Weston or F. Harackiewicz
Engineering Resource Center
College of Engineering – Mailcode 6609
Southern Illinois University
Carbondale IL 62901-6603

In addition, any information you request to be faxed should be sent to

A. Weston or F. Harackiewicz
Engineering Resource Center
FAX: 618-453-7455
Voice: 618-453-2842

Please note: If the address on any material that arrives does not contain the words "Engineering Resource Center" and if you have it sent to YOUR name, you will never see the material as students are not known by name to the mailroom staff. Be sure to give SEC management a memo indicating what you ordered and the team number that is to get it.

Engineer will adjust the Scope of Work so that it is suitable for each of the engineers who will be working on the project. If significant design components of the project must be omitted because of time or staff limitations, clearly identify them in your proposal. Your final cost analysis must, in any event, account for them.

The attachments to this letter are listed below:
1. Client's project definition
2. Design Report deliverables checklist
3. Spring 1999 tentative schedule

Egyptian Associates look forward to receiving your proposal. Engineer shall deliver the proposal to **Room A319b** of the SIU Engineering College complex in Carbondale, Illinois, addressed to the attention of Dr. Frances Harackiewicz, SEC's Manager of ECE Projects or Dr. Alan Weston, SEC's Manager of ME Projects.

Sincerely,

F. Harackiewicz

Frances Harackiewicz
Manager of ECE Projects

Brief description:
Design and build an antenna array that can be mounted on top of a vehicle to track animals wearing a transmitter. The antenna pattern is to be able to be rotated by changing the antenna pattern electronically using a manual controller.

Major tasks involved:
1. Use or improve the existing the antenna array.
2. Design and build the electronic phase selector
3. Design and build the controller
4. Design and build the power supply and housing.

In case of a conflict between this RFP and Client's design requests, Client's design requests control. As new data become available, Client may give Engineer additional data and criteria that will be incorporated into the design.

Attachment 2 – Design Report Requirements

The proposal Engineer submits will indicate that these items will be included in the Design Report (**not** the Proposal!):

1. A complete technical description of all solution options studied
2. A recommended solution and a detailed justification for the choice
3. Equipment, component, and materials take-off lists for each solution
4. Engineering drawings defining each solution
5. Identification of the important technical problems and limitations encountered during design, construction and debugging, e.g., time, accuracy of results, reproducibility of results
6. A complete technical description of the recommended system and how it works
7. A complete engineering specification for the system including all drawings necessary for manufacture, maintenance and repair
8. Tables of performance data
9. ***A fault analysis of the recommended system, including identification of all faults which could occur, a technical solution to eliminate their consequences, and the cost for incorporating the improvement***
10. A Technical Manual that includes a technical description of both the hardware and the software, together with, but not limited to: appropriate hardware diagrams and component lists; software flowcharts, listings, and disks; and instructions for construction, maintenance, trouble shooting, and modification
11. A User's Guide for the individual using the prototype, including both instructions on how to connect and use the hardware, how to set up and use the software, what performance can be expected, and what limitations the prototype has
12. A conclusion and recommendations section that summarizes the performance in includes recommendations for improvement, enhancement, and manufacture
13. The actual itemized cost to construct the prototype
14. The time-line schedule actually used to design and construct the prototype.

5.2.6.AN OUTLINE FOR AN ENGINEERING SERVICES ONLY PROPOSAL

For a services only bid, the proposal outline, which lists all of the elements that must be prepared, looks typically like this:

1. Binder, cover, and title page
2. Transmittal letter to the client
3. Abstract
4. Confidentiality statement
5. Table of contents
6. Introduction
7. Literature review
8. Basis of design
9. Project definition
10. Engineer's scope of work
11. Design activities list
12. Subsystem technical discussions
13. Resources needed
14. Validity statement
15. Organization chart of assigned personnel
16. Responsibility Approval Support Information (RASI) Chart
17. Timeline for work schedule
18. Action item list
19. Appendix: Personnel Resumes

When proposal request is for a full scope of work through construction, a full-fledged commercial proposal is required. An outline of such a commercial proposal is located at the end of this chapter.

5.3.**A DISCUSSION OF PROPOSAL ELEMENTS**

Proposal preparation begins by looking at some past proposals. Every engineering company has a file of past proposals. This does NOT mean that the current proposal should be a copy of past proposals either in part or in whole. The proposal being prepared should match the requirements given in the RFP whether or not any of the past proposals do so. A fresh, original, readable text may be the difference between getting an award and losing a job.

In engineering offices, many components of a proposal, such as resumes and company experience and qualifications, are on computer disks and need not be prepared from scratch each time, but merely adapted to the proposal at hand. Proposals often contain several items, such as the introduction and schedules that will go into the Design Reports and Progress Reports; therefore, these pages should be placed on computer disks as they are created. Several levels of backup are desirable.

Here are some explanations and suggestions on the elements of the proposal.

5.3.1.BINDER, COVER, AND TITLE PAGE

A proposal of 20 to 30 pages should be spiral bound it so it does not fall apart while it is being read. An attractive cover and efficient binding put the reader in a good mood to review your proposal. To make a cover attractive, use colored paper and/or a background picture that is relevant to the project.

The title page is the first page of the document inside the cover. The information on the cover should be the same as that on the title page, as follows:

- client's name
- client’s project number, if any
- client's project title
- the engineering company’s name
- the engineering company’s project number
- the word that identifies this document, such as “Proposal” or “Design Report"
- the **date**.

Note: In some requests, the client is not identified, and a consultant is presenting the request. This is not unusual when a company wants to keep its expansion plans confidential. In those cases, read consultant for client, in the above.

The cover frequently has a picture overlay, indicative of the project to make the proposal attractive. Visual appeal makes the client receptive to reading the proposal with a positive attitude. Real world proposals frequently show the client’s logo and may even have binders and/or pages colored to match the client's colors.

5.3.2.TRANSMITTAL LETTER TO THE CLIENT

This letter is not usually bound in to the proposal; however, for this course, Client requests that you do so.

The contents of the transmittal letter can vary tremendously, depending on the client request and the preferences of the company writing the proposal. In its simplest form, it just tells what kind of document is being conveyed (e.g., proposal, progress report, design report), briefly describes the project being addressed, for proposals thanks the requesting company for being included in the bidding list, and gives a name, telephone number, and email address of an individual, usually the project manager, to contact if there are any questions.

Some request letters, however, request that the price be put in the letter and not in the body of the proposal. If you are the client, that gives you a way to keep the pricing information confidential. This is usually desirable for several reasons. First, it keeps the loose lips in the company from telling the bidders how they stand vis-à-vis one another. Industrial espionage is a thriving business. All managers have to decide when it is desirable to keep pricing information secret and how to do it. Second, it lets the management get a technical assessment of the bids from its engineers without the prejudicial information of which is the low bid. If the price is in the transmittal letter, then the validity statement should be in the letter also. The request for a proposal will tell the bidders if the pricing section is to go into the letter.

Some engineering companies write all of the business elements of simple proposals, such as our services proposal, entirely into the letter. They then append such elements as the organization chart and resumes that do not fit conveniently into the letter.

The proposal is a contract document. It is an offer to do a specified amount of work in a finite time period for a specified pricing arrangement. As such, a corporate officer who is authorized to commit the engineering company to do work of this order of magnitude must sign it. This is usually a vice president or higher. It is almost never the project manager unless the project is of sufficient magnitude that the project manager is a vice president.

5.3.3.EXECUTIVE SUMMARY

In a proposal the Executive Summary fulfills three purposes:

1. It gives some clue as to how the report is organized, including a list of the subsystems.
2. It summarizes the content of the proposal, including the problem statement and proposed solution.
3. It gives the time during which the work will be done and cost. In this case, the total real dollars you expect to spend.

In this case, it will be no more than one page in length. In the real world busy executives read the Executive Summary in order to decide if they want to read the entire document. It should, therefore, be brief but comprehensive.

5.3.4.CONFIDENTIALITY STATEMENT

This is a legal paragraph to protect the engineer and any licenser who has provided information contained in the proposal. The text, which should be used verbatim, explains the nature of the protection.

RESTRICTION ON DISCLOSURE OF INFORMATION

> The information provided in or for this proposal is the confidential, proprietary property of the Saluki Engineering Company of Carbondale, Illinois, USA. Such information may be used solely by the party to whom this proposal has been submitted by Saluki Engineering Company and solely for the purpose of evaluating this proposal. The submittal of this proposal confers no right in, or license to use, or right to disclose to others for any purpose, the subject matter, or such information and data, nor confers the right to reproduce, or offer such information for sale. All drawings, specifications, and other writings supplied with this proposal are to be returned to Saluki Engineering Company promptly upon request. The use of this information, other than for the purpose of evaluating this proposal, is subject to the terms of an agreement under which services are to be performed pursuant to this proposal.

This paragraph should be located on a separate page in the proposal, immediately following the abstract and preceding the table of contents.

5.3.5.TABLE OF CONTENTS

The table of contents should make it easy for the client to read the proposal and find the important pieces of information. All tables and drawings must be listed in the table of contents by drawing or table number, title, and page number.

Each of the items in the list in section 2.6 is a separate section, and the proposal is considered as a whole. As a concession to the fact that this is really a class, the initials of the author will follow these entries in the table of contents so that extra credit can be awarded appropriately if merited. The work in each report should be divided among the team members so that each member can have the opportunity to get some extra credit. Some items, like the cover letter, are not table of contents entries; these items should be listed at the end of the table of contents identifying the authors so they can receive credit. Initials will appear only in the final draft proposal that will be graded.

The table of contents will list each subsystem; the title of each subsystem will indicate its function in the project and will NOT contain the engineer's name. Engineers' names are never to appear in any table of contents or the title of any section. The names of these subsystems should be the same as the subsystem names on the block diagram.

5.3.6.INTRODUCTION

The two purposes of the introduction are to indicate that you understand the client's point of view and to provide a context for the proposal.

The introduction will indicate to the client that you understand why the project is wanted. Client almost certainly will have stated in the request what the reason is. Parrot it back to them. If you know other reasons why your proposal will be valuable to Client, include them here. Keep in mind that the people who are paying you for this project are looking for the overt benefit, a real reason to believe you, and the dramatic difference this project can make. They will be looking to make money selling the system you are proposing to design for them. Their customers will be asking, "What's in it for me?" "Why should I believe you?" and "Why should I care?"[1] Write this section as well as the rest of the proposal with the client's point of view in mind. You need to connect with them. Do not add a commercial. They know you are delighted to bid because you are doing so.

The introduction provides readers with general information that they need to understand the more detailed information in the rest of the report. It introduces the subject, the purpose, and the scope, and it gives the reader a clue as to how the rest of the proposal is organized.

5.3.7.ENGINEERING COMPANY EXPERIENCE AND QUALIFICATIONS/LITERATURE REVIEW

A real world engineering company will have paragraphs, which are stored on computer disks, that describe their qualifications and experience for every type of project that they have completed in the past. These paragraphs are updated and kept current with each project the company wins. In a commercial engineering contract, these are pasted into the current proposal. In a proposal where the company is proposing to do engineering research, they also need to show knowledge of the latest results produced by others in the field; i.e., they need to include a literature review. Proposals for graduate school theses and dissertations also need literature reviews that show that the researcher is familiar with current work in the area. Student engineers, having no record of accomplishment, will indicate their familiarity with the type of project by including a literature review.

The literature review describes (not just lists) what is known about the topic and has been published. The literature review does not tell what the design team has done or will do. Since everything covered is someone else's work, all of the information will have one or more references that are given in footnotes or endnotes, hereinafter called *Footnotes*. A list of references at the end is insufficient; the reader should be able to tell which information came from which reference in case more information is wanted. The engineering team should pick one style for the Footnotes and reference list; the whole team should use the same style, e.g., the American Psychological Association (APA) (2001) style or *The Chicago Manual of Style* (University of Chicago Press Staff, 2003) lists several acceptable styles. The style used in a real world proposal will be the style specified by the agency that requests the proposal; if no style is specified in the request for proposals, the style will be the one the engineering company prefers. SEC recommends the APA style.

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[1] Cass, Stephen, "The Idea Man," *IEEE Spectrum*, Vol. 43, No. 8, August 2006, pg 46, quoting Doug Hall

The literature review should have an introduction that tells what the review will be about and how the material relates to the project. The introduction orients the reader to how the content is organized. The introduction is not optional.

The team should provide a comprehensive literature review indicating what is known about projects of this type. The literature review will include descriptions of similar projects, devices, or systems that others have designed and which may be on the market. The literature review should cover the published performance and the features of these competing designs that can be compared to the team's design. This part of the literature review is not optional.

In addition to reviews of similar designs, literature reviews typically include, but are not limited to, the following types of literature:

- Relevant work which has never been applied to this type of project, but which you think might be used or adapted to advantage
- Relevant codes and standards
- Vendor data that indicates the components that are available in the market place
- Non-standard or unfamiliar design procedures.

The some of places where literature is to come from include, but is not limited to:

- Refereed journals
- Trade journals
- Code books
- Books of standards
- Design manuals
- Vendor catalogs and publications
- Web sites.

The literature review should have a conclusion that indicates how the material reviewed will impact the design of the project. The conclusion is not optional.

A literature review is NOT:

- an annotated bibliography that lists what each reference discusses;
- an introduction to why the project is important or needed, nor
- a discussion of what you are going to do.

5.3.8.BASIS OF DESIGN

The "basis of design" is a concept which beginning engineers find difficult to comprehend. The "basis of design" is a list of documents that the courts use if there is a contract dispute to determine who is in the right. When a contract is developed from a proposal, these listed items are included in a contract section, usually called "Contract Documents." This section will be headed with words that clearly indicate that the design will be based on the listed documents; the statement will also indicate which documents control if any of the documents contain conflicting requirements.

Since the Basis of Design is a legal portion of the contract, the engineering team must be sure to list all of the defining documents produced both by the client or client's consultants and by the engineering company. Each document must be dated; each attachment must be listed with its date. All relevant correspondence must be included. Both clients and engineers try to use this list to their advantage.

As a the minimum, a list should include the proposal request and the proposal itself and its attachments. Remember: if the engineering team has to re-quote, then the basis of design in the resubmitted proposal must be expanded to include such things as the client's letter of acceptance, the client's letter stipulating what changes are needed, and resubmitted proposal itself.

5.3.9. PROJECT DESCRIPTION

The Project Description is what the client requested to be built, installed, manufactured, or, in the case of a software project, coded. Many times what the client requested and what the engineer will give the client are the same. If, however, the description is too vague or the project as defined by the client is too big, then the proposal needs to state clearly what the engineer is proposing to provide. The client's, or consultant's, statement of what is wanted may be simplistic, such as, "Build the tallest office building in the world on my plot at Tenth and Main." Or it may reference a stack of detailed attachments that are to be the basis for the design. Or it may reference a licenser's design basis package. You may have to sign a "nondisclosure agreement" with the licenser – even to bid on the work.

The Project Description section of the proposal repeats the client's project definition statement. If the statement has given no real definition, it may be because the client wants to see what the engineering team will propose. For example the client may say, “I want a preliminary design of a dual fuel car – electricity plus X plus cost to get a prototype to market." The project description in the proposal may win or lose the job. The engineering team should talk to the client and their consultant as much as possible before bidding.

The biggest building proposal might include study of the setback law in effect at the site, and may suggest deviating from it by "buying" air space on adjacent property over 200 feet in the air. The proposal may suggest studying parking solutions or buying more land. These recommendations will only be made at the end of the study, but saying they will be explored may win the contract.

A request for a proposal for an Ethanol-from-Wood Plant might include extensive background information for the project. In this case, the engineering team would be able to list the process units as part of their proposal. Although a suggested process unit area layout might be included, the proposal might indicate the need for additional area for such items as effluent treatment and emergency power generation. In essence, the engineering team takes the client's definition, as far as it goes and adds additional definition that is needed to make the project complete and doable with given resources.

The basic rule is that the project description is about what will be built, installed, manufactured, or coded. It is NOT about what the engineers will do under this contract. **If the client does not define and limit the project, then the bidder must.**

In some cases where the client will give a relatively specific request and will request enough to keep twenty engineers busy for two years. This section will scope the work by describing the system that the four to six engineers available for eleven to twelve weeks of work will design. In the real world, of course, the engineering company would hire as many engineers as would be needed to do the project in the requested amount of time. As a concession to the fact that this is really a class, each engineer picks a portion of the project to design in an area of interest. The engineering team will estimate the other items required for the construction, installation, or manufacture of the design for costing and scheduling purposes. This section and the Work Scope section following should clearly indicate which parts of the project the team will design in detail and for which parts the team will estimate the cost and scheduling data.

Projects that involve the flow of something, e.g., process plants, power plants, and electronic build projects, will have a block diagram. This diagram will illustrate how the subsystems will fit together and which subsystems send materials or signals to which other subsystems. Some projects, such as power distribution studies, are better described with a site map. Architectural engineering projects, where the building itself is the purpose of the design, will not usually need a block diagram. If a block diagram or a site map can reasonably depict a project, the proposal will have one.

The Project Description should clearly indicate what the resulting device, system, or modification will do; in other words, the function it will perform for the client or the end user.

This section contains the deliverables list, i.e., a list of everything that you can now foresee putting into or accompanying the design specification report at the end of the project. Note: this will not be a “final” report; no engineering report is a final report. All engineering reports include an explicit or implied offer for a contract to do more work.

5.3.10.ENGINEER'S SCOPE OF WORK

This is where the engineering team defines what it will produce under this contract; i.e., this is an overview of the documents and prototypes that will be produced under this contract. A "design" is not a “thing” that can be delivered . What is delivered to the client under the contract are design *documents*, *prototypes,* and *working or non-working models.* In essence, during the design phase (next semester) you will prepare a design specification document together with a capital cost estimate and a schedule to construct, install, or manufacture. This section is for the list of documents and devices that your team will produce and deliver to the client, i.e., a deliverables list. This is a legal section of the proposal. Be as specific as you possibly can. For instance, instead of saying "Drawings," list the drawings: wiring diagram, logic diagram, layout, exploded assembly drawing, etc.

This is a list of every document the engineer is going to put in the design report, plus, if applicable, the working or non-working model. In short, this is a list of the actual objects the client can expect to get at the conclusion of the project. Be as specific as you possibly can. For instance, instead of saying "Drawings," list the drawings: wiring diagram, logic diagram, layout, exploded assembly drawing, etc. This is a legal section of the proposal; therefore, whatever else you may say, do NOT say words like "every" and "all." The purpose of this section is to *limit* the amount of work you do for the contract. Words like *all* leave you open to everything the owner can think of to keep you working for months of overtime for the profit on this one contract!

If the project is such that each engineer will be doing the same design activities and producing the same documents for different geographic parts of the design, then there should be only one deliverables list. If there is only one deliverables list, then there should be an accompanying list of the geographic subsystems to which it applies. If there is one general deliverables list and further deliverable items listed in the subsystem descriptions, then the general list should include words that indicate additional deliverables are listed in the subsystem descriptions.

Every document or other item listed should be the result of one or more design activities, and any design activity that does not result in a deliverable is wasting the client's money. Any listed deliverable that does not result form a listed design activity raises questions about the accuracy of the list.

5.3.10.1. *Design Activity List*

This is the only place in any document where the engineer gets to tell what he or she will do. This is a list of verbs since it is a list of what the engineer will do. Every activity on this list should lead to something that was described in the functional description; it should also result in something on the list of deliverables below. Conversely, everything described in the functional description should come from one or more activities listed here and every deliverable in the list below should be a product of one or more of these activities. These activities should also appear on the Action Item List. The proposal should be self-consistent.

If the project is such that each engineer will be doing the same design activities and producing the same documents for different geographic parts of the design, then there should be only one Design Activity list. If there is only one Design Activity List, then there should be an accompanying list of the geographic subsystems to which it applies.

5.3.10.2. *Subsystem Descriptions*

Each engineer will write the technical discussion(s) for his or her subsystem(s). The title of the subsystem discussion will reflect the function of the subsystem. The discussion will be a functional description of what the subsystem will do and a description of how it interfaces with the other subsystems.

If the project is organized geographically, the subsystem descriptions will be accompanied by a site plan or a building layout.

5.3.11. PRICE

5.3.11.1. *Types of Contract Pricing*

There are three common bases for engineering contract pricing. These are the cost-plus-fixed-fee contract, the lump-sum contract, and guaranteed-maximum contract.

5.3.11.1.1. The cost-plus-fixed-fee contract price

In a cost-plus-fixed-fee contract, the contractor is reimbursed at actual cost for specified items. The profit or fee is then usually calculated as a percentage of the total payroll cost; that is, estimated salaries plus payroll burdens, and stated as a fixed sum.

5.3.11.1.2. The lump-sum contract price

Under a lump sum contract, the contractor undertakes to do the defined work for a single, simply stated sum of money. If the client wants a change in the work scope, the client must pay the contractor additional moneys which are called "extras."

5.3.11.1.3. The guaranteed-maximum contract price

The guaranteed maximum contact is similar to the cost plus, except there is a fixed sum, which the contractor guarantees as the maximum cost of the project. Frequently, there is a sharing clause in the contract, so that the contractor has incentive to finish the work below the maximum. Sometimes there is a date at which the contractor will give the client a price to finish the work for a lump sum.

5.3.11.1.4. Advantages/disadvantages of each type of bid

Some points to be noted in regard to the three contract types include the following:

- The cost plus fixed fee is the quickest to bid and has the least risk for the contractor, but provides no incentive to the contractor to keep the cost down.
- The lump sum takes the longest to bid, because the contractor is taking all of the cost risk. Banks prefer the lump sum because they can see the cost and the financial projections, based on the cost and the guaranteed schedule, before they commit any money.
- The guaranteed maximum is a middle ground which shortens the bidding period, while still retaining some cost protection for the owner.

5.3.11.2. *Pricing Section Details for a Cost-Plus-Fixed-Fee Price*

The proposal or transmittal letter must make a written offer to do work. The "price" is the essential ingredient in engineering company's offer to perform the work. The proposal or transmittal letter must clearly say, "*Name of engineering company* hereby offers to perform the work, as defined in this proposal, for a cost-plus-fixed-fee price of *price in words*, $XX,X00." Put this sentence at the start of the price section. Then the items discussed below will follow. Round the price to three significant figures; since the engineering company will be reimbursed for the actual number of hours worked and the actual cost of some expenses, more accuracy that three significant figures cannot be justified.

In a cost-plus proposal, the engineer gives the client the following price related data:

- a set of rates the engineer will charge for the personnel,
- the salary burden on those rates,
- the corporate overhead charge,
- the contingency believed to be necessary based on the completeness of project definition,
- the items that are to be reimbursed at cost (like long distance telephone calls or parts for a prototype), and
- his desired fee.

When a project involves construction as well as design, procurement and supply of equipment, a complete cost summary sheet must be prepared. For a services only, cost-plus-fixed-fee contract the principal cost elements are payroll costs and overhead costs.

5.3.11.2.1. Overhead costs

Overhead costs are the contractor's non-directly billable costs of doing business such as: office rent, utilities, telephone, insurance, licenses, taxes, non-billable staff (this includes management, marketing, mailroom staff, cleaning and maintenance, staff, legal and accounting staff, and secretarial/clerical staff), travel, and reproduction. Overheads are usually are in the range of 80 to 100% of total labor cost in contracts of this type.

5.3.11.2.2. Payroll Costs

Because all costs are reimbursable, the client gets to see all payroll and material cost invoices. The project manager must produce these for the client at monthly intervals. The progress reports also let the client know whether the engineering team is on schedule; and, if not, their plan to catch up.

The proposal must contain backup data to let the client see how you built up your price. This must include: A payroll rate sheet showing the salaries of everyone proposed for the project, A payroll cost table showing hours promised from each person, the hourly rate charge and the total payroll cost.

There is an essential factor to define: the hourly charge basis. There are two common bases: calendar hours and worked hours.

The calendar-hours basis is determined by the number of hours the company works per week. If it is 40 hours, then the calendar hours/year is 40 x 52 = 2080 hours; and the calendar hour rate is the yearly rate divide by 2080. If this basis is used, then vacations, holidays, and sick leave must be included in the payroll burden, which is explained below.

The worked-hours basis is determined by subtracting the numbers of vacation, sick leave, and holiday hours in the year from 2080; and the worked hour rate is the yearly rate divide by the remainder. Commonly in the USA, two weeks vacation and the same for sick leave are used as averages, plus about ten holidays, which makes six weeks or 6 x 40 = 240 hours. The hours worked divisor is 2080 - 240 = 1840 hours worked per year. Using the lower divisor gives a higher hourly rate; however, the vacation, holiday and sick leave hours are not included in the payroll burden.

A proposal must clearly state which basis the pricing section uses: calendar hours or worked hours, and the vacation, holiday and sick leave hours will appear in the appropriate place (but not both!).

Here is an explanation of the term “payroll burden.” Every company in the USA, and companies in most foreign countries as well, must pay certain sums to the governments of the country, state, and even city in which they are located to pay for social charges and insurance. These are levied on an hourly basis and are collectively referred to as “payroll burden." These are all part of an employer's cost of doing business, and, therefore, the engineering company must be able to charge these costs to the client on a job.

The four personnel cost related insurance burden items are:

Federal Insurance Contributions Act (FICA)
State Unemployment Insurance
Federal Unemployment Insurance
Workman's Compensation Insurance (for injuries)

Other payroll related burdens are benefits, given by the company to the employees, such as life insurance, medical and dental insurance, and pensions. When the company bills on a calendar-hour basis, the burden includes vacation, sick leave and holiday charges also.

A typical statement defining a company's payroll burden, in terms of a percent of payroll cost, is given below. The company worked on a calendar-hour charge basis (they included vacations, holidays and sick leave in their fringe benefits). The actual percentages vary not only by state, but also by the job classification of the worker.

PAYROLL BURDEN AND FRINGE BENEFIT STATEMENT

Federal Contributions Insurance Act (FICA)	7.65%	
Federal Unemployment Compensation	3.65%	
State Unemployment Compensation	3.65%	
Workman's Compensation Insurance (Injuries)	1.85%	
Total Personnel Insurance		16.80%
Paid holidays, vacation, and sick leave	11.55% (note: this assumes a calendar hour basis)	
Other benefits - pension, medical and dental insurance, AD & D insurance, etc.	13.20%	
Total Personnel Benefits		24.75%
Total Payroll burden and fringes		41.55%

A cost-plus-fixed-fee contract must have a table of payroll burden items in the proposal that shows the percent each item is of direct payroll. In a cost-plus-fixed-fee contract based on hours worked, the payroll burden today is about 30% of payroll. The four insurances amount to roughly 16.80%, or slightly more than half; this will vary from state to state and from discipline to discipline.

About 40% of "direct payroll," on an hours worked basis, was a common fringe rate in the 1960's. Today, it is more likely to be in the 30% range, with employees being given a choice of benefits and pension options for which the company will pay. Some companies give the employee the option of paying for additional benefits at the corporate rate. The reduction in fringe benefits is the result of market pressure on the price, in $/hour of engineering.

The vacation, holiday and sick leave percent was derived by assuming 10 days of holiday, 10 days of sick leave and 10 days of vacation, a total of 30 days, or 30 times 8 = 240 hours, per year. The annual office-hour total was taken as 52 weeks times 40 hours per week or 2080 calendar office hours per year. The percent was then taken as 240 divided by 2080 which equals 11.55 percent.

Following the payroll burden table will be a statement of the total labor cost which consists of payroll cost plus payroll burden cost.

5.3.11.2.3.Contingency Cost

Contingency is a real cost that compensates for all of the minor costs not listed at this time. Five to ten percent of total labor cost is a reasonable range. Examples of these costs are builder's "all risk" insurance, public liability insurance, and local or state business taxes required just for the job being quoted on.

5.3.11.2.4. Estimated Reimbursable Items

The pricing section contains a list of items for which the engineer will be reimbursed at actual cost. This will include such items as soil borings, parts for a working model, travel for site visits, and long distance phone calls. Travel items should list the number of engineers, destination, mode of travel, length of stay, and purpose of the trip. These costs will be billed for the actual costs; they are not a percent of total labor cost.

5.3.11.2.5.Fee

Profit percent is a management decision. Profit is usually a large percent of a small contract–perhaps 20% of total labor cost in the size contract we are dealing with this term. If the shop is empty of work, an engineering company may even take a job at no profit to keep staff on a paid basis and available for profitable work in the future.

List all costs in a pricing summary table. Those costs, which are a percent of total labor cost, should show the percentage and indicate of what it is a percentage.

5.3.11.2.6. Payment Schedule

An important corollary to the price is the "payment schedule." In a project of six months or longer, monthly payments are usual. For a shorter period, three payments are common: a down payment of about 25% on contract signing; a payment of 30 to 35% at the midpoint, time-wise; and a third payment of 30 to 35% upon presentation of the design report. This will leave the client with a 10% "retention" of the moneys owed. The client will pay that upon acceptance of the design report. This is the client's way of retaining control and seeing that the engineer does what was promised.

The cost of the time spent preparing the proposal is not included in the price for doing the project although it may cost almost 15% as much as the paid work. This is included in the marketing costs as a part of overhead; a company cannot afford to bid projects on which it stands little chance of getting the award.

5.3.11.3. *Price Section for SEC Proposals*

In real world proposals, all of the above sections are included; however, in many companies the engineering staff only contributes the number of hours required for the personnel and the financial department fills in the cost data related to payroll and overhead.

Since SEC proposals do not have personnel costs associated with the engineering, SEC proposals will contain a Resources Needed section. This section will contain a list of all resources the team can now anticipate needing during the execution of the project, including computer access and any specialized software packages. In this list resources will be listed with a dollar amount if they have to be purchased, a location an name of person responsible if they have to be borrowed, or denoted as on hand if the team already has secured possession of the resource. A total for the dollar amounts will be listed both in the Resources Needed section and in the Executive Summary.

A comment on academe vs. workplace: The commercial proposal contains the financial information required for the commercial client to make a decision on the proposal. The SEC proposal contains the information the course instructors, faculty technical advisors, and real world clients (if any) need to make decisions and preparation for phase two of the work, i.e., next semester.

A sample table is below:

RESOURCES NEEDED

Item	Description	Quantity	$ each	$	Subtotal
1	Microphone	1	2	4.00	
2	Switches	6	On hand	0.00	
3	2-line LED display	1	15	15.00	
	USER INTERFACE SUBSYSTEM				19.00
4	Special sensors	2	Borrowed [1]	0.00	
5	8086 microprocessor	1	On hand	0.00	
6	A/D chips	4	4	16.00	
7	Standard resistors	-	On hand	0.00	
8	PCB for antenna	1 sq ft	On hand	0.00	
9	PCB etching supplies	-	On hand	0.00	
10	Antenna transfer software	1	On hand	0.00	
	COMMUNICATIONS SUBSYSTEM				16.00
11	X-band transceivers	4	10	40.00	
12	Computer	1	On hand	0.00	
13	MS Office on computer	1	On hand	0.00	
14	Matlab on computer	1	On hand	0.00	
15	Printer attached to computer	1	On hand	0.00	
16	Data acquisition card	1	Borrowed [2]	0.00	
	DATA ACQUISITION SUBSYSTEM				40.00
17	CONTINGENCY				20.00
	Total new dollars needed				**95.00**

[1] To be borrowed from Professor I V Gotstuff
[2] To be borrowed from ECE Electronics Lab

5.3.11.4. *Validity statement*

This is a legal paragraph in the proposal to protect the contractor against the client unduly delaying the award of work. The engineering company is making an offer to supply certain people who are well-qualified to do the work. While the offer is pending, these people must be kept available and cannot be assigned to another job. In addition, if the offer has no time limit, the salary levels of some personnel, or other costs, could rise before the work is awarded. Since this is a legal element of the contract, it is a good idea to use court-tested words such as the following wording:

> Saluki Engineering Company's proposal is valid for a period of thirty (30) days from the date of submittal. After this time, we reserve the right to review the content to determine if any modifications are necessary.

Note that the paragraph is polite and indicates that if the client cannot make a decision within 30 days, the engineering company will be willing to talk about any action they need take. This leaves the door open for a successful contract closing discussion.

This paragraph will be in the cover letter if the cover letter contains the price. If the price is in the body of the proposal, it should be the paragraph following the price and payment schedule.

In SEC proposals requesting real dollars, this paragraph will follow the Resources Needed statement.

5.3.12.ORGANIZATION CHART

Each engineer should have a block in which his or her name, discipline (CpE, EE, ME) is shown, as well as his or her principal responsibility. Reporting lines to the project manager should be shown. The chart should have a table number. The page should have the engineering company's name, the the consultant's project number (if any), the engineering company's project number, and the date. The words or phrases used for the principal responsibilities will match at least one of the names of the subsystem blocks on the block diagram, subsystem sections in the proposal, and the design items in the Responsibility-Approval-Support-Information (RASI) chart described below.

5.3.13. RASI CHART

The RASI chart will show the principal design items and indicate who is responsible for each, who will provide support, who needs to give approval, and who will provide or be given information. See Chapter 3 for more information.

5.3.14.TIMELINE

All proposals include a timeline for the work that is proposed; this includes not only the SEC proposal and commercial proposals, but also proposal submitted in graduate school for the thesis and dissertation and proposals submitted to government and other funding agencies to perform research.

The included timeline work schedule will show all the important activities and milestones required by the project. For an example milestone, all SEC projects that include a prototype will have the device wired together and tested as a whole, with the software, at least once by the end of the eighth week. This means that each subsystem will have to have been built, tested, and debugged before then. Individual timeline work schedules may be required. Each engineer should plan to work an average of ten hours per week on this project.

5.3.14.1.*Work Schedule versus Construction Schedule*

This section discusses two completely different types of schedule: work schedule and construction schedule. The term "work schedule" will apply to the schedule that the engineer will follow during the fifteen-week design-documentation phase of the project in order to design the facility, modification, or product that the client requested (your next term's work) and provide the required documentation of your design work. The term "construction schedule" will apply to the schedule that will be followed to actually manufacture, install, or construct the device, system modifications, or physical facilities. The engineer that the client hires for the next phase will follow this schedule if approval of the work is given after review of the Design Report. A work schedule goes in the proposal submitted at the end of this term and **you** will use it during the design period after acceptance of the proposal (next term). A construction schedule is determined during the design period and goes in the Design Report submitted to the client at the conclusion of the design period. The work schedule will include time for the engineering team to assemble the construction schedule. Graduate school proposals generally do not need a constructions schedule.

Production of a project work schedule requires an analysis of the project work-element sequence. In a real engineering company, the project manager assembles the staff required to make the proposal requested by the client. In student engineering teams, the number of personal is fixed and the problem must be scoped to fit. See Section 3.10.

For projects with working models, "design-build" projects, what can be physically built by the team with the allotted budget determines the scope. The Conclusions and Recommendations section of the Design Report discusses additional features for which there is no time, personnel, or money.

For paper and pencil projects, "design-study" projects, the amount of work that can reasonably be accomplished in the fixed design period with the fixed number of personnel determines the scope. The client usually requests a capital cost and construction, installation, or manufacturing schedule for the whole project. Therefore, each engineer will choose a portion of the design to design in detail. The team will apportion remainder of the project among themselves, and during the design phase (next term)they will then make an estimate of the cost and schedule for these portions that were not designed in detail. The proposal will clearly indicate which elements will have a detailed design, which elements will have an estimate, and which engineer will be responsible for each element. The schedule will clearly show that the team has scheduled time to make these estimates.

All engineers do their work in the same sequence:

- defining and obtaining basic design data,
- engineering, designing and preparing drawings and equipment lists and specifications,
- talking to vendors and/or using vendors' catalogs or Sweet's Catalog in the resource center, and getting prices for their list of equipment and/or materials, as well as schedules for delivery from the date that an order is placed.

Each engineer will list each of his or her work elements in the left-hand column of the schedule. The schedule should be simple enough so that it fits on one schedule page. The project is principally design. The schedule should reflect that by having the bulk of the person-hours scheduled and the bulk of the activity entries allotted to design activities.

The first activity is getting basic data. Every engineer needs to do this first. Each engineer will list in the design notebook all of the basic data needed. Opposite each item on the list will be the data if it is known; if not, the place or person where it can be acquired together with how many hours it will take to do so. The team members should check their individual lists together to eliminate duplication. If "Joe" will get data you need, say so in your list. The needed data is determined by asking questions. What do you know? What are you given? What do you need to produce? For example, the client has asked for a technical specification, a capital cost estimate, and a construction schedule. What do you need to know to begin each request? What will be needed to satisfy each request? Since this a contract document, the engineering company's goal is to say what it will do and so limit its liability.

For example in a design-study, a project may have a hotel. Hotels need elevators, escalators, stairs and garages, to mention a few elements. Someone must determine the people flow, 24 hours per day.□ This data is needed by the civil engineers for laying out the public areas in buildings, roads and parking areas; the mechanical engineers doing HVAC and determining the elevator and escalator quantities and location; and the electrical engineers locating motors, lights, transformers and communication equipment.

□ A people flow is determined by asking questions such as: When do guests come? dining room clientele? convention meeting groups? How many people will want to use the elevators at rush hours? What are the rush hours? How many floors should each bank of elevators serve? How many people per minute will one elevator serve? How many cars will the guests, want to park? How many extra visitor spaces? How many tour or convention busses? Will you have to handle? How do you make parking areas safe? How many staff members will want to park their cars? Do the shifts overlap?

In a design-build project, the team will decide any design components or technique not specified by the client. Because procurement difficulties are the primary cause for delays, the team needs to do enough design work during the proposal phase (this term) that the team can identify and order any unique, unusual, non-standard, or critical components before the team leaves for break. The team will have one designee to maintain contact with departmental purchasing to determine that the parts do arrive, that they are the correct parts, and that the purchasing agent orders substitute parts for parts that are unavailable, or have unacceptably long backorder times.

In their design notebooks, all engineers will scope their eleven to twelve-week design effort. Approximately ten hours per week is appropriate. The team divides the work into work elements, or activities, for the schedule. Engineers then determine which activity will develop data for another activity; the two activities so related may be on schedules for different engineers.

For example in a design-study project, some of the components of a high rise building were discussed above as well as the need to make a people flow count to establish design bases for elevators, power demand, parking spaces, etc. Engineers should be sure that the necessary design data is available before a work element is scheduled. In a design-build project, the engineer responsible for the software will need to know how the hardware engineer will wire microprocessor in order to determine the Input/Output and memory addresses.

The progress report and design report will take time, and the client will expect to pay. For each engineer it will take about two hours for the progress report, during the week preceding the submittal date, and at least fifteen hours for the design report during the last three weeks in order to get it right.

The design report represents approximately 65 per cent of the grade for the second semester. There will be no design hours scheduled during the last three weeks before the report is due. The team will schedule and complete all design work by the end of week twelve.

Then comes the final puzzle: Putting a capital cost estimate and a construction schedule together. It is recommended that the last weeks (13, 14, and 15 of the fifteen-week design period) be left for:

1. developing the schedule from the component schedules,
2. putting the global cost together from the component prices that each team member has obtained, and
3. for writing and assembling the final technical report.

One engineer in each team will do the final overall capital cost estimate, and a different team member will do the overall construction schedule. But every team member will be responsible for the backup cost data and the backup schedule data relating to his or her design items. Individual schedules should clearly show who will be responsible for the overall items (capital cost and construction schedule) for the team.

Whether or not an engineer does the overall construction schedule or capital cost summary document, backup input will be required from him or her. The schedule should show time for the required effort on separate work lines. The overall items usually are done principally in the fourteenth week of the design period. Vendor contacting to get prices and delivery terms must be completed before that.

5.3.14.2. *Establishing the Work Schedule*

After the team scopes the project, the next step is for the team members to write down in their design notebooks all of the activities that they can now foresee being required to complete the project. In order to do this, start with the last activity: Turn in the design report. Then work backwards: What needs to be in the design report? For each of these items what needs to be done before it is complete? Keep asking that question until the answer is, "Nothing, I could start now."

Next sequence the activities; for each activity ask, "What must be done before this activity can be started?" At that point, there will be some activities that have a definite sequence and some that could be performed in parallel, or in serial in any order. By this time, each team member should have his or her own subsystem(s) and be able to see where the related activities fit within the framework of the whole project.

The next step is to prioritize. Which activities are the ones that will have the greatest impact on the success of the project if they are completed? … that will cause failure if they are not completed? These are the A-list activities. Which are the ones that should be done, but will have only mild consequences if they are not? These are the B-list activities. Which ones would be nice to do, but have no real consequences if they remain un-done? These are the C-list activities – the bells and whistles the team can add if there is time. The team should apportion the A- and B- list activities approximately equally among the team members so that everyone has a chance at a good grade. As a minimum, the A- and B-list activities for each of the team members should appear on the timeline. For more about the ABCDE classification scheme see Tracy (2006)

5.3.15.ACTION ITEM LIST

The proposal will contain an action item list for the work of the design phase (next semester). This will be very detailed for the first two weeks and more general thereafter. See Chapter 3 for more information on action item lists.

5.3.16.CONCLUSION

The purpose of the last paragraph of the proposal is to summarize the proposed work and repeat to the client the statement, also contained in the cover letter, that SEC is pleased to have been included in the list of bidders for this work. The summary should repeat the overall functional description, the total real dollar cost from the Resources Needed statement, the total time of the contract, and highlight any special features of your design.

The project manager's name, telephone number, and email address should be given with a statement that s/he will be glad to answer any questions and explain any portions of the proposal. Since this is a contract document, it would ordinarily contain the signature of a vice president, or higher, i.e., someone with fiscal responsibility high enough to be legally able to commit the resources of the company. Unless the project is unusually large, the Project Manager is not usually a vice president. However, in the case of SEC proposals, the signature of the project manager is acceptable.

5.3.17.APPENDIX: PERSONNEL RESUMES

The purpose of a resume is to show the client the experience each team member has had on the type of project being undertaken. In a real engineering company the computer data bank will have experience cross-filed by type of project. This gives the project manager a list of employees from which to pick for the team. It also lets the computer print out resumes that highlight the significant experience references for each nominee.

Since student engineers have no track record, for the most part, they include the resume they will be using to find a job at the end of the term. This has an added bonus: the student engineers get a resume, reviewed by the faculty, to use for job hunting.

5.4. WRITING FOR THE CORPORATE WORLD

In academe, writing is expected to be varied, interesting, and appropriate for the context. In the corporate world cost and efficiency are paramount. Efficiency includes the speed at which a document can be produced, the speed with which it can negotiate the formidable approval process, and the likelihood that it will be successful in winning more work for the engineering company. This emphasis results in most documents being copied from previous similar documents. This is good in that the previous documents have already been through the formidable approval process. On the other hand, a more original proposal may be more likely to catch the eye of the client and have a better chance of winning the contract.

Another difference is that the corporate editors and those that must approve documents in the corporate world are more stringent with regard to grammatical rules. Part of the reason for this is that the purposes of grammatical rules are clarity of expression and reduction of misunderstanding. Since proposals and design specifications are legal documents, it is necessary that all parties clearly understand them in the same way.

5.4.1. SALUKI ENGINEERING COMPANY STYLE GUIDE

This style guide is a checklist of the problems most frequently encountered in documents submitted to management. Please use the following list before submitting any document to SEC management.

1. Just describe the system; do not use first person or people's names. Refer to a team-member's section by the section title, i.e., principal responsibility.
2. Write your discussion as a description of what the client is going to get if your system is implemented.
3. Present calculation results in tables; do not include calculations or refer to design notebooks.
4. Describe the results of your design efforts; do not write a how-to-design-it manual.
5. Use present tense to describe existing conditions
6. Using future tense to describe proposed systems.
7. Make a list look like a list; do not write a list as a paragraph. Use a numbered list if the items will be referenced or the order is important; otherwise, use either numbers or bullets.
8. Avoid contractions; i.e., use "do not" instead of "don't."
9. "Its" is the 3rd person, neuter, possessive pronoun; use "it is" instead of "it's."
10. Say, "The project has …." Do NOT say, "The project was broken into …" or "The project was divided into…." If the project is broken or divided, the client does not want it; the client wants a whole, integrated project.
11. Define all abbreviations either at their first appearance or in a list of definitions before the text except
    - commonly accepted abbreviations, such as i.e. and e.g.
    - numbers with common units, such as 69 kV and 420 ft-lb.

    When in doubt, spell it out.
12. Numbers with units have:
    - one space between the number and the units if the quantity stands alone
    - a hyphen between the number and the units if the quantity is used as an ajective
    - the spelled-out units in lower case
    - the abbreviated units in upper case IF they are derived from a person's name
    - abbreviated prefixes less than 1 in lower case: cm – centimeters, dl – deciliters
    - abbreviated prefixes greater than 1 in upper case, except k- for kilo-:
      Dl – decaliters, MΩ – megohm, km – kilometer

- examples:

–A distance of 10 km or a distance of 10 kilometers
–A 300-cm board or a 300-centimeter board
–The motor requires 24 V or the motor requires 24 volts
–A 24-V motor or a 24-volt motor
–A carrier wave of 3 GHz or a carrier wave of 3 gigahertz
–A pressure of 2.5 kPa or a pressure of 2.5 kilopascals
–The resistance is 12 MW or a 12-megohm resistor

13. Check your work for
–complete sentences
–subject-verb agreement
–pronoun-antecedent agreement
–spelling.

14. Tables:
–Give tables unique table numbers and unique titles.
–Put the table number and title at the top of the table.
–Discuss the significance of each table in the system description.
–Refer to tables by table number.

15. Figures:
–Give figures unique figure numbers and unique titles.
–Put the figure number and title at the bottom of the figure.
–Discuss the significance of each figure in the system description.
–Refer to figures by figure number.

16. Engineering Drawings:
–Give drawings unique drawing numbers and unique titles.
–Put the drawing number and title in the title block
–Put the title block in the lower right hand corner
–Discuss the significance of each drawing in the system description.
–Refer to drawings by drawing number.
–Put drawings at the end of the discussion section where they are described
–Fold drawings to 8 ½ x 11 with the title block and page number visible

17. Use active voice; avoid passive voice.
18. Use parallel structure to present parallel ideas; concepts in a list joined by *and* or *or* should all be the same part of speech: nouns, gerunds, prepositional phrases, or whatever.
19. Read your work to see if it makes sense. If in doubt, read it into a tape recorder and listen to the playback. Have someone else read it.
20. Discuss all options considered and use numeric comparisons to justify your choice. Do not use non-engineering terminology (bigger, smaller, cheaper, more reliable, faster, etc.) without numeric comparison.
21. Discuss the limitations of the design and possible improvements in a section entitled "Conclusions and Recommendations." Write what needs to be done before it is implemented and how it could be improved. Do NOT include any excuses. Do NOT write one word about what was not done.
22. Bind landscape documents at the top.
23. Check document clarity for
–precision in word usage; is the meaning of each word clear?
–document accessibility; are there enough headings and subheadings that people can find what they are looking for?
–corporate language: is it used and used correctly for your company?

24. Be

–correct grammatically and technically
–clear enough that you cannot be misunderstood
–consistent in style, content, and terminology
–complete so that the reader has all the information needed
–concise: use as few words as possible while being consistent with these requirements.

5.4.2.REPORT ORGANIZATION

Most entry-level engineers have not had to give much thought to report organization. Either the required organization was give to them, or organization was of at most secondary importance. The writers should identify, and continually remind themselves of, the thesis. In other words, what is it about? Just as important is creating a narrative structure that helps get the point across while keeping the reader or listener engaged. Report organization affects the efficiency by which the reader can comprehend a report. In the corporate world, this efficiency is paramount and can make the difference between having work and not getting the contract.

Moving through a report should be like strolling through hilly terrain. At the hill peaks, the writer introduces the readers to the 'bigger picture' with more general, abstract words. Then the writer descends the hill from these heights of generality to the examples and details down in the valleys. Here the writer explains in concrete terms the meaning of the lofty claims and show them in action. Eventually, the writer takes the reader back up again so that readers can see the examples in their context, that is, what they mean to the bigger picture. This is how reports should flow: up and down and up again. If, on the other hand, the valleys mutate into vast prairies, readers begin to lose a sense of the original general assertions. Or, if the peaks become heady plateaus, the readers will get dizzy from the high altitude and dismiss the report as being all fluff. Therefore, the writer must always achieve a sense of balance between the general and the particular. (The Purdue Writing Center, 2006) The list of elements in an SEC proposal shows such an organization. However, in this class, like in the commercial world, one size does not fit all. It is the responsibility of the team to organize the report not only to be sure that the required elements are present, but also that the report flows in a way that promotes fast, efficient reading without misunderstandings. For instance, the report should present the need for the inputs to the system before the details of the system input mechanism. In order to determine if the report organization is good, the team can have someone not on the team read it. In addition, for SEC proposals, it is a good idea to submit the report early and make mistakes for free rather than spending final exam week making corrections for partial credit.

5.4.3.COLLABORATIVE WRITING

Since teams execute most projects in the corporate world, the documentation is also. There are three ways that teams can be organized: Parallel, Serial, and Stratified.

5.4.3.1.*Parallel Organization*

In parallel organization, each team member is assigned a portion of the document to write, and that team member does all the work for the assigned part: research, outline, draft, revise, edit, type, and proofread. This type of organization results in mediocre reports with inconsistent style and quality. For instance one part may be well organized but poorly edited; a second, long and dull; a third, well crafted but incomplete; another, complete and concise, but pompous. There is considerable duplication of material, and illustrations will vary from too many to insufficient.

5.4.3.2. *Serial Organization*

In serial organization, all of the team members do all of the activities as before, only in this organization one team member writes what he/she thinks is the complete document and then passes it to the next person, and so on until everyone has made revisions. Usually this goes through several iterations with each one changing what the others have done. This process results in a better, less piecemeal report. However, it is Justas time consuming and inefficient. Moreover, it usually results in the team members not speaking to each other.

5.4.3.3. *Stratified Organization*

In this organization, each team member has a function to perform based on his or her skills. Usually this will result in the best document with the least amount of pain, but it is the most difficult to organize effectively.

As a concession to the fact that this is really a class, if a team uses this organization to get the document written, the document will contain a statement in the acknowledgements section that lists and explains what each team member's contribution was.

5.4.3.3.1. Manager

The manager organizes the document, assigns responsibilities, checks up to see that each member is doing his or her work on time, and is generally accountable for the document being high quality and finished on time. This person needs to be able to see the big picture; and to have effective people, organizational, and managerial skills.

5.4.3.3.2. Data Gatherer

The data gatherer assembles the information that needs to go into the report, writes notes, and documents the source of all data. This person needs to be knowledgeable in the subject matter, thorough, accurate, and careful in documenting sources.

5.4.3.3.3. Writer

The writer is responsible for quickly generating a first draft from the data and notes of the data gatherer and following the organization of the manager. This person needs to like to write, have empathy with the reader, and be able to compose rapidly.

5.4.3.3.4. Editor

The editor checks the copy for consistency, writing mechanics, and word usage. The editor fixes minor problems and negotiates major problems with the writer. The editor converts a good document into an excellent one. This person needs to have extreme politeness, a good foundation in grammar, writing mechanics, word usage, and writing style and to pay attention to detail.

5.4.3.3.5. Graphics Editor

The graphics editor is responsible for engineering drawings, figures, tables, photographs, and charts. The graphics editor or other team members under his or her direction either create these items. The graphics editor is also responsible for the font, layout, headings, spacing, and incorporating the graphics items into the document. This person needs a strong artistic sense, a thorough knowledge of publishing techniques, and strong computer skills.

5.5. **REAL WORLD PROPOSAL PREPARATION SCOPE**

In the real world, which senior engineering students are about to enter, preparation of proposals and the decision to participate in competitive tender of proposals, is the life blood of engineering companies. The remainder of this chapter discusses a real engineering company's marketing and business activities.

5.5.1. THE COMPLETE ENGINEERING COMPANY PROPOSAL

A Complete Commercial Proposal has three sections: technical, commercial and management.

5.5.1.1. *The Technical Section*

In broadest outline, the technical section describes what the owner wants done and what the engineer will do to achieve the owner's goals. The owners definition may be simple, for instance, "I want a 100 megawatt, wood-fired power plant." The engineer will then have to define what the design will provide, in terms services and equipment, such as boiler plants, turbines, substation equipment, buildings, etc.

The engineer will also be expected to give a schedule for designing and building the facility in the proposal. Frequently, the owners will have their own or a hired engineering company prepare a preliminary design as the basis for the proposal. The proposal may also be based on a patented, licensed process, in which case the licenser will provide a design definition to be included in the proposal request.

5.5.1.2. *The Commercial Section*

The engineer will have to tell the owner the charges to do the work defined by the owner's request for proposal, which is commonly referred to as an "RFP." The engineer's offer, or price to do the work, is in the commercial section of the proposal. The commercial section also has a payment schedule, guarantees and warranties the engineer, licenser and equipment suppliers will make, a contract, full details of insurance coverage during construction, and a validity statement which limits the time the contractor or bidder gives the owner to consider and accept the contractors offer.

5.5.1.3. *The Management Section*

The Management section of the proposal contains data on the contracting company: its annual report, corporate organization, banking references, bonding capacity, current workload, availability of needed staff, resumes of the principal staff being offered which show their experience on similar successfully completed projects, and a project plan to do the work. This plan usually contains examples of all key corporate procedures for cost control, planning and scheduling, risk analysis, procurement, project management and site management.

5.5.2.TYPICAL COMMERCIAL PROPOSAL CHECKLIST

The reader will notice, by comparing the outline below with the one in Section 2.7, that the services only proposal, while not in full commercial detail, does contain the key elements of all three commercial proposal categories.

1. Cover Page
2. Table of Content
3. Proposal Letter (may be separate especially if it contains all commercial terms. Engineers usually see only technical-unpriced-proposal)
4. Technical Checklist (all items not in every proposal)

- Purpose
- Scope of work definition
    - Description of what is being built
    - Sizes
    - Plot plan or other defining drawings
    - Equipment list, data sheets, specifications
    - Line list
    - Industry standards & general specifications
      (not included - defined by reference, i.e. - client's stds/specs or engineer's stds/specs)
    - Special job conditions
    - Site checklist including soil bearing; utility specs(source, quantity available): air, water, steam, electricity, inert gas, C02, fuel, fire protection; EPA requirements: air and water quality, effluent treatment, impact study, etc.
    - Specific drawings:
      Process flow sheets equipment/bldg layout piping & instrumentation, electrical single line control system, instrument list & data sheets, utility system drawings, layout, equipment details/specs
    - Auxiliary system definition

      Storage
      Roads
      Fencing/Security system,
      Special bldgs: i.e. guard house
      Fire protection
      Commissary, Medical (Frequently included in a multipurpose administration bldg)
      Cooling tower
      Steam/Power plants
      Effluent treating
      Water storage

      If very detailed:

      Vendors lists
      Material suppliers lists
      Subcontractors lists
      and even quotations, bid comparisons, equipment selection
    - Project execution schedule

      Detail dependent upon type of proposal

5. Commercial Checklist
    - Proposal letter (may contain all other commercial items)
    - Scope definition (may *be* by references to technical part of proposal)
    - Basis of design - list of all defining document - owners request to bid & explanatory letters & technical definition; defining correspondence; your definition documents.

      <u>IMPORTANT</u> State what is the order in which documents control conflicting statements.
    - Price plus t price list for alternates
    - Payment schedule/Terms of payment
    - Contract terms (detailed list in other text) or list of exceptions to contract offered by client
    - Guarantees/Warranties

- Commercial definitions (need for these depends on type of contract and wording of contract clauses)
- Revolving fund terms
- Progress payment milestones
- Basis of reimbursement
    - Overheads
    - Fringes
    - Salary Schedule
- Checklist of reimbursable and feeable items
- Insurance
- Validity

6. Management Data Checklist
    - Corporate identification/Qualification
    - Annual report
    - Qualifications for the project - List of completed projects
    - Corporate organization charts
    - Resume's of key staff - Bank references
    - Bonding capability
    - Project plan
    - Project team
    - Corporate procedures (a brief but definitive explanation of many project management procedures is now required by major clients in all proposals including

        Project management
        Planning & scheduling
        Cost control
        Quality control
        Risk analysis
        Procurement, Expediting, Inspecting
        Shipping/Receiving
        Site labor management
        Expatriate policy (especially if more than one nationality will be on site in management team)
        Project procedure manual
    - Current/Projected workload
    - Adequacy of office(s) to do the job
    - Availability of key people & staff
    - Conflicts of interest

5.5.3. PROPOSALS – A PART OF MARKETING ACTIVITY

A proposal is one element in the marketing activity of the engineering company. It may be external which means the proposal is made to an outside company. Or it may be an internal exercise as part of the annual budgeting cycle of your company, in which case it helps management decide between alternate capital projects all competing for your company's available capital expenditure dollars.

Marketing, or sales activity, on a proposal begins when the project is identified. This is usually the result of a salesman making customary calls on the client list to identify new work opportunities for the company. When s/he identifies a project, s/he prepares a screening report so management can decide whether or not to pursue the opportunity.

The proposal request may also originate from an internal decision to undertake a new activity within the company.

The screening document, either by itself, or together with an executive summary, if enough data is available to prepare one, is the basis on which a decision is made on whether it should be added to the prospective work list. Of course, internal requests are mandatory.

5.5.4.THE SALES CAPTURE FORECAST

When a company decides to follow the prospective work, it is given a file number and entered on the sales capture forecast. Two probabilities are a key components in a company's staff and profitability forecasting. The two factors are: the probability that the identified project will go ahead on the forecast schedule, if, in fact, ever; and the probability that this work will be awarded to the company. Both man-hours and profit are factored from these two probability estimates, and the profit per man-hour is calculated. This has two purposes.

First, the management knows about what the company's current profit per man-hour is running. So, if this number is very different, it may be either wrong or too low to make the prospective contract desirable to try to win.

And second, the sum of the predicted workload and predicted profit is management's picture of the future of the company. If there is not enough work or profit, management has to take urgent action to get more work or cut operating costs. If there is too much work for the existing staff, then management has to consider whether to try overtime or whether to add staff. The forecast also tells management when the decisions have to be made.

5.6. **THE ORAL PRESENTATION**

The oral proposal presentation gives the engineering team an opportunity to meet with the management team. In US companies today it is less likely that there are engineers on the management team than in foreign companies, especially Japanese companies. Since the management team will make the go/no-go decision, it is important that engineers be able to communicate their ideas and plans to these non-technical personnel. Indeed, even if the management team does consist of engineers, it is unlikely that they will be from your particular discipline or versed in the particular details of your discipline needed for this project. Management will have their own engineering staff review the technical portion of your proposal.

The thrust of the presentation is to show management what they will get (from their point of view) if they hire you to do what you are proposing. They will be looking at the proposed design from the point of view of "Can we make money with this?" Consequently, the presentation should emphasize what the design will do or be. Management will also be looking your team over to see whether you work together well and if there is a reasonable probability that you will be able to get the job finished on time and within budget. Therefore, your presentation should be organized to make a complete, logical plan.

Most of the formal presentations that you make should be extemporaneous. That is, they should be unscripted, given in your own words from an outline. This does not mean that they should be impromptu! They must be practiced so that they fit into the period given.

The only times you should ever be giving a scripted presentation is when you are discussing legal issues and are reading the words that have been approved by the legal department or when your presentation will be translated into several languages and international diplomacy requires careful word selection. In these cases, you will be reading your presentation.

Never ever attempt to memorize a presentation. This is a prescription for disaster if anything occurs that causes you to lose concentration.

If you are making a presentation in a language that is not your native language and if you have a very strong accent, it is helpful to your audience if you put more of the words of your presentation on the transparencies so that the audience can follow what you are saying more carefully. In this case, you should have a very detailed outline, but still do not write out the information in narrative form.

5.6.1. PRESENTATION OUTLINE

Proposal presentations should have a rhythm: present the big picture idea – what your system will be/ do; add depth and details; repeat the big idea; add different details, … ending with a final statement of the big picture idea.

The presentation should follow this general pattern. The team members should split the material among themselves so that all speak about the same amount of time.

5.6.1.1. *Introducton*

This part tells

- Team number
- Project title
- Client, if there is a "real world" client
- Faculty advisor
- Team members.

5.6.1.2. *Outline*

This part tells who will present what and in what order.

5.6.1.3. *Executive summary*

This includes

- Project background – what you are doing, why this problem is worth solving, how it is functionally different from what has been done in the past or is already on the market, the idea, method or procedure you have that will make it better. For more on what the audience is looking for, re-read Section 3.6.
- List of deliverables
- Designation of principle responsibilities (Do not use the term "RASI chart," that is jargon known only within SEC)
- Total dollars needed

5.6.1.4. *Discussion*

This is the most detailed part and includes

- Detailed project description
- Literature review summary
- Work completed to date – individual efforts may be mentioned here
- Plan to complete the project
    - Simplified action item list

- Simplified RASI chart
- Simplified Timeline

  If you use the terms "action item list" or "RASI chart," you need to recognize that these terms are defined only within SEC, so you will have to explain them. Also note that photocopies of these items from the written proposal is NOT acceptable. The written proposal is to be detailed, these may have **no more** than 7 items each in the presentation.

- Resources needed
  - Money
  - Equipment
  - Personnel

5.6.1.5. *Summary*

The summary is a brief restatement of the …

- Project overview
- Plan to finish on time
- Resources needed

A summary is NOT a statement that says, "We told you what our project is about, our schedule for finishing, and the resources we need," or some similar list of topics discussed.

5.6.1.6. *Other presentation guidelines*

- The presentation should not be filled with technical jargon that may confuse management or put them to sleep.
- The presenting team should also avoid revealing how they are going to accomplish what they are proposing. It may be that the request for proposals went out because the owners had a problem that they did not know how to solve. Be careful about revealing too much about how you intend to solve the problem. It may be that the owners will tell you thank you, take your ideas, and then solve the problem themselves without having to pay you for your work.
- Each team will have a 15-minute slot; this includes getting into place, getting your equipment out of the way, and sitting down. Do **<u>NOT</u>** plan to present actively more than 10-12 minutes.
- If you use Power Point, get your presentation loaded on the computer **<u>before</u>** it is time for presentations to begin. You may bring your presentation on a flash disk (preferred), loppy, Zip 100 disk, or CD. You should practice and become familiar with the equipment ahead of time.
- Remember, the presentation is a *team* effort and a *team* proposal. You, personally, do not necessarily have to discuss what YOU, personally, will do. Make the presentation flow as a unified whole, not sound like four or five individual presentations tacked together.

CHAPTER 6 – THE DESIGN REPORT

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CHAPTER 6 – THE DESIGN REPORT

6.1.INTRODUCTION

The Design Report is the result of all of your effort for two semesters. This and the accompanying oral and poster presentations will showcase your engineering talents. This report is unlike any of the others. Proposals repeat the work elements from the request for proposals and promise to do the work in exchange for a particular fee. Except for the technical aspects of the work, they are all pretty much the same. Similarly the progress reports are all pretty much the same except for the technical details. However, each Design Report is unique. Each Design Report will reflect the engineering work elements accomplished by your team. You should organize your report to best showcase the work that your team has actually done. There are certain elements that all engineering design reports will have, but the nature of the project may determine the order in which you will present them, the extent of each, and to a lesser extent, which elements will be included. The report should be organized to flow easily from one section to the next and to tell a complete, integrated story. In order to determine what to put in the report and how to best present it, ask your self this question: "If I had hired these folks to design this (*fill in title of your project*) for me, what would I like to see in the report and how would I like it to be arranged?" The answer to that question is the way you should do it. The bottom line is that the report should flow well with one section leading naturally into the next. The report should be complete. After reading the report Client should know exactly what is being recommended and why and what the comparisons and considerations were that led to the recommendation. There should be no questions about the recommended solution itself or the process that produced it. The report should be clear and concise and in standard technical English.

Notice that while this document is the final result of two semesters of work, it is NOT called the "Final" Report. In engineering, there never is a "final" report. You always hope that your work is sufficiently good that Client will hire your company to do more work for them. All design reports contain an explicit or implied offer to do more work.

Some of the elements in design reports are common to all design reports, other sections will be similar in purpose but very different in content, and there some elements common to the projects that are accompanied by a working model. In addition to particular elements that will be included as separate sections, the design reports will have design content incorporated into the report in a manner appropriate to the individual reports. All reports will be written in a style consistent with standard engineering prose.

Re-read the section “Writing for the Corporate World” in the chapter on Proposals.

6.2.DESIGN REPORT ORGANIZATION

The basic rule is that your report should flow from the introduction through the description, cost, and schedule to the conclusions and recommendations. Disclaimer: Each project is different; each team chose different items to design. The organization suggested here is generic; it may or may not fit your specific project. Your team is responsible for producing a report that best showcases the work that your team did. The items listed here are required unless some omissions are negotiated with Client and the course instructors before the report is submitted; the order is a suggestion.

Title page
Table of Contents
Executive Summary
Acknowledgements
Introduction
Overall description including:

- Definition, including classification and differentiation
- Description of the function or purpose
- Discussion of options and trade-off studies, justification for chosen option
- Description of appearance
- Expected performance data and actual performance data for working models
- List of subsystems and a block diagram or layout diagram that shows their interrelationships

Cost summary

Implementation schedule

Discussion of health, safety, economic, environmental, societal impact, risk assessment, life cycle economics, manufacturability, product reliability, and sustainable development

Conclusions and recommendations

- Summary of function or purpose and re-listing of subsystems
- Description of expectations and limitations of performance
- Recommendations for improvement or further investigation before implementation

Subsystem sections (each):

- Description of function or purpose
- Discussion of options and trade-off studies, justification for chosen options
- Description of relationships to the other subsystems
- List of equipment, materials, and components
- Cost data
- Schedule data
- Transition to the next subsystem
- Engineering drawings

6.3. **COMMON ELEMENTS**

The cover, table of contents and executive summary will be similar in all design reports.

6.3.1. APPEARANCE, COVER, TITLE PAGE, AND SPINE

In order to simplify last minute changes, teams will submit their design reports in three-ring binders of an appropriate size — neither too thick nor too thin. If possible, all materials, including engineering drawings, will be three-hole punched, folded to 8 ½ by 11 inches and inserted in the binder. Do not use page protectors for the pages of the report. Diskettes and CDs are to be place in pockets, which are either in three-hole punched pockets and inserted into the report or on the inside of the covers. Remember that if one section or element looks like an unmade bed, it will detract from the professional appearance of the entire report.

The purpose of the cover is two fold: (1) to provide an attractive, professional appearance, and (2) to provide enough information to the observer when it is lying on a desk or sitting on a bookshelf that the observer will know what he/she is looking at.

The title page is usually just a black and white copy of the cover since both require the same information. The inclusion of a pretty picture is optional. The use of Client's corporate colors is also optional. Both of these require extra effort and put the Client in a good frame of mind to read your report.

The specific information required is:

- Design report for *title of project*
- For *name of Client*

- Prepared by Saluki Engineering Company
- SEC Reference number
- Date of report.

The spine of the report usually has much less space. The spine need have only the title of the report, the SEC Reference number, and the date.

Make it easy for Client to think of your company the next time he has some money to spend on engineering.

6.3.2.TABLE OF CONTENTS

The Table of Contents is one of the least creative, but most critical elements of the design report. It is the road map to all the hard work and clever ideas you have incorporated into the report. The titles of the sections and the page numbers in the table of contents must match the titles of the sections and the page numbers in the report. In an extensive report that is put together by several people, this can get to be a real problem. To reduce the amount of work necessary and increase the probability that it will be correct, the design report should be have sections. Label the common section in the front that pertains to the design as a whole as Section A. Label each of the subsystem sections, which will be written by the person responsible for that part of the design, with successive letters. Thus, the pages in the main section will be numbered beginning with A-1, A-2, etc. The pages in the first subsystem description will be numbered beginning B-1, B-2, etc. That way, when there is a change in the number of pages in one section, the entire report will not have to be renumbered at the last minute.

A similar problem arises in references to tables of data and engineering drawings. In books and journals, the author refers to drawings and tables by drawing or table number and by page number. However, for purposes of engineering design reports, authors should use drawing or table numbers only. The reason for this is that teams usually put design reports together rather quickly without the extensive editing that goes into books and journal articles. The page number a particular drawing or table will be on is determined during the final printing, thus there is no effective way to go back and be sure all the page number references are correct without re-printing the report several times. This is expensive in terms of both time and money. However, the table of contents is a much shorter document that the team can be easily edit and print after the rest of the report is complete. Therefore, in order for the reader to be able to find the drawings and tables while reading the report, <u>every drawing and table must be listed in the table of contents</u>. When a table is incorporated into the report and appears on the page where it is discussed, or on the next page, it does not have to be listed in the table of contents unless there is a reference to it somewhere else in the report. Tables that are longer than one page, contain much detailed data, or were produced by an application package other than the word processor should be grouped together just before the engineering drawings at the end of the text for the particular section (A, B, etc.). Each table and engineering drawing will be identified in the table of contents by three pieces of information: table or drawing number, title, and page number. Drawing numbers, table numbers, and titles will be unique to each drawing or table; page numbers will be correct.

The completeness and accuracy table of contents is critical; readers will use it as they read the report.

6.3.3.EXECUTIVE SUMMARY

The purposes of the executive summary are to provide clues to the organization of the report and to provide a summary of the contents of the report to busy executives so that they can decide whether they want to read the report or not. The executive summary of the design report will tell what is included in the report, summarize the design, point out any particularly clever features, tell what the total cost and time for implementation are, and give the reader a clue as to how the report is organized. Remember, this is not a “final” report; it is a design report. You hope that your work is of sufficient quality that Client will choose your company for the next job that Client has.

The management of Client’s company is reading the report in order to determine whether to implement this design. They will make go/no-go decision based on whether or not Client’s management believes their company can make money by implementing the design. While engineers are most concerned with the technical aspects, management is most concerned with the financial aspects and, increasingly, about the societal impact. The amount of time required for implementation will influence the financial viability of the design by determining how long the company will have to pay interest on the loan before it can start realizing a return on its investment. The cost of implementation and the length of time the implementation will take are as critical to management as the soundness of the technical solution.

The length of the executive summary will be a maximum of one page. Look at your design report from the point of view of someone who wants to use it in order to make money, and choose what you include in the executive summary carefully.

Avoid vague statements in the executive summary. Statements like, “A widget was designed and a prototype was built,” or “The report contains performance data” are useless. State what the designed system, facility, or device does. Indicate what its performance is, or is expected to be. Indicate what the subsystems are. Give specific terms and numeric data whenever possible.

If the results of your study are negative and the design should not be implemented for either cost or technical reasons, say so. Then follow up with a brief summary of what needs to be done to make the venture potentially profitable.

The executive summary will contain the capital cost to implement and the total time to implement the recommended solution.

6.3.4. ACKNOWLEDGEMENTS

This section should have its own page. In this order acknowledge: (1) any companies that donated, loaned, or provided at reduced cost equipment, software, or components; (2) any individuals not in the ECE or ME departments that provided help and advice or donated, loaned, or provided at reduced cost equipment, software, or components; (3) any individuals in the ECE or ME departments, other than course instructors, that provided help and advice or donated, loaned, or provided at reduced cost equipment, software, or components; and (4) acknowledge course instructors only if they provided your team with special help beyond course instruction and guidance provided to all teams.

Also provide a list of credits for the individuals who contributed to the creation of this report and indicate what the contribution of each was. This is especially important if your team used the stratified organization approach to creating your design report. If you used the parallel approach, you may omit this list and instead put initials in the table of contents of the person or persons who contributed each item or subsystem description.

6.4. COMMON ELEMENTS WITH SIGNIFICANT VARIATIONS

All design reports will have an introduction, overall functional description of the recommended design, a functional block diagram, an estimate of the total cost to implement the design, a tentative schedule to implement the design, a conclusions and recommendations section, and subsystem descriptions. However, the extent of each section, the content of each section, and the order in which the information is presented will be determined by the nature of the project, the design aspects actually pursued by the team members, as well as the results of the design effort. The discussion of these elements below is of necessity a generic discussion. Some projects may not require some of the elements, or may require that they be presented differently. If your project has specific elements that are not part of the generic list, they will be listed in Attachment 2 to the Request for Proposals letter that your team received at the beginning of the project. You may also have additional elements for your design report specified in the comments you received from Client or SEC Management regarding your proposal. Be sure to review these documents frequently. When the specific requirements for your project conflict with the generic instructions given here, the specific requirements for your project control. When the requirements of Client and SEC Management are different, include all of both sets of requirements if possible. When the requirements to Client and SEC Management are mutually exclusive, the requirements of Client control.

6.4.1.INTRODUCTION

Tells why the project was needed and what was known about the subject before your project began. Usually you can get a clue as to why Client wanted the project from the Request for Proposals letter. Whenever possible, use Client's own words and quote these back to Client. That will give them the warm feeling that you understand the problem from their point of view. Information gathered from your literature review that pertains to the project, as a whole, will usually fit well into this section. When you use information from your literature review, be sure to use footnotes or endnotes to indicate where the source of the information. The literature review included in the proposal included everything you read that you thought might be useful or have some bearing on the design work you were going to do. When you write the design report, your design work is complete. Include only that literature that shows the significance of what you have accomplished or that you actually used in your design work. Omit all the literature you previously reviewed that turned out not to be relevant to the work you did do. Do not include any literature or design documents that Client gave you. Client will assume that you used these. Remember that these reports are going to be read, not weighed. Include only what will enhance the value of what you did or make your report clearer.

6.4.2.OVERALL FUNCTIONAL DESCRIPTION

There are two types of information needed in this section:

1. Client wants to know: If I implement this design, what will it do for me?
2. How is this design organized; i.e., what are the subsystems and how are they related?

A description of the design as a whole will provide this information. When you write the functional description (what the designed system will do) remember that Client is reading it looking for ways to use it to make money. Be sure to emphasize the benefits and advantages that will accrue to the user. If, for example, you have designed a petroleum refinery, be sure to tell how many barrels per day of crude oil it will process, how many gallons per day of gasoline, kerosene, etc. it will produce, what transportation methods you have provided for the products, etc. Also include any limitations on the inputs and outputs of your system.

In addition to all of the wonderful benefits, provide some idea of how you accomplished your wizardry. That is, give a list the subsystems with a brief description of the contribution of each to the design as a whole. Usually the relationship of the subsystems is much too complicated for someone not involved in the design to envision in their head. Therefore, provide some sort of pictorial help. The particular nature of the pictorial help will depend on the nature of the project. It may take the form of a block diagram, simplified process flow sheet, plot plan, site map, flow chart, or other diagram that shows each of the subsystems and their relationships to one another. The terminology used in the overall description, on the diagram, and in the titles of the subsystem sections will all be the same. Internal consistency is critical to the understanding and acceptance of the design report.

This section should describe all of the options considered for the overall design and explain why the choice of the recommended/implemented option.

This section will also give the overall performance data. If this is a design study, this section will report what performance can be expected if Client chooses to implement your recommended design. If the project includes a working model, the data reported should be both the expected values and the values of the performance data actually achieved. A discussion will also be included of the performance limitations.

Engineering designs do not occur in a vacuum. This section should also discuss the context in which this design will be implemented. This includes health and safety, environmental, ethical, and societal issues.

6.4.3.CAPITAL COST ESTIMATE

Every design report will contain an estimate of the amount of capital (dollars) Client will need to implement the recommended design even if the conclusion is that the design is not feasible. Exactly what this will be included in this cost will be determined by the nature of the project and the requirements of Client. For example, if your project is to design an improvement to the materials handling system of a manufacturing plant, you will estimate the cost of removal of the non-reusable equipment and the procurement and installation of the new system. If your task has been to design a special purpose device or instrument, the cost Client will probably want will be the cost to make one, or a few of them. If you project has been to design a new gadget that will be sold to the public, Client will want to know how much capital will be required to manufacture the first production run. If your project was to design and build a single device or instrument, then the capital cost Client will want to know is how much it would cost to make another identical, or improved, one if all of the components must be purchased. In the capital cost section, your report will give three vendors that could supply the materials or components. Early in your work your team should establish exactly what cost Client or SEC Management wants, so that the necessary data can be gathered as the design proceeds.

The cost section in the main section of the project report contains a summary of the capital cost required and the cost of the working model; if the project involves physical components (as differentiated from a software project), it should have at least one total that comes from each of the subsystems. Each engineer is expected to contribute to the capital cost estimate. The report should make it clear where in the report each number comes from and the source of the value being reported. In the main section, each subtotal needs a reference to the subsystem from which it comes. In the subsystem sections each price, labor cost, etc. will have a source. If an estimation method is used for a particular item, specify the basis of the estimate.

6.4.3.1.*The Cost Estimate in Design-Study Reports*

Design study projects are expected to include all costs (including labor, shipping, taxes, permitting, etc.) to implement the recommended design unless otherwise specified by Client. For devices that will be manufactured for sale, a rule of thumb is that the cost will be about three times the cost of the components; the selling price will be the cost per each plus profit for the manufacturer, distributor, and seller. For process plants the capital cost will be approximately double the cost of materials plus the cost of installed equipment. For projects that have a real world client, consult Client to find out what Client wants in the cost section.

Note that this section will be longer and more detailed than in design-build reports. Allow more time in your schedule to gather the data and assemble the report.

6.4.3.2. *The Cost Section in Design-Build Reports*

If your project includes a model, regardless of the purpose of the project, your report will include the actual out-of-pocket cost to build your working model; this cost section will clearly show which components and materials were on hand, donated, or borrowed and which were purchased for this project. The source of each cost component will be clearly indicated. The cost of the working model will include all money spent, including money spend for parts ruined and parts left over.

Note that projects with models will have TWO cost estimates: one will report the actual out-of-pocket costs to build the model together with a list of the donated and borrowed components, the second cost will be the cost to make another one, the cost per each to make a few of them, or the capital cost for the first production run, or the capital cost to implement the design. For devices that will be manufactured for sale, a rule of thumb is that the cost will be about three times the cost of the components; the selling price will be the cost per each plus profit for the manufacturer, distributor, and seller.

6.4.4. IMPLEMENTATION SCHEDULE

Every design project will contain an estimated schedule for the implementation of the design. The total time required will be the amount of time from January 2 of the year following the day the design report is turned in until the design your team has recommended is implemented. The nature of the implementation may be the manufacture of the first production run; the installation of modifications to an existing system; the construction of a plant, building, or device; or the making of a small number of duplicates of your design.

Executives often make go/no-go decisions based on the time factor. The time that capital has to be tied up in implementation before benefits can be realized is costly in terms of dollars. This cost is the interest that must be paid on the loan or the loss of revenue from other ways the money could have been used. One of the design considerations when choosing among possible alternatives is the speed with which profit can begin to be realized.

This section should be a summary or compilation of the schedule items from each of the subsystems. Each engineer is expected to contribute activities and their durations to the overall schedule. Document the source of all values.

Note: This is NOT your SEC work schedule from this semester. Your SEC work schedule will be in the SEC end-of-project memo, see the chapter on Other Paperwork.

6.4.5. SUBSYSTEM DESCRIPTIONS

Each engineer should contribute a detailed description of the subsystem work that he/she performed.

6.4.5.1. *Subsystem Description Requirements*

This section contains not only a functional description of the subsystem(s) and relationships with other subsystems, but also a description of each of the options studied and reasons for choosing the recommended solution. The engineering drawings will be located at the end of the subsystem description section. ALL subsystems will have engineering drawings. The subsystem description should explain the significance of every engineering drawing included in the section.

In most projects, this section is where the use of good engineering design is demonstrated. This is where the details of the options studied, principles and procedures used, and results obtained will be explained in detail. Discuss and describe in this section anything you want to get credit for doing. This section contains not only a description of the design and design procedures, but also an evaluation of the results. Included in this section is tabulation and analysis of expected performance data and, for design-build projects, observed performance data. See Section 5.3 for expectations regarding fault analysis, health, safety, environmental, and societal consideration.

In the subsystem description sections each engineer will provide the cost and schedule data details that will be summarized in the main section of the document. The materials and components take-off lists will reference the engineering drawing numbers where their locations are shown. For the capital cost section, each of the components required by the subsystem will be listed together with the cost and three recommended vendors. The activities related to this subsystem will also be listed with the expected amount of time each will take. These include procurement, delivery, and installation times. Each of the costs and estimated times listed will have its source clearly identified. Some possible sources of cost and schedule data are catalogs, phone quotes, email, web sites, and conversations from on-site visits. Document each cost and time and its source in your design notebook so that it will be available for your report and you will not have to go back to get it again. When you phone or email companies for costs and schedule times, identify yourselves a students and tell them you need a 10 second answer. Take whatever they tell you, and say, "Thank you," even if you think the value is wrong. You may note your concerns in your report. You may also use data factored from previous reports, note the name and date of the report and the factor you used to adjust the cost to today's prices. Estimates for construction projects may also be obtained from Means Estimating guides. Note: Means and Client price lists are a sources of estimated costs; they are NOT a vendors!

In order to be of professional quality, the work in this section needs to be complete. The recommended way to insure this is to write up everything you do, just as soon as you have done it. It will take much less time to write it up now when it is fresh in your mind than it will at the end of the semester when all of the other parts of the report, as well as finishing the project itself, have become urgent. At that time, if this part is finished for each aspect of the design, only editing and combining the pieces will be necessary. Not only is editing much faster than the initial write up, even with extensive revisions; but also the more frequently a document is edited, the better it becomes.

Remember first-rate design work includes not only significant technical effort, but also professional quality documentation. If you want an A in the course, it is not either-or; it is both-and. A report without significant technical content is expensive bumph; a superbly executed project without good, complete documentation is an expensive toy.

6.4.5.2. *Subsystem Description Quick Checklist*

The subsystem description subsection should contain all the work related to this subsystem that was performed including, but not limited to, work in the following areas:

- ✓ Design options
- ✓ Justification of choices including any selection matrix used
- ✓ Detailed description of expected performance
- ✓ Engineering drawings
- ✓ Software listings
- ✓ Performance data and analysis, including experimental design and setup
- ✓ Fault analysis
- ✓ Health, safety, environmental, economic, and societal issues
- ✓ Cost data for implementation
- ✓ Cost data for prototype (design-build projects)
- ✓ Schedule data for implementation
- ✓ Conclusions and recommendations
- ✓ Bibliographic references
- ✓ Recommended vendors

6.4.6.CONCLUSIONS AND RECOMMENDATIONS

In this section, you summarize the performance of your design and indicate to Client whether your design is ready to implement or needs further study. This is the place, in a real world report, where you put additional work that you would like for your company to do as well as inform Client of any deficiencies without actually calling them deficiencies. If during the course of your design work you have discovered elements that should be incorporated into the design but were not, this is the place where you discuss additional work. You may have become aware of enhancements that are beyond the scope of this contract, or, if you have a working model, you may be aware of enhancements that were not incorporated into the working model that could not be funded or that were not discovered in time. If you have a working model and it is satisfactory for one device, there may be changes that need to be made to the design so that it may be manufactured more cost effectively on a large scale. If you have concluded that your solution is not ready to implement, this is where you outline what needs to be changed or done in order to make your solution ready for implementation. If you are recommending additional engineering work before implementation, be sure to include additional engineering in your implementation cost and schedule. Internal consistency is one factor that determines the credibility of your work and your report.

6.4.7.FINAL SUBMISSION

Once the report has been submitted, no pages will be returned for any reason — no drawings, nothing. If you need a copy for yourself or your oral or poster presentation, make the copy before submission.

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6.5.**GOOD ENGINEERING DESIGN**

Engineering design is the methodical application of mathematics and scientific principles to the solution of problems. The application of good engineering design is a significant part of the defense when a company is sued in a court of law. Client has hired you to do this engineering project for them. If they decide to implement your design, they will want to know that your design work will stand up in a court of law. Your report must show the application of good engineering design procedures. Good engineering design includes the number of options studied, fault analysis, performance data, and context considerations. Your report should clearly show the results of all four. While the chronological, blow-by-blow account of your work is contained in your design notebook, which belongs to SEC, not Client, the design report will contain an organized account of what you studied, the results of those studies, and your evaluation of your design.

Most of the time, part of the engineering design documentation will appear both in the overall project description in the main section of the report, as well as in the individual subsystem sections of the report. Design options studied, performance data, and fault analysis applied to the total device or system designed should be included in the overall description. But, for instance, if one or more subsystems have data available that only applies to a particular subsystem, the data should be presented in the relevant subsystem section(s).

While the nature of the project and the requirements of Client will determine where in the report the data occur, every design report will show evidence of the consideration of several options; actual and/or expected performance data; and fault analysis; safety, environmental, ethical, and societal considerations.

6.5.1.DESIGN OPTIONS

It is an engineering heuristic that you do not know that you have a good idea until you have compared it to several other ideas. For purposes of this design report, “several” is interpreted to mean “at least three.”

When several options have been studied in depth, they should not only be explained in the narrative portion of the report, but also have a comparison chart. The comparison chart should have the various options on one axis (rows or columns) and the important characteristics considered on the other. The entries themselves will indicate how nearly the option meets the particular criterion. The discussion of the recommended option should reference this table.

Remember, this is engineering design. While making a brainstorming list and eliminating the implausible ideas as too big, too small, too hard, too complicated, too expensive, etc. is a part of the design process, it alone is not an engineering study of options. An engineering study of design options includes the methodical application of mathematical and scientific principles, i.e., numbers, to at least three different options.

6.5.2.PERFORMANCE DATA

The purpose of the engineering project is to design an engineering system to solve a problem. When the designed system is implemented it is supposed to do something. What? The expected answer to this question, for your project, is the expected performance data you are to report in your design report. This means numbers with units and, usually, in tables. Expected performance data is to be in the design report for every option studied. There will be performance data for each subsystem, and for the system as a whole. This data will be in the report for every option studied for every subsystem and every configuration of the system as a whole. Include references to these data and data tables in your comparisons and justifications of the option chosen or recommended.

In projects that include a working model (design-build projects), actual performance data will be in the table together with the expected performance data. Your report will include the experimental design and setup. If it does not fit into the flow of the report, put it in an appendix. The discussion will include an analysis of how nearly the actual performance data agrees with the expected performance data. Limitations of the design that are discovered during the testing phase will also be included in the discussion.

The report will present all data and tables of data with an accompanying description and explanation of the significance. If the data are numerous computer printouts and spread sheet variations extending over more than one page, the data may be put in the appendix and only the summary tables of the important results presented in the discussion. Reference should be made to the specific tables in the appendix where the detailed analysis data may be seen. In a design study report the data may be numerous enough that the appendix will be a separate volume.

6.5.3.FAULT ANALYSIS – HEALTH AND SAFETY CONSIDERATIONS

Part of good engineering design is analysis and evaluation. That is, engineers carefully look at the tentative design from the point of view: What can go wrong? What will happen if it does?

Many areas of engineering, such as construction and manufacturing, are covered by codes and safety standards. In areas where such standards apply, the engineering system that is being recommended needs to comply with these codes and standards. This compliance will be documented in the design report.

In addition to the failure methods covered by the codes and standards, all engineering designs need to have all possible failure modes analyzed. The design report needs to document expected consequences to the performance of the failure of each component. What Client needs to know for each component is:

1. How and under what circumstances could this component fail?
2. What will happen if this component fails?
3. How much will the damage cost?

4. How could the design be modified to remove or mitigate the consequences? [Note the question is NOT “How could the failure be prevented?” although that could be one option.]
5. How much more would it cost to make this modification?

Modifications discovered during this phase of the design that are cost effective or that will prevent injury, loss of life, or significant property damage, will be included in the conclusions and recommendations section of the first section of the design report. A summary of all the results of the fault analyses will appear in the appropriate section of the report: overall section or the relevant subsection.

6.5.4.ENVIRONMENTAL AND SOCIETAL ISSUES

Engineering solutions do not occur in a vacuum. They take resources to produce, and require disposal at the end of their useful life. Engineering solutions are requested to solve some problem. Often the solution has consequences beyond the immediate problem being solved. It is the responsibility of the engineer to advise Client on these issues. For instance, if the solution requires the use of a rare material, scale-up possibilities may be limited. If after the device or system has outlived its useful life, it can be recycled or have another use, its value will be enhanced. Are there any byproducts or other waste produced? Can they be sold? How much will it cost to deal with them?

The societal context of the solution also needs to be considered. What is going to be required of the end user? How will the end user interact with the system or device? Is it user friendly? Will it require any change in the way the end user operates? Will in encourage any behavior that would not be in the best interests of the end user or society in general? Both the pros and the cons need to be considered and discussed.

Read the chapter on Macroethics.

6.6.**WRITING STYLE**

The design report is a formal document for which Client paid serious money. In return, Client expects to get a serious document written in standard, technical English prose. Clarity and ease of reading are your goals. Any material that can be presented in tables or lists will be presented in tables or lists and not written into the narrative. Re-read the section on Writing for the Corporate World in the chapter on proposals. The following sections highlight the areas where many students have difficulty.

6.6.1.GRAMMAR AND SPELLING

The entire document will be written in accordance with standard American English grammar and spelling rules. If you prefer British English, the entire document will be in accordance with standard British English grammar and spelling rules. One or the other, but the entire document must be consistent. If you are uncertain about your execution of standard American English, you may see your course instructors, the communications seminar instructor, or a university approved style manual such as *The Little, Brown Compact Handbook*, *5th Edition*, by Jane E Aaron, Longman, New York, NY 10036, 2003, ISBN 0-321-01112-0.

The two most common problems occurring in student reports are sentences that are missing either the subject or the verb, and sentences in which there are agreement problems. Agreement problems come in two forms. The first is agreement of the subject and verb in number. The second is agreement of a pronoun and its antecedent in number. Also check to see that the antecedent of any pronoun used is clear.

6.6.2.PARALLELISM

The report will present items and concepts that are parallel with identical parts of speech. In other works, lists, whether in-line, bulleted, or numbered, should all be the same part of speech: all nouns, verbs, adjectives, or whatever. When several concepts are listed, then discussed, then listed again, all of the lists and the discussion of the concepts will be in the same order. This requirement may dictate the order of presentation of the subsystem sections in the report.

6.6.3.NO FIRST PERSON

The design report will not contain any names of individual engineers. The design report will not contain any first person pronouns: I, me, my, we, us, our, or ours. Substituting the number of your team for a reference to yourself or your teammates is not acceptable either. This design report is to be about your design. Client bought your design, not you. Client wants to know what he will get if he decides to implement your design. Unless you intend to let Client build you permanently into his implementation of your design, keep yourself out of the report. Obviously you did it: it is your report!

Client does not want to read about you; Client is not your mother; your design report is not a diary of your activities. Report your process by describing the results of what you did. For example:

WRONG: Team 13 studied three options, and we found that the second one was the least expensive.
CORRECT: Descriptions of three options follow; the second one is the least expensive.

Notice that the second version is complete, correct, clear, and more concise. The rule to remember is, "Keep yourself out of the report; just describe the system."

6.6.4.BIBLIOGRAPHIC REFERENCES

There are many styles for bibliographic references. When you go to work for a company, that company will have a preferred style. Client's request for proposals may have included a request for a particular style for references. Saluki Engineering Company (SEC), however, recognizes that there are many acceptable styles. The only requirement that SEC has is that the entire document has all bibliographic references in the same style in all sections of the same document. There are several styles in the book referenced by Jane E Aaron (2003). *The Chicago Manual of Style*, which is available in the university library, has many more. Each team should select one style, and all members should stay with it through out the entire document. In addition it does not matter whether the team selects footnotes or endnotes for the references, but, again, the entire report should be consistent in style. SEC recommends the American Psychological Association style.

All material taken from other sources will be referenced. This includes background and explanatory narrative, design procedures, special purpose equations, and drawings that were used in whole or in part or were modified. Also all cost and schedule data will have a reference. Other than omitting them, the most common error in references is to forget that <u>all</u> references have <u>dates</u>. If there was no date on the reference document itself, use the year you received it.

6.6.5.COLLOQUILISMS

There will be no colloquialisms in the design reports. Colloquialisms are things you say when you talk to one another and when you write informally, for example, in a letter to a friend. Most writing manuals, such as Aaron (2003), have lists of common colloquialisms that tend to creep into formal writing and speaking. For instance, one of the more common ones that try to get into design reports is "The project was broken up into five parts: …" or "The project was divided up into five parts: …" then a list follows. This has several problems:

1. If the project is broken or divided, then Client does not want it.

2. Using passive voice is just another way for you to sneak yourself into the report.
3. The term, “broken up” or “divided up,” is colloquial.

Instead, the report should read: “The project has five subsystems: …” then the same list follows.

If you are uncertain about whether you have included any colloquialisms, you may see your course instructors, the communications seminar instructor, or use a university approved style manual.

6.6.6.FIGURES, TABLES AND ENGINEERING DRAWINGS

The design report will reference each figure, table, and engineering drawing in the narrative. Tell the readers what they should conclude from it. If you leave it up to the reader because you think it is obvious, you can be certain that the reader will conclude something other than what you had in mind.

You should place figures that illustrate the narrative, but are not part of the engineering definition, in-line in the text. Each of these illustrations will have a figure number and a title. Figure numbers and titles are unique and are placed below the figure. Each figure that is a graph will be accompanied by either a data table for performance data that you acquired or by a bibliographic reference that indicates its source. Each other figure will be accompanied by a reference to an engineering drawing where it may be seen in greater detail, or in relation to other components, or by a bibliographic reference that indicates its source.

Information that can be displayed in a table will be displayed in a table and not written into the narrative. Summary tables that are small enough to be created in the word processor can be in-line with the narrative. Full page tables and tables created with other software packages will be gathered together and inserted at the end of the narrative discussion for the section. These tables will be in numeric order by table number. Each table will have a table number and a title. Table numbers and titles are unique. Table numbers and titles are placed at the top of the table.

Engineering drawings are part of the design definition. They are usually produced by a software package other than the word processor used to produce the report. The drawing number and title go in the title block. The title block goes in the lower right hand corner when the drawing is right side up. Engineering drawings are placed at the end of the text section in which they are discussed. They are folded to 8 ½ by 11 inches so that the title block and page number are visible without unfolding the drawing. The page number may be hand written. See Folding Engineering Drawings in the Resources on Web CT.

6.6.6.1.*Suggested Numbering Plan*

Each engineer on the team chooses a digit, *n*, between 1 and 9. Then each engineer will number figures as Figure *n*01, Figure *n*02, etc.; and tables, as Table *n*01, Table *n*02, etc.; and engineering drawings as Drawing *n*01, Drawing *n*02, etc. Number engineering drawings and tables at the end of the narrative section numerically in the order in which they are created. Each of these engineering drawings and tables will be listed in the Table of Contents individually by drawing number, title, and page number. Each will have its drawing number, title, and page number visible without unfolding the document. In-line figures do not need to be referenced in the Table of Contents. If there are any tables at the end of the narrative section, then all tables should be listed in the Table of contents. All engineering drawings will be listed in the Table of Contents. Each table and engineering drawing that is listed in the table of contents will be listed by drawing number, title, and page number.

6.6.6.2. *Figures and Tables*

All figures and tables will have a unique title and a unique figure number or table number. Tables that are not created within the word processor are to be grouped together in numeric order by table number after the section in which they are first referenced.

6.6.6.3. *Engineering Drawings*

Every report will have engineering drawings. These are the defining documents for your recommended solution and an absolute must in engineering reports. Every engineering drawing will:

- ✓ Have a title block
- ✓ Have a unique drawing number
- ✓ Be numbered numerically in the order in which they were created
- ✓ Have a unique title
- ✓ Have a unique page number
- ✓ Be folded to 8 ½ by 11 inches and three-hole punched, see Folding Engineering Drawings in the Resources on Web CT
- ✓ Be inserted into the report in numeric order by drawing number behind the discussion section where they are first referenced
- ✓ Be inserted into the report so that the drawing number, title, and page number are visible.

For Client the value of your work and your report is directly proportional to the quality of your engineering drawings. All engineering projects are to be accompanied by engineering drawings. If Client decides to implement your design, the construction/production company will get your engineering drawings, not your whole report. Therefore, your engineering drawings must contain enough information in order to implement your design without reference to your report. Every engineering drawing will have a title block. There is a sample title block in Chapter 2. You may take this to a copy machine, reduce or enlarge as necessary, and tape a copy on your engineering drawings. This will be the simplest if you are making hand drawn drawings. This is available on a diskette from the resource center as an MS Word document. If you are using a drawing program and wish to use the title block tool, compare the title block to the one in Chapter 2 to make sure that you have all of the required information. As you complete your design, complete your engineering drawings. Check each drawing as you finish it to see that it has each of the following:

1. Title block
2. Unique title
3. Unique drawing number
4. Legend
5. Dimensions
6. Materials list
7. Components list
8. Off-page connectors refer to the correct drawing
9. Lines have labels/names
10. Lines with off-page connectors have the same labels/names on each page
11. Every component is labeled with a name and a part number
12. If this is a detail drawing, there is a reference to the overall drawing
13. If this drawing has detail drawings, references are clearly identified
14. There are enough explanatory notes to explain anything that may not be clear.

In addition to the fact that engineering drawings must be complete within themselves, the significance of each engineering drawing to the project needs to be mentioned somewhere within the system or subsystem discussion.

In order to check for completeness, review the following list to be sure that you have included all the necessary drawings:

1. Overall block diagram
2. Overall sketch or photo of the completed device
3. An exploded assembly drawing
4. Mechanical component detail drawings
5. Circuit or logic diagram
6. Circuit board layout drawing
7. Printed circuit board stencil
8. Layout map
9. Floor plan
10. Plot plan
11. Software flow chart.
12. Software subprogram reference chart.

Engineering drawings, unlike figures and short tables, are not incorporated into the body of the discussion, but rather are grouped together at the end of the appropriate discussion section. This section may be either the overall description, or, more commonly, the subsystem description sections.

The next page shows sample SEC title-blocks with the fields required by SEC.

NOTE: These are SEC Title Blocks. Reduce or enlarge them as necessary to make them fit on your drawings.

<table>
<tr><td>3</td><td></td><td></td><td colspan="3"></td></tr>
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SEC Reference #</td></tr>
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6.7. **TECHNICAL MANUAL AND USER'S GUIDE**

When a working, or almost working, model accompanies a project, the design report will include a technical manual and a user's guide. These two documents will stay with the prototype after the end of the project.

6.7.1. TECHNICAL MANUAL

This manual will contain all of the detailed information on the construction of the device, copies of the engineering drawings that apply to the prototype, and an explanation of how the technical aspects of the device work, or are supposed to work. This manual will be used to make upgrades, repairs, and modifications to the prototype. When your team assembles this document, ask yourselves, "If someone gave me this device and assigned me to fix it or modify it, what would I want to know about it?" The answers to that question go into the technical manual. Also include a components and materials list with prices and recommended vendors.

6.7.2. USER'S GUIDE

This plain English document tells how to make the device do what it is supposed to. It tells and shows how to assemble and set up the device if assembly and set up are required. It tells and shows what to type on the keyboard, which knob to turn, and button to push. It tells and shows the response of user's actions. It has many figures and diagrams that clearly indicate where the locations of the various knobs, switches, etc. It does not contain any technical details about the internal construction of the device. It just tells how to use it.

6.8. **APPENDICES**

The appendix is where you put anything that is very detailed or very voluminous that rightly belongs with the report but not in the report. The following is a non-exhaustive list of things that would belong in the appendix. Do not put any thing in an appendix that has not been mentioned and had its significance noted in the body of the report itself.

6.8.1. BIBLIOGRAPHY

All of the bibliographic references from all of the sections will be gathered together in one bibliography. The footnotes still belong at the bottom of the page, or the endnotes, at the end of the section in which they occur. However, the bibliography itself to which the footnotes or endnotes refer belongs in the appendix.

6.8.2. RECOMMENDED VENDORS LIST

Every project will have a list of recommended vendors. Three vendors should be nominated for each component Client will need to purchase in order to implement your design. The report pricing section, of course, base the capital cost on the lowest quoted price unless there is a documented reason otherwise. Remember these are <u>recommended</u> vendors only; only Client gets to specify who the actual vendor will be.

6.8.3. SPREADSHEET AND SIMULATION RESULTS

If your conclusions depend on numerous calculations that were carried out by means of a spreadsheet package, Client may very well want to have a copy of these spreadsheet results. Put them in an appendix. Similarly, if you have much data from simulation results, or much laboratory performance data, put a summary table in the report itself and the detailed data sheets in an appendix.

6.8.4. EQUATION DERIVATIONS

If, during the design process, you have derived original equations that are critical to the solution of your problem, put the resulting equations in the text of your discussion and derivations in an appendix.

6.8.5. COMPONENT DATA SHEETS

If your project has any unusual or special purpose integrated circuit chips or other specialized components, put a copy of the data sheets in an appendix. If your project contains any components that come with extensive vendor data or instructions, put the vendor supplied literature in an appendix.

If your project is a design-study project, or a design-build project that has an incomplete working model, put the data sheets or vendor supplied data in an appendix of the design report. If a working model accompanies your project, put this literature in an appendix in the Technical Manual. Do not make copies of this to put in both documents.

6.8.6. SOFTWARE LISTINGS

The software listings accompanying your project should be listings only of original software written, or modified, by your team. Do not make a hard copy listing of any freeware or shareware software that your team did not write or modify. If there is a freeware or shareware software package that your software needs, submit a copy of it on an appropriate medium (diskette, zip disk, compact disk, etc.), mention it in the discussion, and list it in the bibliography. If your project needs any proprietary software, mention it in the discussion, list it in the bibliography, and list it and include its cost in the pricing section. Saluki Engineering Company does not accept illegal copies of software. If Saluki Engineering Company purchased a software package for your team, please return it together with its documentation to the professor or other person who procured it for you. If you have modified a freeware, shareware, or vendor-supplied software package, clearly indicate in the listing exactly which part is came from the company and which parts you added and the nature of and reasons for your changes. Use many comments.

If a working model accompanies your project, put the complete software listing in an appendix in the technical manual; otherwise, put it in an appendix in the design report. Similarly, put the diskettes, zip disks, compact disks, etc. in an appendix in the appropriate document.

If your project uses a computer and or commercial software, your report should specify the minimum configuration required for the computer, the operating system, and the version number of the software packages required. For example: This project requires a 1.5 GHz Pentium 4, which has 510 MB of RAM and 2 GB of free hard disk space and is running Windows 2000.

6.9. **REPORT EVALUATION**

Your compensation for your work for SEC, i.e., course grade, will primarily depend upon the content and format of your design report. (1) Does the quality and quantity of the design effort reflect three credit hours of design work? (2) Is the report sufficiently clear, continuous, complete, correct, consistent, and concise that it can be used after the designers have left the company?

6.9.1. ENGINEERING DESIGN

Engineering design work is demonstrated by calculations, numeric comparisons of options, performance data, engineering drawings, fault analyses, and listings of original software written. Reports, or individual sub sections of reports, that show little evidence of engineering design work will receive low evaluations, regardless of how well written they are and how professional they look. If you have not done much engineering design work during the project, there is no amount of effort that you can put in on your design report to increase your compensation. The bottom line is that this is a design course and design work takes time and effort. All of your design work should be documented in your design notebook. This will be invaluable in writing your report.

6.9.2.REPORT FORMAT

The report format is evaluated its clarity, continuity, completeness, correctness, consistency, and conciseness. This is a formal report that describes the design that SEC recommends plus all the other options considered.

6.9.2.1.*Clarity*

The goal of writing is not to be understood; the goal of writing is not to be misunderstood. The subject of each sentence should be clear. Each pronoun should have a clear antecedent. If the antecedent or subject is not clear, then repeat enough words that the meaning cannot be misconstrued.

Part of technical writing is the precise meaning of terms. Do not use synonyms; use the same term for the same concept every time it occurs. This may be boring, but it is clear and unambiguous. It does not leave your reader wondering if the terms refer to the same thing or if you have introduced another concept.

Each team member should read the entire document to see if there is any interpretation possible other than the one the writer intended; if so, rewrite that part.

A professional appearance goes a long way to contributing to the clarity of the project.

6.9.2.2.*Continuity*

Your report should flow; that is, it should tell one continuous story from the start to the finish. (For more on the flow of a report, see the Report Organization section in the chapter on Proposals.) The definition of each term will precede its use. For instance, any mention of “the battery” will be preceded in the report by a description of the project that shows the relationship of the battery to the project. Do not leave the reader wondering, “WHAT battery?” The report will present any information that the reader needs to understand any given section before that section. The order of the sections should make the report appear logical to the reader. Be very careful about not referring to something before its definition. This means that the team will consider the order in which the report presents the subsystems.

6.9.2.3.*Completeness*

Completeness refers to both technical completeness and report completeness.

6.9.2.3.1.Technical Completeness

Your report should be complete. There should be no unanswered questions in the mind of Client when your report is read. The design report will contain no references to design notebooks or any other non-public document that is not in, or submitted with, the report. There should be no loose ends; the design report will address issues suggested in design reviews whether or not they are included in the final recommendation. Do not assume that your reader knows anything that is in your mind or experience. Explain everything. On your engineering drawings, label everything. Nothing is understood; everything is spelled out. This is not the place for subtly. If you did the work, tell Client what the results were, even if they did not work for this project or not applicable to this design. Do not report mistakes; report only valid work even if the results were negative. This will prevent the Client from repeating your nonproductive work in the future or repeating your work if it is applicable to another project.

6.9.2.3.2.Report completeness

Use Attachment 2 of your Request for Proposals and the Table of Contents of this document as checklists. Make sure that your report includes any work you have done on each of the items in the checklists. By the time you put your report together, it may be too late to complete some of the items if you have not done so already; however, you can use the checklists to insure that you have not omitted any work that you have completed.

6.9.2.4.*CORRECTNESS*

Check your work for correctness. Your engineering work should obey the laws of physics and mathematics. Your report should obey the rules of spelling, grammar, and style for technical reports.

6.9.2.5.*CONSISTENCY*

Double, no, triple or quadruple check your report for internal self-consistency. If one section says there are three input signals, then every other reference to input signals should say three, including the main section, all the subsystem sections, and all the engineering drawings. They should all account for three inputs and none should reference more than three. Each engineer on the team is responsible for reading the entire report and noting any internal inconsistencies in either terminology or engineering details. If it does not make sense to you, it will not make sense to Client

6.9.2.6.*CONCISENESS*

Generally use as few words as possible to explain your design and the considerations that went into determining the recommendation. Remember that the client will read these reports, not weigh them. Be as concise as possible and still maintain clarity, continuity, completeness, correctness, and consistency.

6.9.3.TEAM EVALUATION AND INDIVIUAL ADJUSTMENTS

Generally if all of the team members have been putting in the same amount of effort, all will get the same compensation/grade. However, if the engineering design effort is uneven there may be individual adjustments in grades. The faculty readers determine who is responsible for which sections by the credits in the Table of Contents. As a concession to the fact that this is really a class, you are asked to initial each section in the Table of Contents that you contribute. Generally, this will be the subsystem section(s) that describes the engineering design work you did plus any of the items in the main section that contain your contribution. The class requirement is that each team member be responsible for one item in the main section and one subsystem section all by himself or herself. After that, other items in the main section and other subsystem sections may be completed by anyone or any combination of team members as a group effort. There should be no reports where one person did the entire main section alone, or any individuals who failed to contribute at least one item to the main section and at least one subsystem section.

All team members assume responsibility for the contents and presentation of the design report. When a team turns in a report, it is assumed that each team member has not only contributed to the report but also has read the report and agreed with final version of it.

Individual grade adjustments will occur because of the quantity and quality of the engineering design effort reflected and the quality of the report subsection attributed to that individual. Reports that reflect individual excellence but do not come together as a coherent, unified report are uniformly devalued. This is a team project, and teamwork is expected of every one. The appearance of one part can detract from the appearance of the whole report.

The whole report is an engineering report. The "team" section consists of those things that apply to the project as a whole. "Individual" sections are the subsystem sections. Usually it is easier for the person who did the work to write up the subsystem description of what was found out/designed. As a concession to the fact that this is really a class the following guidelines are given:

1. If you did the work, put the write up in your subsystem description, whether it logically fits there or not.
2. If your team used the parallel organizational model for the team section, put initials in the table of contents by the items indicating who is responsible for which so that the faculty can correctly distribute the credit; or if your team used the stratified organizational model for the team section, include the appropriate credits in the Acknowledgements section.

6.10. DESIGN PRESENTATION

Your design presentations are where you present the results of your work to management of Saluki Engineering Company, management of Client's company, and others who may be interested in your work or the project itself. While the presentations should reflect significant technical work, these are not technical presentations. Avoid technical details and technical jargon; emphasize functionality, benefits to the user and society, and the cost and schedule to implement the design.

6.10.1. ORAL PRESENTATION

This is a formal presentation, usually held in an auditorium. The target audience is the management of Client's company and the management of Saluki Engineering Company. In a real world setting, you would be laying the foundation to have Client hire your company to implement the design you are recommending. Alternatively, your goal may be to have Client give your company preference for the next engineering design project.

In your audience are the folks who are holding the moneybags; their primary interest is whether they can use this design to make more money. These folks may be MBAs, accountants, lawyers, or engineers of some discipline other than the one you and your teammates are. They are busy executives and have allotted a specific amount of time to come to hear about your design work. It is your responsibility not to waste their time. Pick and choose what you will tell and how you will tell it very carefully so as to put your work in the most positive light possible.

Your oral presentation should be a team effort and come off like a well-orchestrated show. Each team member should speak approximately the same amount of time. In generally, individuals will not be presenting the part of the design that was their personal responsibility.

6.10.1.1. *Oral Presentation Outline*

The outline of your design presentation will be essentially the same as the outline of your other presentation, except that you will not be presenting what you will do.

6.10.1.1.1. Introduction

This tells the team number, project title, Client and Client contact (if there is a real world client), the team members, and faculty advisor.

6.10.1.1.2. Outline

Who will present what in what order

6.10.1.1.3. Executive Summary

The executive summary should answer the following questions:

- What is the project background?
- What are you doing?
- Why is it needed?
- How is it different from what already exists?
- What were the expectations?
- What was the outcome?
- Were the expectations met in terms of performance, constraints (time, money, size, etc.)?
- How much will the implementation of the recommended solution cost?
- How long will it take to implement?

6.10.1.1.4.Detailed Project Description

This is where your team presents the details of the design work. By now the audience should know what problem your team is attempting to solve. Begin with an overall description of your project including mention of the subsystem names and an overall block diagram, plot plan, or other orienting diagram. Discuss the options that were studied and present your justification for the options chosen. Also present system performance data.

6.10.1.1.5.Subsystem Functional Descriptions

Describe the function of each of the subsystems and any options studied; present the justification for the options chosen and any subsystem performance data.

6.10.1.1.6.Summary

Give a brief overview of the purpose of the project and its outcome. A summary is NOT a statement that says, "We told you what we have done and how much it will cost to implement," or some similar list of topics discussed.

Also acknowledge the contributions of others, especially any contributions from your real-world client, or any person not directly involved with the course. Acknowledge the receipt of money, components and materials, expertise, help, and the time spent with your team.

End the prepared presentation by opening the floor for questions; then when there are no more questions, or time runs out, end the presentation by thanking the audience for their attention.

6.10.1.2.*Dress*

The dress code for presentations is formal. For men, this includes suit, tie, dress shirt, polished leather shoes, and a fresh haircut. For women, this includes a skirted suit or business dress, neutral hose, 1 ½ to 2-inch pumps, hair neatly combed, off the face, and out of your eyes. If you do not already have a suit and plan to buy one, choose a medium to dark blue or gray color. Choose black for your belt and shoes. You will use this same dress for job interviews and presentations to clients and management on the job.

The purpose of dress requirements is not to shoehorn everyone into the same mold. The purpose is to give you survival skills. When you are going to job interviews or making presentations to clients and management, you are dealing with people who do not know you or your work. These people may have significant influence over the opportunities you will have in the future, and you only get one opportunity to make a first impression. It is very hard to change someone's first impression. Studies have shown that, in the absence of other information, people conclude that those they have just met are more competent, more professional, and more intelligent when they are dressed as described above. When you give a presentation, dressing up just a bit more than the audience shows that you consider the occasion a privilege that merits some special effort on your part. You need to decide which you would like to give up: the right to "be yourself" or the opportunities that may come your way due to others' favorable impression of you.

6.10.1.3. *Jargon*

Avoid jargon and abbreviations. If at all possible, use plain English. If it is necessary to use a technical term or an acronym, be careful to clearly define it first. For instance, "designation of duties" is plain English; "RASI chart" is a term known only to those familiar with that management technique, called by that particular name.

6.10.1.4. *Transparencies and Power Point*

Photocopies of charts, engineering drawings, and other items from the design report are NOT ACCEPTABLE. They have too much information and are invisible in the back of the room. Charts and tables of results or other information need to be simplified for presentation: no more that 5 to 7 items. The detailed charts and tables belong in the written report. Similarly, drawings used on transparencies need to be simplified to an outline or a smaller part of the piece. Avoid covering up part of a slide and revealing parts as you talk. If there is some reason why the audience should not see the transparency in its entirety, you should make additional slides.

Power Point presentations are expected. The other options are overhead transparencies, videos, and demonstrations. Your team should choose the medium best suited to the amount of time you have to prepare and the nature of the design results you are presenting. Check your Power Point presentations on screen to be sure that the colors you have chosen are appropriate and visible.

A good rule of thumb is to plan to use no more than one frame or transparency per minute. If you prepare more than this, you will either rush through them so fast that no one has time to view them properly, or you will exceed your allotted time, which is an even more grievous error.

When you are discussing a part of a diagram or figure, point to the part you are discussing. In this way the audience can follow your arguments and not get lost trying to figure out what which part you are discussing. When pointing in PowerPoint, there are two choices: the mouse and the "pen" on the graphics board. Do not turn around and talk to the screen or wave you hand at it. If you can see the screen on the monitor in front of you, the audience is seeing exactly the same thing.

6.10.1.5. *Time*

Timing is a critical, but tricky part of your presentation. About the only way to get it correct is to have rehearsals. Approximately two weeks before your presentation your team will know exactly when and for how long you will present your design results. Generally, every team will have approximately 20 minutes. Teams that end up with three members may take less, and teams with 6 or more members will be placed last in an evening and may take an additional five minutes or so. Teams with 20 minutes will take NO MORE than 15 minutes for their presentation. The remaining time is for questions from the audience and for the next team to get into position. The worst error is to go over the allotted time. Executives are busy people, when they allot 20 minutes to listen to your presentation and the question and answer session, they allot 20 minutes, NOT 25 minutes. They will get up and walk out if you talk too long. Do not make this mistake. On the other hand, if you take significantly less than your time allotment, you will be giving the impression that this project is not very important to you, and it is unlikely that the client will choose your company for the next job. The bottom line is to plan carefully and practice, practice, practice.

6.10.1.6. *Speech Habits to Avoid*

Say, "The project has …." Do not say, "The project was broken into …." or "The project was divided into …." If the project is broken or divided, Client does not want it; Client wants a whole, integrated project.

Speak extemporaneously; do not read a script. Your presentation will be deadly dull and way too long, and you will look like you don't know anything about what you are saying and are reading someone else's script. Extemporaneously does not mean impromptu! Plan the presentation.

Talk to the audience and make eye contact. Do not talk to your notes or turn around and talk to the screen.

Use your hands to gesture with; if you put your hands in your pockets, you look insecure; if you cross your arms in front of you, you look defensive.

Do NOT say "myself." Ninety percent of the time students use that word incorrectly, so just do not say it. Use "I" or "me," whichever is appropriate.

Do NOT say "cheap"; instead say "inexpensive."

Do NOT say "off of"; instead say "from."

Do NOT say something is "important"; instead tell what its function or purpose is. If it is not important, do not discuss it.

6.10.2. POSTER PRESENTATIONS

Planning for your poster presentation should begin early. That is at the start of your project, along with how you will demonstrate your project if you have a working model.

For any poster presentation, you will be given guidelines regarding size, method of displaying, and identification. For Saluki Engineering Company poster presentations you are to buy one piece of standard size tri-fold poster board for you team. It will be displayed on a table. Usually the posters go up on Monday morning of final exam week; sometimes a visit from outside dignitaries requires that the team create and display the posters while the project is in progress. Be alert for changes in the schedule. Saluki Engineering Company management will evaluate them at noon of the day they go up.

Your team should use a judicious combination of graphics and text that covers all aspects of the project. Each graphic will have a number, a title, and a reference in the text. Use color to enhance comprehension as well as appearance.

The content of your poster will include:

- A title that is visible across the room
- A statement of the problem to be solved
- All parts of the solution
- The cost to implement
- The time to implement
- Identification: Saluki Engineering Company, SEC Reference number, names of people on the team, date.

Construction may include foam backing. This gives additional strength without much additional weight, but is more expensive. The poster may be created using Edge Designer software and the plotter located in EGR E215 (Instructions are posted on Web CT under Resources). Alternatively, the text and graphics may be affixed by spray adhesive. Your poster must hang together for three days. Cut straight edges straight, press out all bubbles from mounted text and graphics, erase all guidelines.

There are many poster examples will be in EGR E215 close to poster preparation time. Go look at them as you plan your poster. Remember that these posters were chosen for the archives because they did not fall apart and because they look nice, not because the content of the poster was correct, complete, or wisely chosen.

Before you glue anything down, check your poster for the C's:

- Clear — The poster should flow from a clear starting place, if the flow is not top to bottom, left to right, use arrows to direct the reader's attention.
- Continuous — The poster should tell a story, usually
  - What the problem is
  - Why it is important
  - What your recommended solution is
  - What the performance is or is expected
  - How much it will cost and how long it will take to implement
- Complete — The poster should reflect the problem statement, recommended solution, subsystems, expected/achieved performance, capital cost, and schedule to implement.
- Correct — The design should obey the laws of physics and mathematics, represent good engineering practices, and the poster should have no grammatical or typographical errors.
- Consistent — The poster should be self-consistent in technical content and in layout and design.
- Creative — The poster should use space and color creatively to enhance comprehension of the project.
- Cost, schedule, and identification — The poster will have these required elements.
- Concise and uncluttered — The poster should avoid being too "busy"; text and figures should not be copied from the written report but should be rewritten in a simpler, visually striking manner.

Bring a camera and take a picture of it for your memory book.

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CHAPTER 7 – OTHER PAPERWORK AND CONCESSIONS TO ACADEME

MEMOS

One of the skills every engineer needs is the ability to write effective memos. Most student writing is to show the professor how much you know. As a result, most entry-level engineers are very deficient in the art of writing memos. When information is given in a memo, the purpose is not to show off the engineer's knowledge, but rather to convey information the recipient needs in order to make informed decisions or acquire information the engineer needs in order to do work. This section explains how effective memos are organized.

The basic purposes of a memo are to solicit or give information and to generate a specific response. Effective memos are the ones that get the desired action. In order to achieve the desired outcome, the memo needs to get the attention of the individual to whom it is addressed, clearly present or request the information, and clearly indicate what the desired action is. Thus, memos have three sections: the Organizational Task (OT), the Technical Task (TT), and the Rhetorical Purpose (RP). Note that these three terms are presented for the purpose of discussing memos: they <u>never</u> appear in the memo itself. Sometimes a very brief memo can get all three parts into one sentence.

7.1.1.ORGANIZATIONAL TASK (OT)

The purpose of the OT is to orient the reader to what the memo is about <u>from the reader's point of view</u>. For instance, if you are writing to your company's Manager of Projects, you should be aware that while you have one project, the manager has many projects. The manager will need the memo to contain a reminder of which project the memo is about and, briefly, what the topic of project is. If you are responding to a memo from someone else, or following up on a telephone call or a request made in a meeting, indicate that at the start of the memo. Look at the memo from the recipient's point of view. What the recipient needs to know is "Why did <u>I</u> get this memo?" and "What does it have to do with, that I am involved in?" and "Why should I be interested?" Be sure that the first thing the recipient sees is how the memo relates to one of the recipient's tasks or interests. This is the organizational task. It tells the recipient why the memo deserves attention.

7.1.2.TECHNICAL TASK (TT)

The TT usually does not give engineers much problem. This is their reason for writing the memo. It presents the information that the recipient requested, the information the engineer wants to relay, or the background information the recipient needs in order to comply with the request in the next section.

7.1.3. RHETORICAL PURPOSE (RP)

Strangely enough, engineers usually omit the RP section. This section tells the recipient what the writer wants done, approved, or decided and when the writer needs the action or decision. Any memo that does not specifically request an action by the recipient becomes an FYI memo: For Your Information. FYI memos end up in the file cabinet, under a pile of papers, or in the wastebasket. They result in no action. There is nothing wrong with an FYI memo, if that is indeed its RP. However, any memo, for which you expect some sort of response, should have the specific response that you want spelled out as well as the time frame within which you need the response. You might not get the response you wanted, but you will get a response; then you can work with it or around it or negotiate.

When you write a cover letter for a job application, use the same OP, TT, RP format. In the RP tell them that you would like to hear from them regarding the job by a specific date. You may also add that if you do not, you will call them, but only if you actually intend to call. Similarly, when you write a job (project) related memo that requests approval for expenditure of money, attendance at a design review, etc., state explicitly what sort of response you want and when you want it.

7.2.SALUKI ENGINEERING COMPANY ABSENCE REQUEST FORM

In a real world company, you are expected to come to work each day; when management calls a meeting, either special or regularly scheduled, management expects you to show up: that is what you are being paid for. However, this is really a class, and some students think attendance is optional, i.e., that they are adults and can, therefore, decide for themselves whether they need to come to class or not. Your course instructors, on the other hand, look at class time as management called meetings. You are expected to show up.

Tuesdays are our regularly scheduled meetings; management will often hold a seminar or have guest lecturer on these days. All engineers will show up and be in their assigned seats on Tuesdays at the regularly scheduled time.

Thursdays are generally, if at all possible, reserved for team meetings; occasionally guest lecturers can come only on Thursdays. However, this is a class in a university and not a department in an engineering company, and university administration and your course instructors need to be able to find you. Teams will hold meetings that occur during regularly scheduled class times in the engineering complex on campus. A minimum of one person from each team will come the auditorium at the appointed time to get any announcements, urgent messages, mail, or handouts, and the course instructors will have a written memo indicating where your meeting is taking place; if this is not arranged in advance, the team representative will bring it to the auditorium. During these times, there are two rooms available and reserved for Senior Engineering Design: EGR A111 – the auditorium and EGR E215 – the EE laboratory space. You may also meet with your faculty technical advisor or in his or her laboratory space that has been assigned to your project. During the first week of the second semester, the course instructors will ask you for a memo; among the information requested will be the location of Thursday class-time team meeting. These meetings are to be formal team meetings with agendas. This is your work time when no one has any other class or work activity scheduled; use it productively. Your course instructors will stop by your meetings to see if you need any help or have any questions you did not ask during the general session at the beginning of the period. Be in your regularly scheduled place for the full one hour and fifty minutes unless you have made advance arrangements to be away, for instance, for a field trip to your client's plant.

All of the engineers in the senior design class are graduating seniors. All of you are expected to go on job interviews or visits to graduate school campuses. Occasionally, someone gets sick of suffers some other family crisis and cannot make a class or team meeting. Attendance is required and unapproved absences are not allowed. However, when you go to a career fair, have a job interview, or campus visit, you will fill out a Saluki Engineering Company Absence Request form and give it to one of the course instructors before you leave. If you should happen to be ill or have another emergency, you should bring a Saluki Engineering Company Absence Request form with you when you return. During the first week you will be give two such forms, there is one at the end of this section, and there is one posted on Web CT under Forms. You may make as many copies as you think you will need. Unlimited approved absences are allowed except during team presentations: you are required to attend your own presentation.

When you are scheduling your job interviews and campus visits, avoid the days on which engineering presentations are made. For the first semester, that means the days that proposal presentations are scheduled. For the second semester, that means days that progress presentations and design presentations are held. For specific days, see the tentative schedule for the current semester. Everyone needs practice making presentations, and all are entitled to have people in the audience when they are presenting; attendance is required at all presentations unless you have submitted an SEC Absence Request for an approved reason.

The SEC Absence Request form is on the next page.

Saluki Engineering Company Absence Request Form

I, ____________________________________, Team # _____, request permission to be absent from work on

____________________, _________________________ because of
(Day of Week) (Date)

- ☐ a job interview with (company and location): ____
- ☐ a professional meeting (organization and location): ____
- ☐ a religious holiday (specify holiday): ____
- ☐ a death in the family (relationship to deceased): ____
- ☐ serious illness in the family (relationship of patient): _______________________________________
- ☐ personal illness
- ☐ other reasons (specify): ____

___________________________________ (Signature)

____________________ (Today's Date)

Saluki Engineering Company Absence Request Form

I, ____________________________________, Team # _____, request permission to be absent from work on

____________________, _________________________ because of
(Day of Week) (Date)

- ☐ a job interview with (company and location): ____
- ☐ a professional meeting (organization and location): ____
- ☐ a religious holiday (specify holiday): ____
- ☐ a death in the family (relationship to deceased): ____
- ☐ serious illness in the family (relationship of patient): _______________________________________
- ☐ personal illness
- ☐ other reasons (specify): ____

___________________________________ (Signature)

____________________ (Today's Date)

PROGRESS REPORTS

At approximately mid-term in the second semester, management will ask your team to submit a progress report and make a progress presentation. These are formal reports presented to management and perhaps the client.

7.2.1. WRITTEN PROGRESS REPORTS

The purpose of the progress report is two fold: (1) to advise management where the project is, compared to where it is supposed to be, and (2) to require you to rethink your work schedule for the rest of the project. The progress report is designed to take the minimum amount of time consistent with the two-fold objective, i.e., the minimum amount of time for you to prepare and the minimum amount of time for management to read. Remember that the people funding the project are primarily interested in what they are going to get. This is the time for brutal honesty. If the project is not going to be finished as planned, NOW is the time to say so and re-negotiate what the project outcome will be. The Saluki Engineering Company progress report has four documents: (1) a memo, (2) an updated timeline, (3) an updated action item list, and (4) an updated RASI chart.

7.2.1.1. *The Memo*

Your progress memo will summarize the current state of your project with focus on

- Major currently unresolved problems
- Your plan to overcome them
- Major design changes since the proposal
- Major tasks completed and design decisions you have made
- What you need from management or the client; if nothing, say so.

You will, of course, write the memo in standard OP-TT-RP format, and it will include the SEC Reference number. The OP will inclde a brief description of the project, and the scope of this report.

7.2.1.2. *The Bad News Memo*

The progress report is the place to reveal any bad news whether it is that the project has been modified beyond all recognition, some of it will not be completed, you need a lot more money, or whatever. The goal of the bad news memo is to convey the bad news while at the same time maintaining a good relationship with Client and not creating ill will or closing any doors.

The structure of the bad news section is as follows:

- Introductory buffer: a neutral or positive statement about the subject
- Reasons for the situation: repeat some of the words and terms from the introductory buffer
- Bad news: briefly stated with a transition like, "For this reason, …"
- Closing buffer: a neutral or positive statement about the future of the subject

Under no circumstances let **any** of these words into any part of this memo: *However, but, yet, nevertheless, on the other hand, all the same, even, on the contrary, although, despite, in spite of, unfortunately,* or *regrettably.* These are all transitional axes that cutoff and nullify any of the neutral or positive things you have said previously, that announce to the reader to the fact you are about to relay bad news, and generally close doors and create ill will.

Be positive while delivering bad news by repeating words and concepts from the introductory buffer in the reasons section, and then transition to the bad news using one of these words or phrases: therefore, and, consequently, for this reason, because. These words and phrases create bridges from the positive statements. Do not forget to close with a positive, or at least neutral, closing buffer.

7.2.1.3. *The Updated Timeline*

This timeline will be the timeline from your proposal with an additional bar that shows when work on each activity began and when it finished. If an activity is not yet finished, indicate when you expect it to be completed.

If there will be changes to your schedule AFTER the date of the progress report, indicate those changes you can now foresee in a way that makes it clear what the as-bid schedule was and what the as-modified schedule is.

Include important milestones, such as **design review(s)**, both past and future.

Keep a copy of this updated timeline; you will need to update it again at the completion of the project and include it in the end-of-project memo.

7.2.1.4. *The Updated Action Item List*

This will include your normal action item list with the activities you have closed since your last submittal and the activities due to close in the next two weeks. Also it will have all the major activities from now until the end of the semester, including items for the design report.

7.2.1.5. *The Updated RASI Chart*

This will be the same RASI chart you submitted in your proposal – unless you have added or eliminated responsibilities or changed responsibilities around. Do not show the changes; just submit the current version of the RASI chart.

Add to the RASI chart responsibilities for items for the design report.

7.2.1.6. *Other Considerations*

If you have been keeping your timeline, action item list, and RASI chart up do date, the progress report will be almost trivial.

For written progress reports, following are NOT necessary:

- Expensive paper
- The whole report in the same font
- A cover – just staple the four documents together in the upper left corner with the memo on top.

Management will tell you whether they require a written progress report; ask your faculty technical advisor and client, if you have one other than your faculty technical advisor, whether they want one: written, electronic, both, or neither.

7.2.2. ORAL PROGRESS PRESENTATIONS

This is a formal presentation to upper management of your company and your client's company. Dress accordingly. Prepare the technical level accordingly. For more details, see The Oral Presentation and Other Presentation Guidelines from the chapter on Proposals. It is your responsibility to invite your faculty technical advisor(s) and client contact(s). A suggested outline of the presentation follows. Make a unified presentation and divide the time approximately equally. It is not necessary (or even desirable) for the engineers to talk about their own individual work.

7.2.2.1. *Introduction*

This tells the team number, project title, client, client contact person(s), team members, and faculty technical advisor(s).

7.2.2.2. *Outline*

This tells who will present what in what order.

7.2.2.3. *Executive Summary*

In this section, you will provide the project background: what you are doing, why it is needed, and how it is different. Continue with the assurance that everything is under control if it is. Explain any major design changes. If you need anything from management, make your requests known now. Do you expect to be finished with the project by the end of the design period?

7.2.2.4. *Discussion*

In this segment give a detailed project description with subsystem designations and a block (or other appropriate) diagram showing subsystem relationships. Give a summary of design decisions made. Present a plan to complete the project on time by showing a simplified, updated timeline and a simplified, updated action item list for the rest of the semester. Remember that each of the last two slides should have no more than 5 to 7 activities total. Explain the need for any additional resources.

7.2.2.5. *Summary*

The summary will include a brief project overview, summary of plant to finish on time, and a reiteration of resources needed, if any. A summary is a brief restatement. A summary is NOT a statement that says, "We told you what we have done and our schedule for finishing," or some similar list of topics discussed.

7.2.2.6. *Other Considerations*

Please look though the following checklist:

- Stay within your time limits
- Formal business dress is expected.
- No technical details.

7.3. **END-OF-PROPOSAL AND END-OF-PROJECT MEMOS**

During the course of business, companies must keep certain records. Some of these records are required for accounting and regulatory reasons; others facilitate planning, making bid/no-bid decisions, and creating reports. Likewise, SEC keeps records to facilitate planning, making include/don't-include decisions regarding proposed projects, and improving SEC policies and procedures. Specifically, SEC requests summary memos with specific information with the submission of proposals and design reports.

7.3.1. THE END-OF-PROPOSAL MEMO

When the team the final version of their proposal, they will also submit to the course instructors an End-of-Proposal (EPM) memo. This EPM will include:

- if the project will include a working model, a copy of the Resources Needed section from the proposal
- a time log for the proposal preparation phase that shows for each engineer: Date, Hours worked, Task(s) worked on

- a project management assessment report that tells what tools they used to manage the project to keep it on schedule and under budget, including any changes they made to their management process as the project proceeded
- recommendations to engineers undertaking proposals of this type in the future
- the complete project action item list with all items un-hidden
- the final RASI chart
- the initial timeline with as-bid blocks clearly identified and space for the as-worked blocks
- copies of all the team meeting agendas during the work period since the proposal acceptance. Do NOT re-type, if they are handwritten or the electronic copy has been deleted, just scan them in from the one you used, handwritten meeting notes on it are OK but obliterate any non professional notations.

The team may submit this memo either electronically or on paper, whichever is more convenient to the team.

7.3.2. THE END-OF-PROJECT MEMO

At the end of the project, the team will submit an End-of-Project Memo (EPM) to the management of Saluki Engineering Company, i.e., the course instructor. This EPM contains information relevant to your project valuable to the engineering company but of no interest to, and no business of, the client. This EPM will include:

- if the project included a working model an accounting of all the actual out-of-pocket, real-dollar expenses, copied from the design report
- if the project included a working model, the cost to build a duplicate, or slightly improved, prototype with no components donated or on hand; this may or may not be the same as in the design report
- a time log for the whole project that shows for each individual: Date, Hours worked, Task(s) worked on
- a project management assessment report that tells what tools they used to manage the project to keep it on schedule and under budget, including any changes they made to their management process as the project proceeded
- recommendations to engineers undertaking projects of this type in the future
- the complete project action item list with all items un-hidden
- the final RASI chart
- the initial/final timeline with as-bid (from the proposal)/as-modified (as shown in the progress report), and as-worked blocks clearly identified
- copies of all the team meeting agendas during the work period since the proposal acceptance. Do NOT re-type, if they are handwritten or the electronic copy has been deleted, just scan them in from the one you used, handwritten meeting notes on it are OK, but obliterate any unprofessional notations.

The team may submit this memo either electronically or on paper, whichever is more convenient to the team.

CONSESSIONS TO THE FACT THAT THIS IS REALLY A CLASS

7.3.3.EVALUATION

In the real world, the evaluation of your performance results in raises and promotions. According to S Kariya in the July 2002 issue of IEEE Spectrum, "Well-managed companies rate employees' performance with grades; typically the lowest acceptable rating is 'meets requirements.' Top workers earn a rating of 'consistently exceeds requirements.'[1] Performance evaluation in this class follows the same format; it is assumed that any engineer who can graduate can meet stated requirements.

In Saluki Engineering Company, the evaluation of your performance results in a grade in the course. In most courses there are exams for which the answers are known and laboratory exercises or projects that are limited in scope and that either work or they don't. The criteria for obtaining a specific grade is generally pretty clear cut and obvious to everyone. However, this class is different. Everyone in the class is doing something different from what everyone else is doing; also most people are doing something that has never been done before in the same way that it is being done now. For many projects, the probable, or even possible, success cannot be determined in advance. This makes criterion grading impossible. Your performance will be evaluated on the complexity of the part(s) of the project you work on, the diligence with which you work each week of the entire semester, the engineering results you produce, the contribution you make to the team dynamics, and the engineering documentation you submit. Your performance will be reviewed by a minimum of two people: one course instructor and your faculty technical advisor. It may be reviewed by all course instructors, teaching assistants, and industrial contacts as well. All of the people reviewing your project performance are experienced in teaching or reviewing engineering reports. Grades are not arbitrarily assigned.

Most items in the class are evaluated on a seven point scale:
0-1 => Missing or incomplete (MI)
2-3 => Meets requirements or OK (OK)
4-5 => Very good or well done (VG)
6-7 => Exceeds expectations (EE).

Any student who aspires to a grade of A will have many grades above 5 and no grade less than 3 that has not been corrected or improved and will have no unapproved absences.

Any student who aspires to a grade of B will have mostly 4s and5s in all subcategories, with no grade less than 2.

Any student who aspires to a grade of C will have mostly 2s and 3s in all subcategories and will have any grades less than 2 balanced by one, or more, greater than three.

Major deficiencies result in D level grades.

Work that is mostly missing or incomplete results in Saluki Engineering Company's permitting you to work for them for an additional semester.

Students who wish to debate their grade on the basis of design effort will present their design notebooks and demonstrate design effort commensurate with the grade they are seeking. If they are seeking an A, they will need to be prepared to explain why the work that they think they did not get credit for is not in the design report. All design work is reported in the design report; it is just as important to know what does not work as well as what does work. Having the particular option you worked on be selected for

[1] Kariya, Scott, "What I Did Last Summer," *IEEE Spectrum*, Vol. 39, No. 7, July 2002, page 49

inclusion in the recommended design is not a criterion for a high grade unless it was other than what the team needed for a successful project.

Students who wish to debate their grade on the basis of teamwork contribution will present their design notebooks where they have documented their teamwork activities; they will also have confirmation from their teammates. See the chapter on The Art of Teamwork for suggested teamwork activities.

Overall evaluation of work performance occurs in three generals categories: Design Process, Communication, and Teamwork.

7.3.3.1. *Design Process*

Elements of the design process are documented in detail in Design Notebooks, and the results are summarized in reports and presentations. Elements of the design process include information gathering, problem definition, idea generation, evaluation, decision making, implementation, and process development. The following descriptions indicate what is expected in each of these elements for maximum compensation.

7.3.3.1.1. Information Gathering

Excellence in information gathering is based on the use of many, widely varied sources. These will include state-of-the-art references as well as extensive interviews with Client to determine Client's needs and verify that you have understood them correctly. In addition to a summary of the information gathered together with complete bibliographic references, there should be documentation of the quality of the information and a synthesis of the information. That is, after the information is summarized, information from different sources should be related to each other and to the project.

7.3.3.1.2. Problem Description

The problem description includes the development of design goals and the specific requirements that will ensure a successful design. These design goals should come from with in the team, the Client, and others outside who are outside of the team and who have relevant knowledge. They will encompass technical, non-technical, and life-cycle issues. The goals will be clear and measurable, will have specified ranges, and will be revised over time.

7.3.3.1.3. Idea Generation

Gathering and creating new ideas and concepts for consideration are essential in the development of a design. This should be done initially at the system level and later at the subsystem level. Multiple methods should be used, varied, and used multiple times. All team members will participate.

7.3.3.1.4. Idea Evaluation

Appropriate methods and tools will be used to determine how well concepts meet the requirements. Considerations will include technical, financial, system, failure, life-cycle, environmental, ethical, and societal issues. Most evaluation tools will be some variant of the ideas vs. criteria matrix with numeric, symbolic, or qualitative evaluations of how well each idea meets each criterion. These matrices should appear in the design report along with an explanation of how they were used.

7.3.3.1.5. Decision Making

The full team will participate and decisions made by consensus. The system requirements will be periodically review, refined, and weighed. The solution will be improved and optimized by iteration and refinement.

7.3.3.1.6.Implementation

For design-study projects the implementation will be a set of engineering drawings and simulation results. For design-build projects the implementation will be a working model. It is expected that this model will be complete, delivered early, within budget, and meet or exceed all Client expectations.

7.3.3.1.7.Process Development

All of the design elements above will be used repeatedly, refined, and improved. The design process will be planned, recorded, and revised regularly. The details of the design process will be recorded in individual design notebooks. The results of the process will be summarized and recorded in the design report.

7.3.3.2.*Communication*

Communication includes professional quality recording and transfer of information. The information supports design excellence. The process ensures reliability and security.

7.3.3.2.1.Organization and Structure

The purpose of organization is clarity and understanding. The relationships of parts are clear and support the whole. Understanding of the information is greatly enhanced for varied readers.

7.3.3.2.2.Style and Language

The language and style should enhance the understanding and acceptance of the information by the target audience. It should support and stimulate understanding; be flawless, clear, and effective; look and sound impressive, attractive, inspiring, and professional. In short, the reports and presentations are to achieve a greater positive impact than desired and enhance credibility. Remember that the audience includes engineers and engineering managers. These people do not react favorably toward "Madison Avenue hype"; they are impressed by facts and numbers flawlessly presented.

7.3.3.2.3.Value and Reliability

Value and reliability includes ensuring and documenting the completeness and accuracy of the information. Information should be reviewed and updated regularly and contribute to the improvement of the design. The use of terms and statements of concepts should be accurate and illuminating. Error tolerances should be given and defended.

7.3.3.2.4.Listening and Responding

Communication is a two-way street. There should be evidence of active listening, willingness to learn, and the ability to outline, summarize, and ask questions. This will be evaluated primarily in your weekly meetings with your project director. Missing these meetings is not recommended.

7.3.3.2.5.Availability and Access

Information generated by team members will be generally available to all team members and will be kept up-to-date. Documentation of work will be irrefutable in a court of law.

7.3.3.3.*Teamwork*

Teamwork means that the team is structured for responsibility and performance, that members are empowered for success, and there is a clear team focus and commitment. Teamwork has elements of identity and purpose, roles and responsibilities, attitude and climate, resource management, operating procedures, and rewards.

7.3.3.3.1.Identity and Purpose

The team has a name and logo that enhances team identity and inspires success. The purpose of the team is clear, measurable, precise, challenging; focuses the team; and drives team achievement.

7.3.3.3.2. Roles and Responsibilities

Functional roles are assigned and revised over time. Members perform multiple roles during the project. All members accept, assess, and improve roles, Each member skillfully performs his/her own role and helps others.

7.3.3.3.3.Attitude and Climate

The team has energy that is positive, motivating, inspiring, lively, and charged for productivity. Members are respectful and supportive; they identify, encourage, and build each other's strengths. Conflicts are not only resolved effectively, but also they are used to develop team understanding and growth.

7.3.3.3.4.Resource Management

The skills of team members and outsiders are assessed, used, and developed. Both team and member milestones are set, monitored, and revised. A large variety of internal and external resources are creatively accessed and used.

7.3.3.3.5.Operating Procedures

SEC operating procedures are used to ensure effective team interactions and productivity. These processes are written, supported and approved by all, enforced, and revised as needed. Operating procedures are adapted and revised to define and aid interdependence, to build relationships, and to produce synergy.

7.3.3.3.6.Rewards

The team will have a reward system. The rewards will have multiple occurrences over the course of the project; some will be for team performance and others for member performance. Each of the rewards will be tied to team success and process improvement.

7.3.4.WHAT GRADE CAN I EXPECT IN 495A,B?

Probable Grade	**Quality of Reports & Notebook**	**Quantity & Difficulty of Design Effort**	**Contribution to Teamwork**	**Prototype Working (if applicable)**
A	Professional	Extraordinary	Inspiring, encourages team achievement, improves processes	---
	Rough draft	Extraordinary		Yes
	Professional	Average		Yes
B	Professional	Average	Positive, effectively performs major roles, organized	No
	Professional	Trivial		Yes
	Rough draft	Extraordinary		No
	Rough draft	Average		Yes
	Incomplete	Extraordinary		Yes

C	Incomplete	Extraordinary	Polite, minimally fills roles, generally dependable	No
	Rough draft	Average		No
	Rough draft	Trivial		Yes
	Incomplete	Average		---
D	Rough draft	Trivial	Disrespectful, disruptive, unreliable	No
	Incomplete	Trivial		Yes
	Very incomplete	Average		---
F or INC	Incomplete	Trivial	Usually absent, little interaction	No
	Very incomplete	Trivial or none		---

Notes:

1. Poor attendance in lectures or team meetings may lead to a substantially lower grade, even failure.
2. Reports include written reports, oral presentations, and, in 495B, poster presentations.
3. In general,
it is extremely difficult to earn an "A" without professional quality reports;
to get an "A" or "B" you need both professional-quality reports and significant design effort; and
to pass the course you need both at least student-quality reports and some design effort.
4. These are not hard and fast rules; however, grades usually follow this outline.
5. Extraordinary design effort includes timeliness as well as quantity and quality well beyond what would normally be expected of an undergraduate engineering student
6. In general, expect an "A" ONLY if you have done significant design work AND there are no omissions in your design report from the check lists given in Sections 5.2 and 5.4.5.2.

7.3.5.ECE 495A GRADING POLICY

The grade for ECE 495a will be based on the following:

- Technical Communications (50%)
- Attendance (7%)
- Weekly Action Item Lists plus other requested documents (10%)
- Oral Proposal Presentation (8%)
- Written proposal (25%)

In order to earn a grade of A, students must

1. correct all of the problems with their written proposals to the satisfaction of their real-world client, if any; Faculty Technical Advisor; and course instructor
2. have satisfactory attendance, Action Item Lists, and oral presentation
3. earn an A in Technical Communications.

Unsatisfactory completion of items 2 or 3 above will result in one letter grade reduction each for the course grade. An INC or F in either the Technical Communications part or the Senior Design part will result in an overall grade of INC or F.

Grades for ECE 495a will be INComplete until the course instructors have received:

- an electronic copy of your final, corrected proposal posted on Web CT by the team
- two spiral bound copies of your proposal, from the team
- the ECE 495a Course Evaluation Form, located on Web CT under Forms, from each individual
- the Teamwork Evaluation Form, located on Web CT under Forms, from each individual

7.3.6.SALUKI ENGINEERING COMPANY EXIT POLICY

Engineers who wish to leave SEC for better paying jobs need to review the following checklist. In addition to the regular engineering reports, SEC engineers are required to submit the following:

- All SIU keys that your were issued to you
- All other things that you have borrowed from people on or off campus
- Your team work evaluation form
- Your exit interview: do NOT show up for your exit interview without your exit interview form filed out.
- Your design notebook.

Work for SEC will be INComplete until all of the above have been satisfied.

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