NAVFAC
Naval Facilities Engineering Command

FUNCTIONAL ANALYSIS CONCEPT DEVELOPMENT MANUAL

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ABSTRACT

This manual will present a function-based system that quickly focuses teams on a task, facilitates communication, builds a consensus and achieves results. Function Analysis Concept Development, (FACD) was originally used to prepare design concepts for military construction projects. It has since been applied to master planning, project programming and other applications where it was essential to quickly build a consensus and achieve results. FACD has reduced design and construction costs on military construction projects and has improved customer satisfaction with the design process.

The manual will focus on the FACD operating philosophy and application of FACD tools rather than describing a step by step process. Application of FACD requires hard work and commitment. It is only through understanding and acceptance of the FACD philosophy and a working knowledge of the FACD tools that the power and flexibility of FACD can be realized.

References to steps in FACD used on design concepts for military construction projects are provided to illustrate the application of the FACD tools. They are not intended to present a recommended step by step procedure. It is recommended that readers develop their own policies and procedures to implement the FACD philosophy. Identification, communication and agreement of required functions are the key elements in FACD. It is recommended that this first step be retained in the FACD methodology.

The FACD philosophy is: "Understand the customer's wants, needs and expectations in functional terms; identify materials, systems and processes that can provide those functional requirements; and jointly select high value systems that provide the best possible performance within identified constraints." This may sound like an obvious task. It often goes astray, however, when customer expectations are incorrectly identified or when customer input and consensus aren't fully nurtured.

FACD tools described in this manual include:

Description	Application
Function Analysis	Function identification and communication
Function Analysis System Technique	Function identification and communication
Development of Proposals	Identification of materials, systems and processes
Life Cycle Costing	Identification of materials, systems and processes
Cost Cutting	Identification of materials, systems and processes
Charrette Format	Getting customer input and facilitating consensus
Conduct of Meetings	Getting customer input and facilitating consensus
Making Presentations	Getting customer input and facilitating consensus
Documenting Agreements	Getting customer input and facilitating consensus

FOREWORD

FACD is a powerful tool that facilitates quick understanding and consensus on the functional requirements of any task or assignment, identifies possible materials, systems and processes that can furnish those requirements and facilitates reaching consensus on a specific plan of action.

Individuals from other agencies have participated in FACD activities first hand and gained an appreciation for what the FACD can do and how it differs from more traditional approaches. Hopefully, these individuals will be able to convey their experience to their organizations and incorporate some of the FACD principles in their work processes. This manual was developed to assist them in carrying that message.

INTRODUCTION

This manual is organized into two parts. It starts with a discussion of the events that lead to the development of FACD. It will discuss use of the FACD "process" to prepare design concepts for military construction (MILCON) projects in the early 1990s and the adaption of that "process" for master planning, project programming and ad hoc studies. It is intended that this discussion of FACD's progressive development will allow the reader to better understand the FACD operating philosophy and application of the FACD tools. The second part of the manual will present the FACD tools. The tools are presented roughly in the order that they are used in the MILCON FACD process. This organization was selected to help the reader better understand its application. This organization is not intended to imply when the tool should be used or in fact that it should be used at all. This section should be considered to be similar to a carpenter's tool chest. A carpenter will generally use a saw, then a plane, then a hammer, then a screw driver and then a sanding machine. These tools don't have to be used in that order, however, nor does every tool have to be used. Tools should only be used when they can improve the results.

Neither reading this manual, nor participating in a live FACD study can provide the complete FACD experience. It is suggested that individuals wanting to learn and apply the FACD methodology first read this manual and attend a FACD training workshop where the FACD tools will be practiced. The final step in the FACD learning experience is to participate in several live FACD studies. It is only through this academic and practical learning experience that a complete understanding of the FACD philosophy and tools can be obtained. The FACD practitioner can then adapt the philosophy and tools to be more appropriate for his own organization and environment.

The concept of constant improvement was the impetus that started FACD. Other practitioners will develop new tools and procedures that improve FACD. Sharing new ideas and experiences can only improve the methodology. FACD, Charrette, Squatters Session and practitioners of other similar systems are invited to share their ideas and experiences.

FACD History

In the early to mid-1980s the Pacific Division, Naval Facilities Engineering Command (PACNAVFACENGCOM) was using what can be called the traditional design process (see Figure 1). The traditional design process starts with the project programming document. For military construction projects this is normally Form DD1391. This document describes in detail the planned construction and authorized project cost. In most instances it defines the authorized floor area, the building materials and systems, project justification, environmental considerations, and other aspects of the planned construction. It doesn't explain the work process that the facility must support nor relate how the design details listed in the document support or relate to that work process. An example of a DD1391 is shown in Figure 2. You will notice that the document does not address work functions, but addresses facility construction. The traditional design process starts with a two to four hour pre-design meeting between the project designer and representatives of the Base acquiring the new facility. Optimally, the facility operator should participate in this meeting, but most often it is the Base Engineering staff that prepared the programming document that attends this meeting. Usually, the discussion focuses on clarification of the facility construction described in the DD1391. For example, the designer may ask what is included in the authorized floor area shown on the DD1391.

Traditional Design Process

Programming Document

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Pre-design meeting

↓

35% design submittal

↓

VE study

↓

Design review

↓

Redesign

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Further cycles of design submittals, reviews and redesigns

Figure 1
Traditional Design Process

1. COMPONENT: NAVY — FY 1997 MILITARY CONSTRUCTION PROJECT DATA — 2. DATE: 26 Apr 95

3. INSTALLATION AND LOCATION: MARINE CORPS BASE HAWAII KANEOHE BAY, HAWAII

4. PROJECT TITLE: AVIATION SUPPLY FACILITY (BRAC 93)

5. PROGRAM ELEMENT — 6. CATEGORY CODE: 211.96 — 7. PROJECT NUMBER: P-274T (REV E) — 8. PROJECT COST ($000): 2,700

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
PRIMARY FACILITY	SF	20,000		1,660
AVIATION SUPPLY FACILITY	SF	20,000	83	(1,650)
INFORMATION SYSTEMS	LS			(10)
SUPPORTING FACILITIES	LS			750
SITE IMPROVEMENTS	LS			(120)
CIVIL UTILITIES	LS			(240)
ELECTRICAL UTILITIES	LS			(390)
SUBTOTAL				2,410
CONTINGENCY (5%)				121
TOTAL CONSTRUCTION COST				2,531
SIOH (6.5%)				165
TOTAL REQUEST				2,696
TOTAL REQUEST (ROUNDED)				2,700
EQUIPMENT FROM OTHER APPROPRIATIONS				(24)

10. DESCRIPTION OF PROPOSED CONSTRUCTION
Construct a permanent aviation supply facility to accommodate Navy aviation units relocation to Marine Corps Base Hawaii (MCBH) Kaneohe Bay. Proposed project will construct a permanent one-story building of reinforced concrete structure/slab/foundation, masonry exterior wall and insulated built-up roof, to house Navy aviation supplies and associated administrative office space. The building will be equipped with fire sprinkler system and office space central air conditioning system, and the supporting facilities include, driveway pavement, fencing, and utilities. The project also include relocating displaced parking.

11. REQUIREMENT:

CAT CODE	REQUIREMENT	ADEQUATE	SUBSTANDARD
211.96 Aircraft Spare/Storage	20,000 SF	0 SF	0 SF

PROJECT:
Construct permanent concrete aviation supply facility at MCBH for Navy aircraft relocating from Naval Air Station Barbers Point (NAS BARPT). (BRAC 93)

REQUIREMENT:
Base Closure and Realignment Commission 1993 (BRAC 93) requires the closure of

DD FORM 1 DEC 76 1391 — PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED — PAGE NO. 1

Figure 2

Programming document addresses hardware not function

He may also ask what is included in the site improvement work. He may then share cost or other problems that he sees with the planned construction. Items that often cause cost problems are difficult geotechnical conditions, inadequate utilities and environmental remediation that were overlooked when the project was programmed. If the facility operator attends the meeting he may also add items to the project that were again overlooked when the programming document was prepared. The designer often uses this forum to get feedback on the acceptability of lower cost/ performance options. These options are most often rejected because the Base isn't given the full picture and they see that accepting lower performance will adversely affect their operation. For example, one potential lower cost proposal may be to use a pre-engineered metal building for the Aviation Supply Warehouse. The design team then returns to their office and develops the preliminary design. Several months later, the preliminary design submittal arrives and a design review is scheduled. A value engineering (VE) study is usually commissioned at this time and the recommendations of the VE study is presented at the design review. Projects are often over-budget at this stage of design, but the designer is often asked to proceed on the expectation that something will happen that will resolve the cost problem. As an example, roughly seven of the eight military construction projects in the fiscal year (FY) 1993 U.S. Navy military construction program (MCON program) being design by PACNAVFACENGCOM were over budget at 35% design. Resolution of these cost problems later in design caused significant redesign and consequent design completion delays. After the design review is completed, design review comments and the VE recommendations are incorporated in the design and another series of design submittals, reviews and redesigns ensue until the project is finally constructed. Occasionally, these series of redesigns continue through construction with major impact on the final constructed cost of the facility. For example, there was one aircraft hangar project where the construction was stopped and the floor plan redesigned after the hangar foundation was in place and the superstructure was being erected. In this instance, the customer wanted to accommodate a second squadron in the hangar which was originally designed for one squadron. The construction contract change order for this change was almost 50% of the original contract amount.

Typical complaints about the traditional design process are:

- User says scope not adequate
- Project under-budgeted
- User changed his mind

Some of the reasons why these problems exist are: 1) The military does not put enough resources into project planning and programming. Often less than 80 man-hours of work are put into preparation of the DD1391 for a multimillion dollar facility. This is only enough time to prepare schematic drawings and cost estimate and to generate a justification for the project based on whatever information is at hand. There isn't enough time to thoroughly investigate infrastructure improvements, alternate materials and systems or alternate sites let alone to learn about the work process that the facility is to support. 2) Designers don't realize that the project scope and cost shown in the programming document are based on such limited information and assume that the DD1391 accurately depicts the exact facility that the client wants constructed. He therefore focuses on understanding the construction details described in the DD1391. It is not surprising that designers often have very little understanding of the functional requirements that the facility has to fulfill. The poor communication between the designer and facility operator is often the reason why customers are often unhappy with the services that we provide.

At the same time we were using the traditional design process we were conducting many value engineering studies. We all understand what value engineering is, don't we? Value engineering means cutting cost, deleting aesthetics, reducing scope, "cheapenizing" the facility, etc. These cost cutting efforts result in increased maintenance, reduced performance and increased risk. Good value engineering studies, and the emphasis is on "good", improve value. What does this mean? Value can be improved if performance is increased for the same cost or a modest increase in cost. Value can likewise be increased if cost is reduced and performance remains the same.

Good value engineering studies take a different approach to identifying project requirements than traditional design. As shown in Figure 3, good value engineering studies start by identifying required functions. It then proceeds to identify alternate materials and systems that can provide the required functions at hopefully less cost or provide more function at the same cost. Formal design and cost analyses are prepared and are presented to the project stakeholders for their consideration. High value alternates are selected and are incorporated in the design.

VE Studies

Identify required functions

↓

identify alternates

↓

evaluate alternates

↓

select high alternates, if any

↓

redesign project

Figure 3
Value Engineering Process

This function approach to project development sometimes leads to a different conclusion on facility requirements than are developed in the traditional design process. For example, there was a project to construct a breakwater, small boat harbor and boat repair facility along an open section of coastline (see Figure 4). The first phase of the project was to design and construct the causeway, breakwater and landfill. The second phase was to construct finger piers and moorings for the boats and the small boat repair facility. The design for Phase 1 was already completed when we were asked to conduct a value engineering study on the preliminary design for the second phase. The cost of constructing the breakwater and causeway in open water had increased the estimated construction cost for the first phase to the point where the first phase of the project was over-budget. The second phase of the project was also over budget, so the berthing piers were identified as an additive bid item. The small boat operators said they were aware that the berthing piers were an additive item, but said they really did not understand what an additive bid item meant. The small boat operators were shocked when it was explained that an additive bid item meant that it was unlikely that the berthing piers would be constructed because the designer does not think that the piers can be constructed within the authorized budget unless we find a contractor that is willing to lose money on the

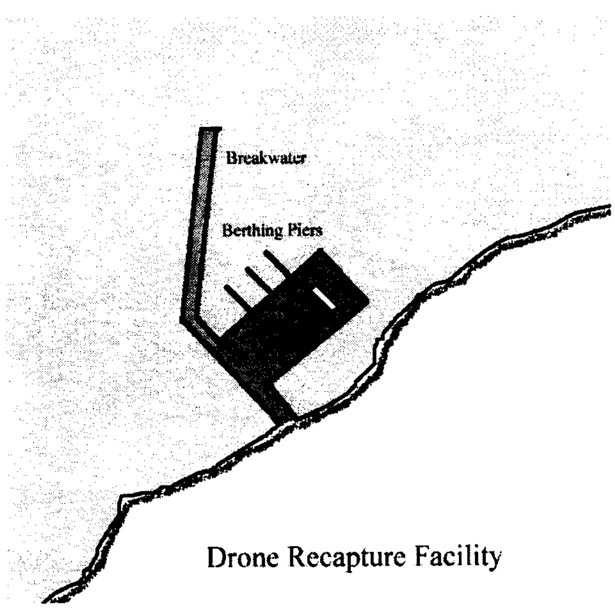


Figure 4
Small Boat Harbor

contract. They told us that the whole purpose for the project was to construct berthing for the small boats and they didn't need the project if the piers were not constructed. Eventually the project was canceled and the small boat operation moved to a leased wharf in the nearby commercial port. The point of this story is to illustrate that often the designer and in this case the design agent did not understand the functional requirements of the project. Considerable time and design effort were wasted because of this lack of understanding.

There are many other similar stories. We did a value engineering study on a jet engine maintenance shop where the designer planned to install a monorail to move engine components through the shop. As show in Figure 5 the monorail was routed over each workbay. He did not understand that the jet engine is dismantled as soon as it enters the shop and individual components are routed to the specific workbay that works on that component. Having to route engine parts over each workbay would disrupt work in each area. The VE study recommended installation of a bridge crane. Other cost saving measures were incorporated in the design to offset the additional cost of the bridge crane.

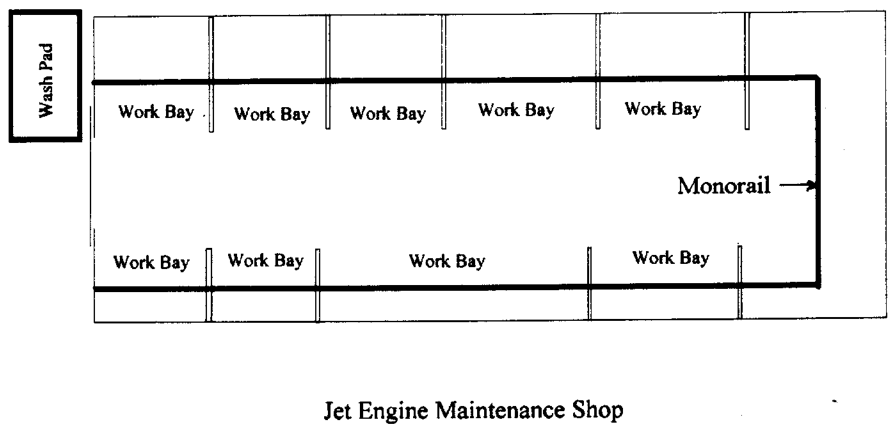


Figure 5
Jet Engine Maintenance Shop

Value engineering studies conducted during this period were helping us meet budgets, but they were increasing design cost and were often delaying projects. Clients also saw VE as an unnecessary expense that was degrading their facilities and designers did not like others second guessing their designs.

It was apparent that both the traditional design and VE processes needed improvement. These are some of the problems that have to be resolved:

- Project scopes described in programming documents don't accurately describe the required facility construction.
- Project budgets are often inadequate to construct the facility described in the programming document.
- Redesign and overlooked items, such as, environmental regulation compliance increase cost and delay execution.
- Facility operators and project sponsors believe that designers and design agents are not providing good service.

To correct these problems the following improvements should be initiated:

- Programming documents need to be improved. If better programming documents can not be guaranteed, then designers have to revisit planning and programming issues and validate that the project scope described in the programming document accurately describes the required facility construction.
- Designers and design agents need to understand the basic work functions that the facility construction is supposed to support to validate that the project scope and design concept provide the facility needed to support the work process . It is only through this understanding that a designer can make appropriate design decisions that affect facility operation.
- Designers and design agents need to understand customer expectations so they can provide better service.
- Designers and design agents need to formally identify and evaluate design alternates that can provide the required functions. System selection based on "experience" often does not result in the best choice.
- Designers need to share design information and analyses with facility operators and project sponsors and to include them in design decisions. This will facilitate resolution of budget problems and will improve customer satisfaction with the design process.

In early 1987, Mr. Michael Koga, the PACNAVFACENGCOM VE Manager, presented an improved design philosophy at a Tri-service conference held at Kadena Airbase, Japan, that incorporated the function identification and system analysis methodology used in value engineering studies. The improved design philosophy shown in Figure 6 is now called FACD. The attendees at that Tri-service conference endorsed the new design approach, but the philosophy wasn't put into the form of a design process until early 1992.

In early 1992, PACNAVFACENGCOM was unexpectedly tasked with executing a large military construction program resulting from the closure of U.S. Military bases in the Republic of the Philippines. Mr. Erik Takai, the PACNAVFACENGCOM Design Director, asked that the FACD be initiated to expedite delivery of facilities in this large construction program on time and in budget. Many of the work processes and procedures used today were developed to implement this directive.

From the initiation of the FACD philosophy in 1987, it was realized that the process flow shown in Figure 6 would have to be repeated over and over until an acceptable product was developed. It was also realized that facility operators were an essential element of the FACD. Who else but the facility operator could provide the information and feedback required to adequately

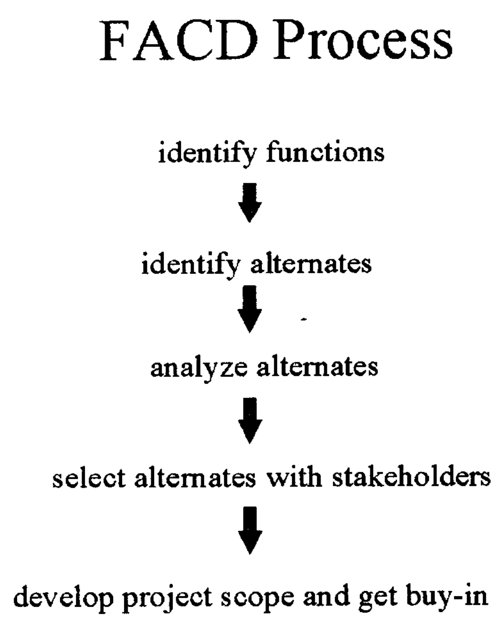


Figure 6
FACD Process

identify required functions. It was also realized that the designer would have to include the facility operator, project sponsor and other stakeholders in the facility acquisition process at each step in the design development to get feedback and buy-in to the final design concept.

Architects use a "show and tell" format called an architectural charrette to develop the architectural scheme for a project. An architectural charrette is a series of concentrated work sessions normally held at the clients place of business where the architectural concept for a facility is developed. The process normally starts with an initial meeting with the client where the designer asks the client questions about the budget and his expectations for the project. The architect then returns to his work space and quickly prepares drawings showing his interpretation of the client's desires. These concept drawings are presented to the client and comments are solicited. The architect returns to his work space and revises the drawings to incorporate the comments. The revised drawings are again presented to the client and comments solicited. The series of show, tell and revise sessions continue until an acceptable architectural concept is obtained. FACD adopted the architectural charrette format to get customer input and buy-in to the final design concept.

It was realized that FACD would have to include much more than development of the architectural plan to realize some of the desired improvements discussed earlier. First, enough design cost estimating would have to be done on the architectural and engineered systems to allow a commitment to be made on meeting authorized budgets. Second, all of the common roadblocks to execution would have to be investigated to insure that action was taking place to address the issue. A list of common roadblocks to execution are contained in Appendix A . Third, formal analyses of materials and systems have to be included to insure that high value components are selected. Value engineering studies show that redesign, increased design cost and design delays can result if system selection is not based on formal analyses.

Although not listed as an area requiring improvement, it was realized that design teams needed to better coordinate their work. Although designers say that they always coordinate their work, most often each design discipline works alone. The usual method is to have the architect prepare the building layout. The layout will be passed to the other design disciplines to prepare their part of the design. Design coordination meetings are periodically held to "coordinate" the design. This operating method is not always successful in coordinating all aspects of the design because design is dynamic and changes from minute to minute. FACD, from its very inception, included renting or obtaining work space for the design team at a location away from their normal place of business. The work space must be large enough to allow all members of the design team to work in. Working away from their normal place of business allows the team to concentrate on one project and improves their efficiency. Also, many designers have said that working in the same room with the other design disciplines made them better understand how their part fit into the whole project. They have also said that the teamwork that is developed by working together continues on through the following design stages and allows them to better coordinate the design. Many designers would rather work in their own office because they feel that they have more resources there and they can also concurrently work on other projects. Working in work space away from their normal place of business is an important part of FACD.

PACNAVFACENGCOM has conducted over 100 FACD studies on military construction projects since it started using the improved design process in early 1992. The immediate result of its "rollout" in 1992 was improved customer satisfaction with our design services. FACD studies on military construction projects are generally completed in two weeks. Customers quickly see the effect of their input in the design as compared to the traditional design process where it may be months or years before the cycle of submittals, reviews and redesigns is completed. Also, design submittals are usually "blueprints", technical specifications and design calculations. Many facility operators are not experts in reading engineering drawings and often they may not fully understand the facility that they approved until they see the constructed facility.

One example where FACD improved the value of a project was for a project to construct a new freezer facility. The project was to construct a 18,000 square foot (sf) freezer plant. Initial on-site discussions with supply personnel indicated that it would be desirable to have more freezer capacity, but the critical deficiency was in dehumidified storage. A larger amount of dehumidified storage was required at this location because high temperature and humidity that prevailed throughout the year would cause rapid deterioration of items such as soft drinks and flour that would normally be stored in general storage. It was also discovered that excess refrigerated storage space was available because most refrigerated product moved directly from the commercial port to customers. Some of that refrigerated space was designed to be used for either refrigerated or freezer use. The FACD resulted in a revised project scope that included construction of a 4,000 sf freezer plant, refurbishing the convertible freezer space and conversion of 93,000 sf of general storage to dehumidified storage within the original project cost.

Another example of FACD's success was on a BEQ construction project. The programming document provided for a naturally ventilated, 17 story BEQ that was to be located near one of the main entrances to the Pearl Harbor Naval Complex. Poor soil conditions and petroleum contamination made it highly unlikely that the facility could be constructed within budget. The user was also unhappy about the visual impact that a massive building would have at the entry roadway and the absence of air conditioning in the project. The use of naturally ventilated barracks was the result of an earlier energy conservation initiative, but experience with previously constructed naturally ventilated barracks in industrial areas had not proven to be satisfactory. The dirty, high noise environment makes it desirable to close windows and air condition interior spaces. The FACD resulted in re-siting of the facility to a larger site with better geotechnical conditions and less contamination. It also allowed the development of a mid-rise complex with air conditioning and is considered to be the best BEQ at Pearl Harbor. However, it wasn't easy to make these changes. The changes required the support of the Commander Naval Base Pearl Harbor and the Commander Submarine Forces Pacific to get the prior planning and programming decisions changed to allow the construction of the new Gabrunas Field BEQ.

Project cost control and design execution have also improved. Facility operators are often willing to accept cost cutting proposals that are required to meet authorized budgets when they are given good information and are part of the decision process. Execution has greatly improved with FACD and a new military construction design schedule that reduces the number of design submittals and reviews. Prior to 1992, a minimum of three design submittals were required - preliminary, pre-final and final submittals. There was normally a six month wait between submission of the preliminary design and authorization to go to final. Currently, after the FACD is completed the next formal submittal is at the pre-final stage. An over the shoulder review at the 65% design stage is also held to insure that the design is implementing the FACD design concept. These changes have reduced the normal design period from 1-1/2 years to roughly eight months.

Other results of the FACD studies we've conducted have been an overall reduction in design costs and a dramatic reduction in construction change order rates. Design costs and construction contract change order rates were examined for military construction projects programmed in roughly fiscal years (FY) 1993 through 1996. FY 1993 was selected because this is roughly the time frame when FACD was started. Financial records for projects in program years after FY 1994 were reviewed, but construction had not yet been completed on those projects. Projects after FY 1994 are therefore not included in the data. Design costs include all costs incurred on a project from the date the design was authorized until the design was completed. Post contract award costs were not included as a design cost even though this cost was often obligated prior to design completion. The design cost percentage was calculated by dividing the total design cost by the initial contract award cost. It was believed that the initial contract award cost more accurately reflected the project construction cost than the estimated cost of construction.

As shown in Table 1, the results of this examination show that FACD projects have an overall design cost roughly 30% less than non-FACD projects. More dramatically, FACD projects also show a construction contract change order rate 44% less than non-FACD projects. Figures 7 and 8 graphically show the distribution of projects within each percentage range. Although the charts show a considerable variation in both design cost and construction contract change order percentages, particularly for non-FACD projects, there is a definite reduction in both design cost and change order rates for FACD verses non-FACD projects.

One can speculate about the reasons for this reduction in design cost. For one thing we have reduced the number of design submittals and reviews. The reduction in submittals should have reduced design costs. It is also evident that FACD reduces redesign cost. Major project redesign, which was a significant problem with the traditional design approach, has been reduced to a minimum. This reduction in redesign has improved execution schedules as well as reduced design cost. This reduction in redesign appears to be the result of the FACD's function approach. Defining project requirements in functional terms makes it less likely that decisions will be made on personal preference. This reduces the problem caused by the turnover of personnel at many military commands.

It is likely, however, that the most important reason is that we are negotiating better design fees. We generally negotiate a fee only for the FACD study and negotiate the fee for the final design after the FACD is completed. Once the FACD is completed the designer and Government fully understand the extent of the design work required to complete the design and are better able to negotiate a fair and reasonable fee. Under the traditional design approach the full design fee is negotiated before the start of the design. Both the designer and the Government therefore have to include contingencies in the negotiated fee to accommodate changes to the scope and design concept of the project.

Explaining why FACD is reducing construction contract change orders is more difficult. It is logical that FACD should reduce customer requested changes during construction because of the work done during FACD to define the project scope. The data does not support this theory. It shows, in fact, that customer requested changes are higher on FACD projects. It is speculated that customer requested changes are more closely related to the amount of funds available after award of the construction contract than overlooked requirements. The change order data instead showed a reduction in all categories - design errors, unforseen conditions, etc. It is speculated that design teams better understand project requirements through the FACD process and are better able to make value judgements on the systems and materials in the project. Designers have also said that teamwork that starts during FACD continues through design and may result in better coordinated designs. An architect in one of our FACD training classes also said that reduced redesign reduces coordination errors. In any event, FACD reduces construction contract change orders even if there isn't a clear relationship between FACD and the change order rate.

Table 1

	FACD STUDY	TRADITIONAL DESIGN
# of Projects	19	26
Design cost % (mean)	10.85%	15.10%
Design cost % (median)	11.66%	14.83%
Range	7% - 31%	1.34% - 24.68%
% Construction Change Orders (mean)	5.14%	10.90%
% Construction Change Orders (median)	2.88%	7.81%
Range	0.83%	0% - 54.51%

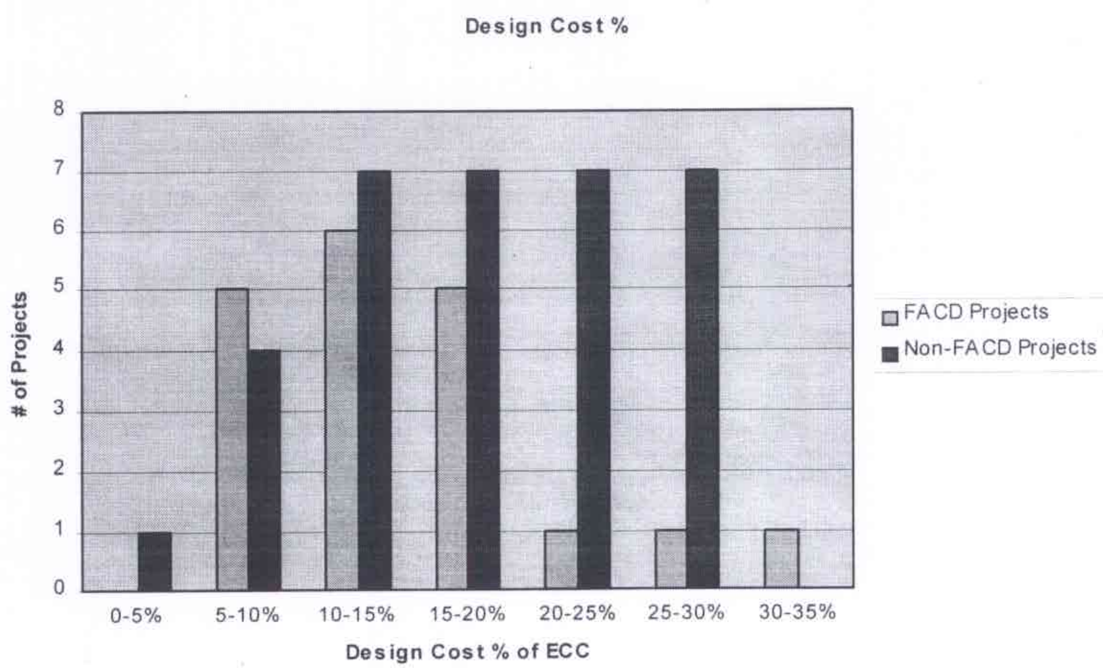


Figure 7
Design Cost Percentage

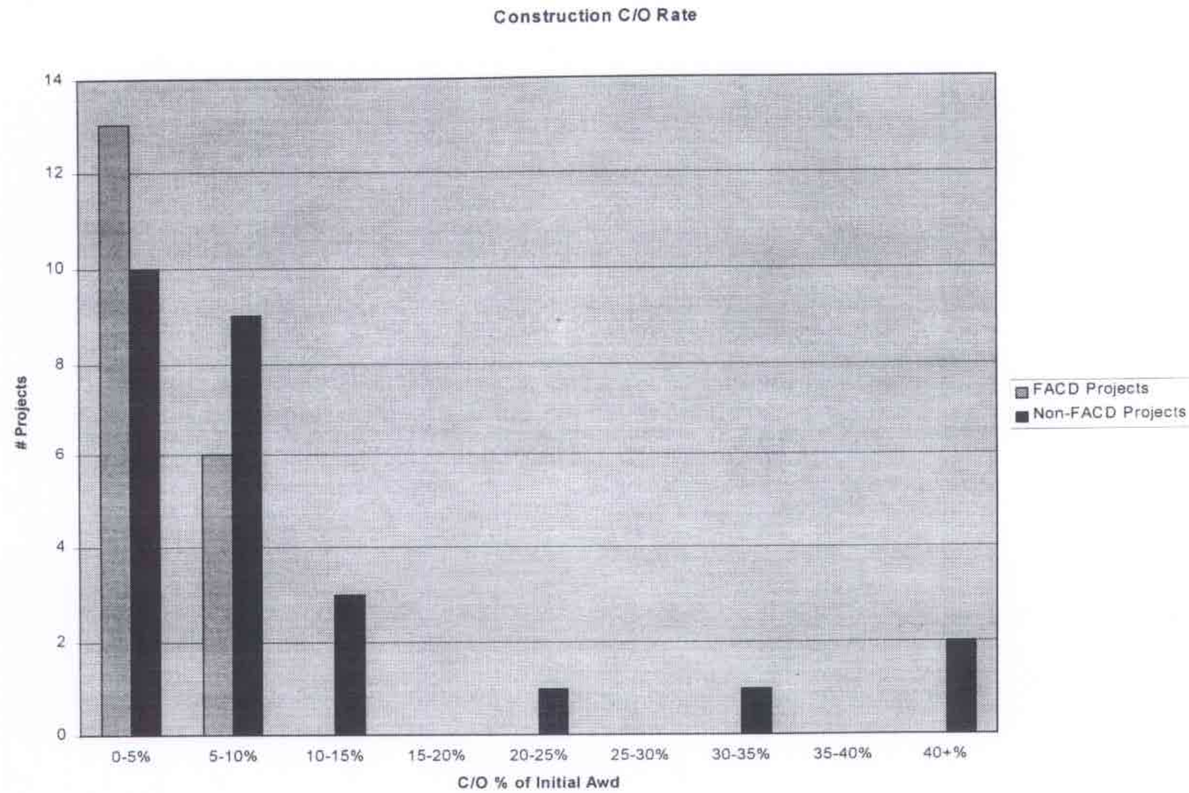


Figure 8
Change Order Percentage

FACD has been used on master plans, programming documents and ad hoc studies subsequent to it's start as an improved design process. Figures 9 and 10 show some examples of FACD's use on some of these assignments:

Master planning

- MWR Recreational Facilities, Camp Butler. Okinawa

- Navy Hospital Relocation, Okinawa

Figure 9

Workshops

- MCAS Futenma Relocation

- Sustainable Design Workshop

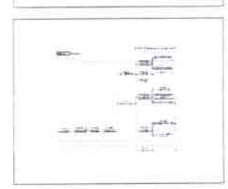


Figure 10

Master plans prepared for recreational facilities at Camp Butler and for relocation of the Navy Hospital on Okinawa used elements of the FACD methodology. They used function identification to understand the customer's expectations for the planned construction, the charrette format to get customer input and buy-in, published a master plan report to document agreements and published minutes of meetings to document the process.

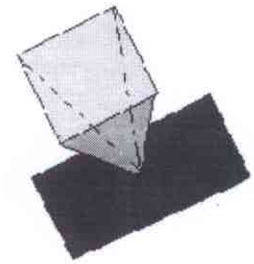
FACD has also been used at workshops where it was necessary to quickly focus the group on the task and to reach consensus on a plan of action to deliver a product in a short period of time. One such action was a workshop to get consensus on the operational requirements and facility construction for relocation of Marine Corps Air Station (MCAS), Futenma, Okinawa, Japan. MCAS Futenma is located in the dense urban center of the island of Okinawa. The aviation operation restricts civilian development and the local government has wanted to get this activity relocated for many years. The Japanese government committed to relocate this activity with the stipulation that it be relocatable. At the time the workshop was conducted the plan was to construct a multi-billion dollar floating airfield. The U.S. Government was to provide the Japanese with the scope of the required facility construction and the criteria to which those facilities would be designed. Over 50 high level military and civilian representatives took part in the one week workshop. Many participants had doubts that anything significant would be accomplished because the military had been wrestling with this problem for over a year with little progress. The workshop used function identification to get concurrence that the air station will be used to preposition helicopters and other vertical takeoff aircraft that support Marine ground forces stationed on the island. These aircraft would deploy with the ground forces during contingencies. The primary activity in garrison is to train and maintain equipment. The group then split up into 6-10 man teams to address specific functional areas identified in the FAST diagram, i.e. fuel, maintenance, ordnance, safety and survivability, etc. Each team further used function identification, function alternates and function evaluation to prepare a plan of action in their assigned area. Workshop's recommendations were accepted by service commanders at the conclusion of the week. Participants were amazed at the quality of the results and the speed that they were developed. They all fully credited FACD with their success.

Our experience on these studies show that the basic FACD methodology is useful to clarify customer wants, needs and desires and to quickly focus ad hoc teams on the study topic. The charrette format, structured analysis of alternates and documentation of agreements results in many of the benefits of the MILCON FACD process, but these elements have to be selectively applied. It is apparent that the perception that FACD is a design process was adversely affecting its adoption on other activities. Also, project managers, project engineers, architects, designers and facilitators believe that FACD, as a rigid step by step process, is only appropriate for MILCON project designs. They don't understand that steps in the process are project specific and need to be selected to achieve the goals of the FACD philosophy. It is apparent that more work and training is needed to distill the essential elements of the FACD methodology and to train individuals in their application. It is only through this further development of FACD that its full potential will be realized.

FACD Philosophy

"Use the FACD to communicate with the customer in functional terms and use it to deliver high quality, value added services that meet his wants, needs and expectations."

The FACD philosophy is based on elements of Total Quality Management (TQM). W. Edward Deming believed that the consumer is the most important part of the production system and it is the consumer that defines quality. Joseph Juran also believed that quality is measured by the ability to meet customer needs. Both of these individuals also believed that continual improvement is essential for survival. These ideas are incorporated in FACD.



We may be expert in designing a pyramid that stands on its head, but we should at least ask the customer why he wants us to do so.

The function identification and analysis tools, that are the essence of FACD, facilitates communication with the customer. Creativity, analysis, presentation skills and the charrette format facilitate consensus building and commitment to a plan of action through which customer expectations can be realized. It is important that FACD participants acquire skill in applying these tools so they can be effective in meeting customer expectations. It is this function approach to problem solving (function definition, function alternates and function evaluation) that makes FACD different than other concept development methodologies, such as, the "charrette" used by the U.S. Air Force and the U.S. Corps of Engineers and the "Squatters Session" used by the Southern Division of the Naval Facilities Engineering Command.

It is appropriate at this time to define function as it is used in FACD. Function is usually defined as the characteristic of an item that makes it work or sell. In other words, the reason why it is desired by the customer. In FACD, function is the reason why the customer is willing to pay for the product of your efforts. It may be performance characteristics that must be provided (work function) or the intangible characteristics that make the item desirable (sell functions). For example, the "work" function of a master plan might be to, "establish a land use matrix that will guide facility development for the next 20 years". Intangible characteristics that may also be desired are to improve comfort of the of the city's residents and to foster civic pride. These last two characteristics are difficult to define and depend on individual preferences.

FACD requires hard work. Acquiring FACD skills is difficult. You have to be convinced that improved customer service requires us to change our traditional relationship with customers. For example, military customers usually complete the planning and programming of projects. It is not surprising that many designers and design agents feel comfortable asking the customer to design the project for them and limit their work to preparing the design calculations, specifications and drawings. This same statement is often true in planning, programming and the other technical areas in which we work. Acceptance of FACD requires a broader view of our responsibility. As technical service providers we should feel responsibility for translating customer needs into physical reality. To accomplish this task you need to understand his functional needs. FACD provides you tools to achieve this understanding.

FACD Elements

What is FACD and what are its components? The FACD philosophy says, "communicate with the customer in functional terms and to use the FACD tools to meet his expectations". The key element is the understanding of customer wants, needs and expectations. FACD uses a number of function identification tools to acquire and communicate this understanding. Use of these function identification tools are at the heart of FACD. Application of the function tools and getting customer concurrence are essential to FACD. Other elements such as the identification and evaluation of materials, systems and processes that can provide these functional requirements are important. Some might argue that this is an essential customer service in a design project, but this element is considered to be less important than function identification. It is also important to include the customer in decisions. Also included in decision making is skill in making presentations. It is important that the customer fully understand all aspects of the decision in which he is participating. Once decisions on a plan of action are made it is desirable that the decision and information that lead up to the decision be documented. Documentation serves two purposes: 1) it helps clarify the elements that are included in the decision by putting it in writing; and 2) serves as a reference when questions later arise.

FACD Element	Importance
1. Use function analysis, FAST diagraming and other function identification tools to identify and communicate customer wants, needs and expectations.	Essential
2. Identify and evaluate alternate materials, systems and processes that can provide the identified functions.	Important
3. Use the charrette format to include the customer in decisions.	Important
4. Document decisions.	Nice to have
5. Get management approval.	Nice to have

The elements that are used on a particular assignment should be based on the product desired and the amount of effort that can be allocated to development of that product. It is suggested that the following guidelines can be used to determine the appropriate tools to use:

Assignment	Suggested FACD Elements	Suggested FACD Tools
1. Design of a small project (less than $500k construction cost), siting study, DD1391 preparation, project cost validation or other assignment where less than 2 days can be devoted to the FACD.	• Function identification	• Function Analysis/FAST

2. Larger design project ($500k - $1 million construction cost), siting study for a major complex, minor master plan update or other assignment where 2-3 days can be devoted to the FACD	Function identification • Identification and analysis of alternates	• Function Analysis/FAST • Brainstorming and judgement of alternates
3. Larger design project ($500k - $1 million construction cost), concept study on a small project, ad hoc study or other activity where 4-5 days can be devoted to the FACD	• Function identification • Identification and formal analysis of alternates	• Function Analysis/FAST • Brainstorming and judgement of alternates • FACD forms • Life cycle cost analysis • Cost cutting
4. Design of a major project (>$5 million in construction cost), preparation of a master plan for a large Base, concept development for programming of a large project where more than 5 days can be devoted to the FACD.	• Function identification • Identification and formal analysis of alternates • Charrette format • Document Decisions	• Function Analysis/FAST • Brainstorming and judgement of alternates • FACD forms • Life cycle cost analysis • Cost cutting • Conducting meetings • Making presentations

The Customer

Who is a customer? A customer is any recipient of a service you provide. The goal of FACD is to fulfil customer wants, needs and expectations, but it is necessary to first identify the customer or customers that you have to satisfy on each assignment. Who are customers on a typical FACD? In most instances there are several customers and it is important that each of their expectations be considered. What do you do when there are conflicting expectations? It is generally safer to first accommodate the customer that is paying the bill, but there are many exceptions. These are some of the customers with whom we normally deal:

Customer	Input and Influence
Facility Operator	Usually has the most in depth knowledge of the work process that must be supported, but often does not have control over project scope, funding, execution schedule or other aspects of the assignment. Often this customer is not conversant with technical jargon. Use him as a resource to understand the required work functions. Communicate in terms that he understands. If you satisfy this customer, you will probably be successful. An example of a facility operator may be the bachelor housing officer, maintenance officer, planning officer, etc.
Project Sponsors	Usually controls funding and often determines execution schedules. If you meet budget, schedule and the facility operator's expectations, you will also meet this customer's expectations. Examples of a project sponsor may be the Commander in Chief of the Pacific Fleet, Department of Defense Finance and Accounting Service, Naval Sea Systems Command, etc.
Facility Operator's Technical Staff	This customer is usually responsible for translating functional requirements into program requirements. They are usually the communication channel between the design agent and the facility operator. The facility operator's technical staff makes technical decisions for the facility operator. If you meet the facility operator's expectations, you will probably also meet this customer's expectations. This customer can sometimes be an impediment to free flow of information from

	the facility operator, but must be kept in the discussion loop. Examples of the Facility Operator's technical staff may be the Base Civil Engineer, Staff Civil Engineer, Headquarters Project Manager, etc.
Project Sponsor's Technical Staff	This customer usually speaks for the project sponsor on technical matters. In that sense, this customer can be considered to control scope, funding and execution. Examples of the Project Sponsor's technical staff might be the Fleet MILCON Officer, Department of Defense Educational Activity's Facility Officer, etc.
Construction Agent	Manages the construction. This customer wants a complete and well-coordinated set of design documents. He does not like construction contract change orders. Provide a complete design that does not generate contract change orders and you will meet his expectations. Examples of a Construction Agent may be the Resident Officer in Charge of Construction, Corps of Engineer Construction Office, etc.
Construction Contractor	This customer wants complete and well-coordinated set of design documents. He likes flexibility in meeting requirements and does not like risky construction or unreasonable construction requirements. Provide clear and well-coordinated construction documents and you will meet his expectations.
Project Designer, Planner, or other individuals that provide the required services	This customer likes clear and unambiguous scopes of work. He does not like risky designs, nor changes. Provide him a clear and unambiguous scope of work with minimum changes and you will meet his expectations.
Project Engineer, Architect or Engineer In Charge	Manages design. This customer likes clear and unambiguous scopes of work. He does not like risky designs, nor changes. Provide him a clear and unambiguous scope of work with minimal changes and you will meet his expectations. An example of this customer may be the Project Design Engineer, Design Project Manager, etc.

FUNCTION

Introduction

Function identification is one of the three interrelated techniques, i.e. function identification, function alternates and function evaluation that are the basis for FACD and make it different than other problem solving methodologies. Function identification is the first step in a FACD after the initial review of available information is completed. This initial review can include review of the programming documents, site information, previous studies, master plans and discussions with the facility operator, project engineer and other stakeholders. If you feel that you know enough about the assignment based on available background information, you can start the function identification phase. Sometimes it is necessary to postpone function identification until you can meet with the customer and get a better understanding of his expectations. This is often the case on MILCON FACD studies.

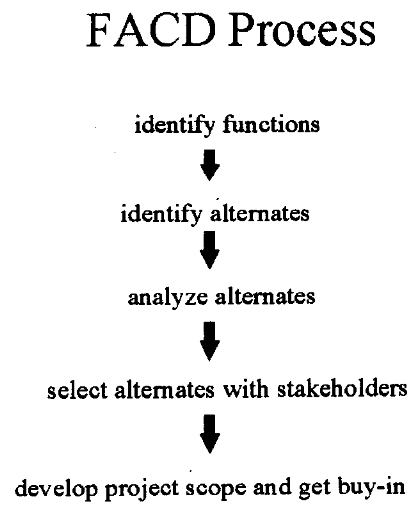


Figure 11
FACD Process

Definition

As presented earlier, function is defined as the characteristic of an item that makes it work or sell. It is the reason why it is desired by the customer. In FACD, function is the reason why the customer is willing to pay for the product of your efforts. It may be performance characteristics that must be provided (work functions) or the intangible characteristics that make the item desirable (sell functions).

Function Analysis

FACD uses a special way, called function analysis, to define functions. Function analysis describes functions with two words - a verb that answers the question, "What must it do?" and a noun that identifies the recipient of the action. This method, the verb-noun description, is used because it focuses attention on the function that must be provided, rather than specific solution. For example, a window is a design solution that transmits light and excludes weather, but this item is only one of many solutions that can provide these functions. Function analysis promotes this wider view of potential solutions by separating the required functions from the item - window. This process is called increasing the level of abstraction. Function analysis also helps you avoid combining functions and forces you to be concise in identifying the requirements. Function analysis is one of the most powerful tools used in value engineering, so why is function analysis important in FACD. **Function analysis is important because it is the language used in FAST diagraming. FAST is the most important function identification tool used in FACD.** Some general guidelines in selecting appropriate verbs and nouns are: 1) use action verbs and measurable nouns for work functions and passive verbs and non-measurable nouns for sell functions. Some examples of words used in the facility arena are:

Action Verbs		Measurable Nouns	
apply	transport	circuit	light
conduct	interrupt	current	protection
control	insulate	damage	radiation
create	modulate	density	repair
emit	protect	energy	voltage
enclose	provide	flow	weight
filter	repel	fluid	
hold	shield	force	
impede	support	heat	
transmit		insulation	

Passive Verbs	Non-measurable Nouns	
decrease	aesthetics	effect
improve	appearance	features
increase	beauty	symmetry

Some examples of function analysis applied to common items are:

ITEM	VERB	NOUN
electrical wire	conduct	electricity
battery	store	energy
exit sign	identify	egress
fence	define	area
electric switch	control	flow
electric conduit	protect	conductors
pavement	stabilize	surface
roofing	reduce	infiltration (moisture)
BEQ	house	personnel

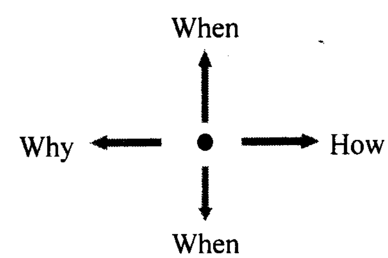
Using function analysis is somewhat like learning a new language. At first you may find it difficult to use and may not appreciate its value. It is recommended, however, that you try to use this tool. The more you use it the easier it will become until you find that it becomes your normal way of defining functions. If you find that following the strict rules of function analysis is to restrictive and is impeding the work you can use more words. Try not to use more than a few words, however, and try to use fewer and fewer words as you get more comfortable with the two word definition.

Function analysis is usually too difficult for the customer to use, however, use function analysis to communicate with him. He may not understand why you use this abbreviated language to describe functions, but he will understand what you are saying. The clarity of thought that function analysis provides will allow you to better communicate with him. Paraphrase customer statements in function analysis terms, because it will allow you to better understand his statements.

Function Analysis System Technique

Function analysis system technique (FAST) is a method that organizes functions in a logical order. It is used in FACD to identify functions; to test if identified functions are correct and to stimulate ideas. **FAST is a powerful tool to organize thinking**. FAST was developed by Mr. Charles Bytheway in the early 1960s. Mr. Bytheway coined the term functional analysis system technique to describe his process. Others call it function analysis system technique. Both these terms can be used to refer to the method.

The logic used to construct the diagram is based on asking the questions, how, why and when. If the diagram is correct, each succeeding function moving from left to right should answer the question, how. For example, how do you distribute electricity? The function to the right says by conducting electricity. How do you conduct electricity? By installing a conductor. The logic should work in the opposite direction by asking the question why. Why do you install a conductor? To conduct electricity. Why do you conduct electricity? The diagram says, "to distribute electricity." The logic appears to work in both directions. This indicates that they are correct. Functions that are caused by a function on the main horizontal line or happen at the same time are placed over or under the causative function. For example, heat is generated when electricity is conducted. If you continue to



Four Directions of FAST

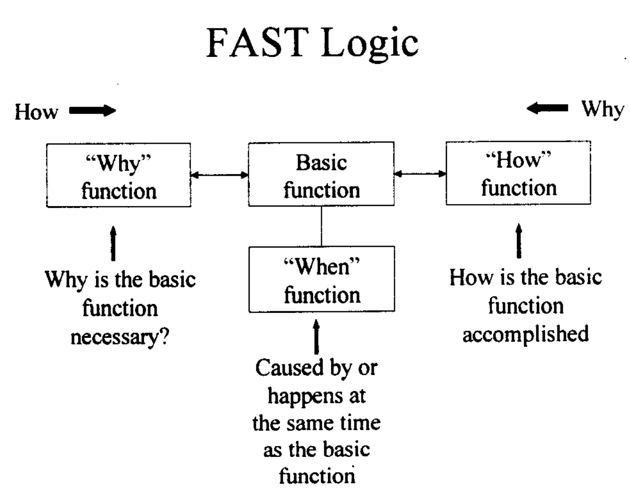


Figure 12

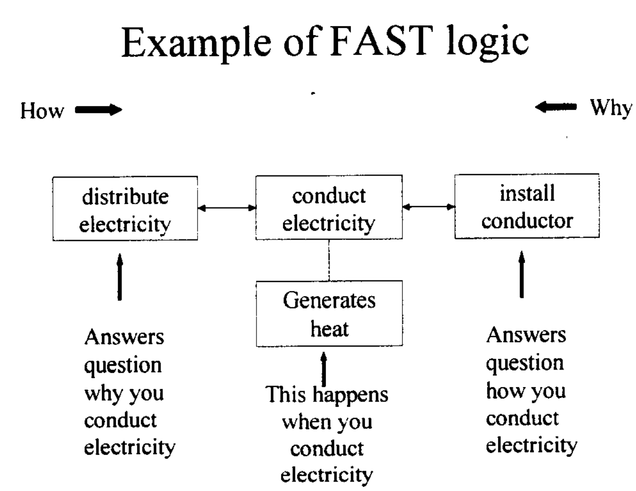


Figure 13

expand the diagram to the left you may decide that the reason you distribute electricity is "supply energy". Distributing electricity isn't only one way you can supply energy. You can, for example, use site generated electricity instead of distributing electricity from a central plant. The methodology increases the scope of your vision and the number of possible alternates as you transition to higher order functions. Function analysis and FAST are good tools to increase the level of abstraction and foster creativity.

There are several variations of the basic FAST methodology but the most common is called technical FAST. Before the FAST structure is explained, some basic definitions need to be understood.

DEFINITIONS

Function

The characteristic that makes an item work or sell.

Basic function

The purpose or mission of the item being studied. For example, the basic function of a warehouse may be to store materials.

Critical path

A critical path is any line of functions that are interrelated by the how and why logic. The critical path that includes the basic function is the main critical path. Other critical paths are minor critical paths. The critical path can split into several branches. This usually occurs when there is more than one dependent function needed to answer the how question or when there are several alternate ways to achieve a function.

Higher order function

The reason why the basic function is being performed. For example, the reason why you store materials in a warehouse is to maintain inventory.

Lowest order function

These are usually specific solutions. If the FACD is for a design it may be a specific design solution for a function or if the FACD is on another activity it may be a specific product. For example, the lowest order function to control the environment in a warehouse may be to install air conditioning.

Dependent functions

Dependent functions are all functions on the critical path that are to the right of the basic function. Each of these functions are dependent on the function to the left starting with the highest order function.

Independent (or supporting) function

These are functions that are caused by a function on the critical path or happen at the same time as the critical path function. For example, when you install air conditioning you have to dispose of condensate. The independent function is, "dispose condensate". This independent function can start an minor critical path. For example, how do you dispose of condensate? You have to "collect condensate"and "transfer condensate" to a disposal site.

Activities

An activity is a method selected to perform a function or the consequence of a function on the critical path. For example, when you install air conditioning you "increase consumption (energy)". Independent functions and activities are tools to avoid situations where placing them on the critical path will lead you away from the direction that you want to proceed. For example, you may answer the question, "How do you store materials?", by replying, "program project". This may not be the direction that you want to proceed. This dilemma can be solved by placing this function above or below the critical path.

All the time functions

There are functions that occur all the time. For example, meeting building codes is an all the time function as is meeting safety regulations and should be placed in an area above the FAST diagram.

Design objective or specification

Specific design objectives or specifications that have to be considered when the FAST diagram is constructed.

Technical FAST

Technical FAST structures the diagram to make it easier to develop. As shown in Figures 12 and 13, the primary functions being examined are placed on the critical path. All functions on the critical path must be performed to accomplish the basic function. The critical path is usually done first, because these functions are often the easiest to identify. When secondary functions are identified that are caused by a function on the critical path or happen at the same time as the function on the critical path they are placed over or under the critical path. Independent functions are normally placed above the critical path and activities are placed below the critical path. These independent functions and activities can also be expanded using the how and why logic. Placing independent functions and activities above and below the main critical path are a tool to avoid forcing the critical path along an unwanted tangent path. The logic line on the critical path or on any logic line can branch or split. All the time function are placed in the upper right corner of the diagram. Design objectives or specifications are placed in the upper left corner of the diagram. See Figure 15.

When constructing a FAST diagram it is important to remember that the diagram is only a thinking tool. Don't let the rules get in the way of your thought process.

Mr. Charles Bytheway says, "I only use the diagram to channel my thinking process and destroy it after I have accomplished the task.". He says, "I have attempted several times to teach people to think the way I do as they develop a diagram, but so far I haven't been successful. The problem I see with what they do is that too often they write down the obvious rather than doing their own thinking. I like to come up with my own reasons why or how a function needs to be performed rather than recording the obvious or the one conceived by the inventor of the thing I am analyzing. As I do this, I may write down three or four functions for each function I analyze as I ask the questions. In order to arrive at them I may have to role play several different roles. Each time I get an answer, I evaluate it mentally to determine if it broadens my understanding or stimulates my creativity. If it doesn't do either of these things, then I repeat my why or how question for the function I am analyzing until I get some thing that give me a new thought."

FAST and function analysis were developed for use on manufactured items and were very effective in clarifying the function of each component of a product. Typically, a product was broken down to individual components and each component was analyzed in detail using function analysis. FAST was used to assist in function identification and more importantly to help differentiate between basic and supporting functions. The methodology must be modified to be most effective when it is used in FACD. In FACD you normally do not have a product that you can disassemble to examine. Facilities are usually one of a kind items made up of thousands of materials and systems. It isn't feasible to examine each component in the same detail as it would be for a manufactured item that will be produced by the thousands. **FAST diagrams used in FACD are therefore developed differently than those used on manufactured items.**

FAST in FACD is most often used to relate construction elements shown in programming documents to the customer's higher order function. For most military projects the higher order function is to "maintain readiness". FAST diagrams on other types of activities may have a different focus. For example, FAST prepared for a master plan may relate goals or characteristics of the plan to the higher order function. This higher order function on military master plans may again be "maintain readiness". FAST helps identify functions to fill in the gap between the lowest order function, which may be a programming document and the higher order function.

FAST diagram construction usually starts off with a function that is the presumed basic for the project. This is in contrast to FAST being done on a manufactured product where the first step may be to perform function analysis on each component. The example used to illustrate preparation of FAST on a FACD is a project to construct a 2,000 square foot building to house ten new electric forklift charging stations for additional electric forklifts the Naval Magazine was acquiring. The Magazine has an existing forklift charging facility with 10 charging stations, but this facility was already fully utilized to charge the station's existing 14 electric forklifts. The programming document is shown in Figure 14. Forklifts are used to move munitions. Ordnance is stored in magazines that are remote from the charging facility because of explosive safety regulations.

1. COMPONENT	FY 19 92 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
NAVY		JAN 1992

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
U.S. NAVAL MAGAZINE, GUAM, M.I.	MATERIAL HANDLING EQUIPMENT CHARGING FACILITY

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
	218-51	P-828	570

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
PRIMARY FACILITY:				
MATERIAL HANDLING EQUIPMENT BLDG..........	SF	2,000	223.00	450
SUPPORTING FACILITIES......................				60
ELECTRICAL UTILITIES......................	KVA	112	258.93	(30)
MECHANICAL UTILITIES......................	LF	250	96.00	(20)
SITE PREPARATION AND IMPROVEMENT.......	LS			(10)
SUBTOTAL..................................				510
CONTINGENCY..(5%).........................				26
TOTAL CONTRACT COST.......................				536
SUPERVISION, INSPECTION & OVERHEAD (6.5%)...				35
TOTAL REQUEST				571
TOTAL REQUEST (ROUNDED)....................				570
EQUIPMENT PROVIDED.........................				(0)

10. DESCRIPTION OF PROPOSED CONSTRUCTION

Construct a one story 2,000 SF of reinforced concrete building with roll-up doors, sprinkler and alarm system, ventilation system, emergency shower/eyewash station, electrical, lighting, plumbing and battery charging equipment. Work includes utilities connection, site preparation and improvement.

11. REQUIREMENT: As Required

PROJECT: Provides a 2,000 SF of reinforced concrete Material Handling Equipment Charging Facility at Naval Magazine.

REQUIREMENT: This project is required to support Material Handling Equipment (MHE) relocating from the Philippines to Guam. NAVMAG Guam is going to receive 20 forklifts (10 electric forklifts) from NAVMAG Subic and does not have facilities available to recharge additional forklift batteries.

CURRENT SITUATION: NAVMAG Guam currently has a total of 14 electric forklifts and only 10 battery recharging stations. NAVMAG Guam cannot support an additional 10 electric forklifts with its existing facilities. There are no facilities from other Naval activities or another military service that can be made available to support the MHE equipment relocating from the Philippines through host tenant agreement, inter-service agreement, or by mutual agreement to share common use.

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Figure 14

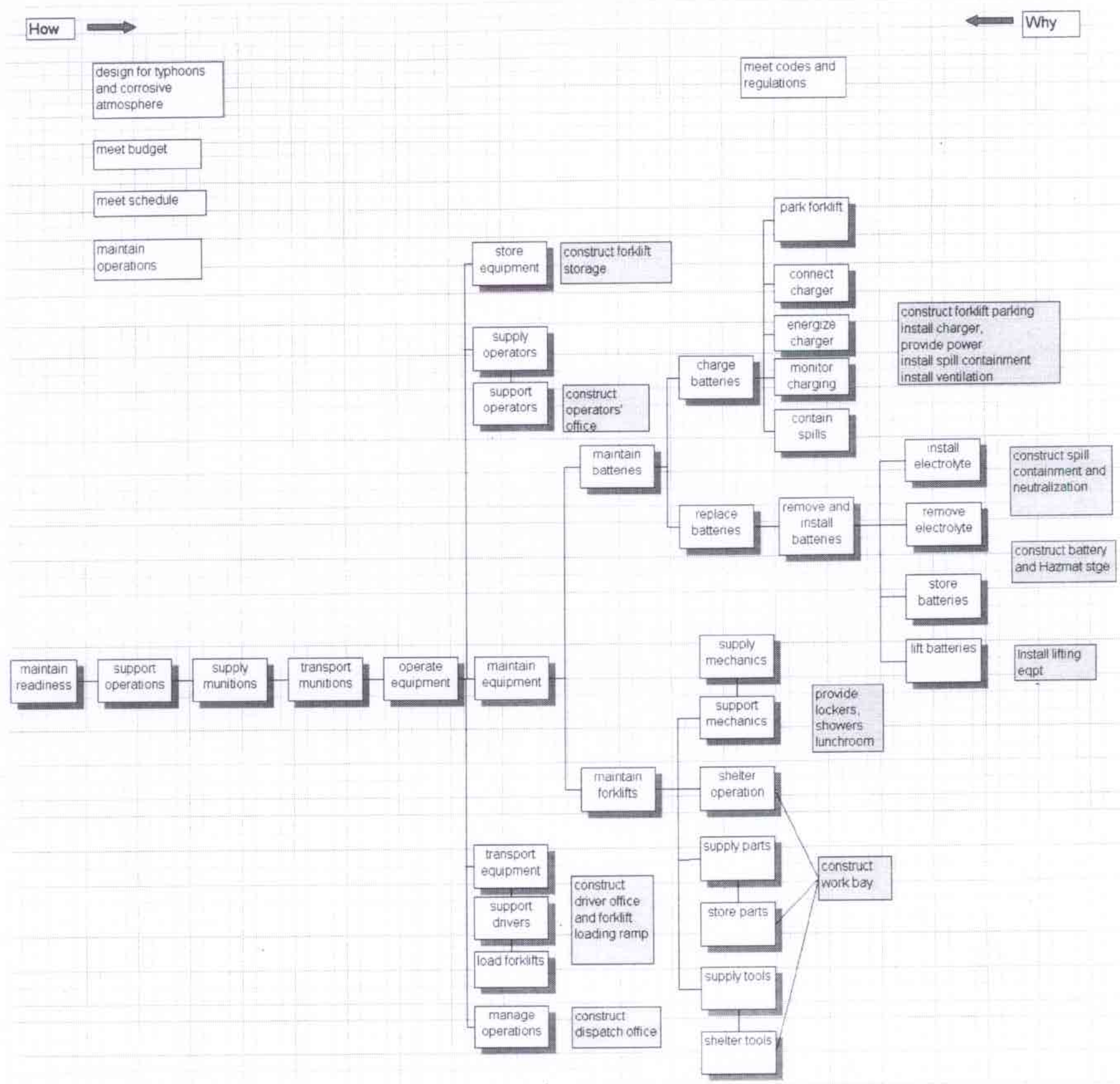
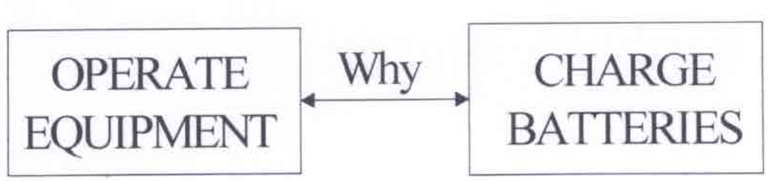
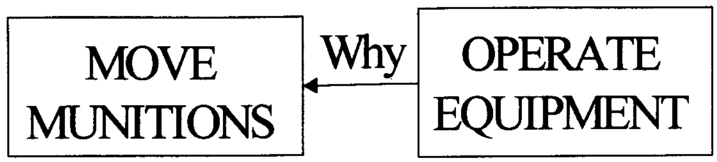


Figure 15

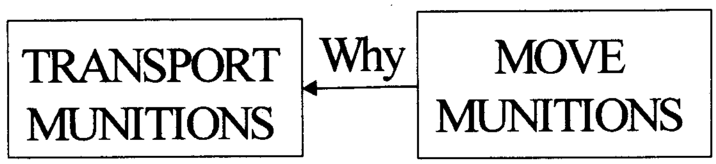
The FAST diagram was started with the presumed basic function for the facility - "charge batteries." Why charge batteries? One answer is to operate equipment.



The question is then asked, "Why operate equipment?" One answer is to move munitions.

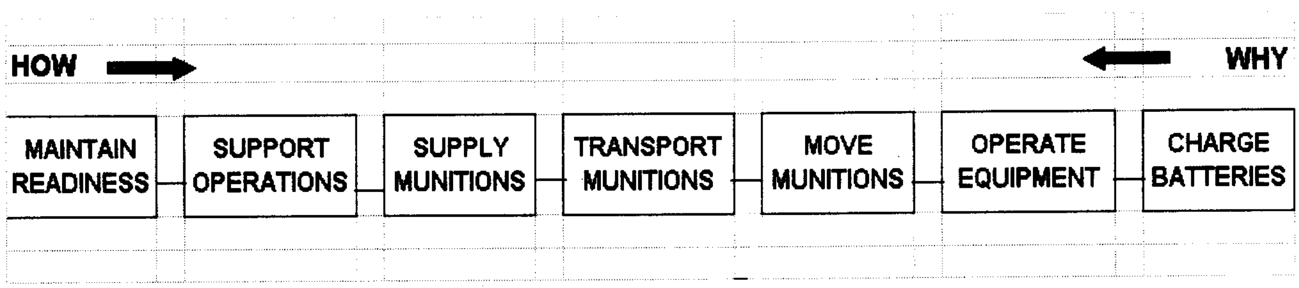


To expand the diagram further to the left, the question is now, "Why move munitions?" One answer may be to transport munitions.



Why do you transport munitions? To supply munitions. Why supply munitions? To support operations. Why do you support operations? To maintain readiness. Munitions are normally delivered to ships on patrol and supplying them munitions maintains readiness.

The FAST diagram now looks like this:



The logic is tested by asking the question, "How?". How do you maintain readiness? By supporting operations. How do you support operations? By supplying munitions. How do you supply munitions? By transporting munitions. How do you move munitions? By operating equipment. How do you operate equipment? By charging batteries. The logic appears to work. Note that there may be many other things required to provide the higher order functions such as "support operations", but these branches were not developed because the focus of the diagram is on the forklift operation at the Naval Magazine. It is appropriate, however, to examine other requirements when you ask, "How do you operate equipment?", because there may be facility construction items that are needed to support the "operate equipment" function.

How do you operate equipment? There are many other supporting functions required. You need to "maintain equipment", "store equipment", transport equipment" and maintain batteries. The FAST diagram now looks like this (See Figure 16).

You may ask yourself, "Why is it necessary to look at other requirements when the work is to design the MHE Charging Facility?". After all, if the facility operator required these items he would have included it in the programming document. The answer to this question is answered by the FACD philosophy, "Use FACD to communicate with the customer in functional terms and use it to deliver high quality, value added services that meet his wants, needs and expectations." In this instance the customer may not fully know the facility construction needed to support his functional requirement to transport munitions. He is an expert in storing and maintaining munitions, but the engineer is an expert in identifying facility construction needed to meet his functional requirements. Asking him to confirm that he has already accommodated the other facility requirements is part of the high quality, value added services that the philosophy commits you to provide.

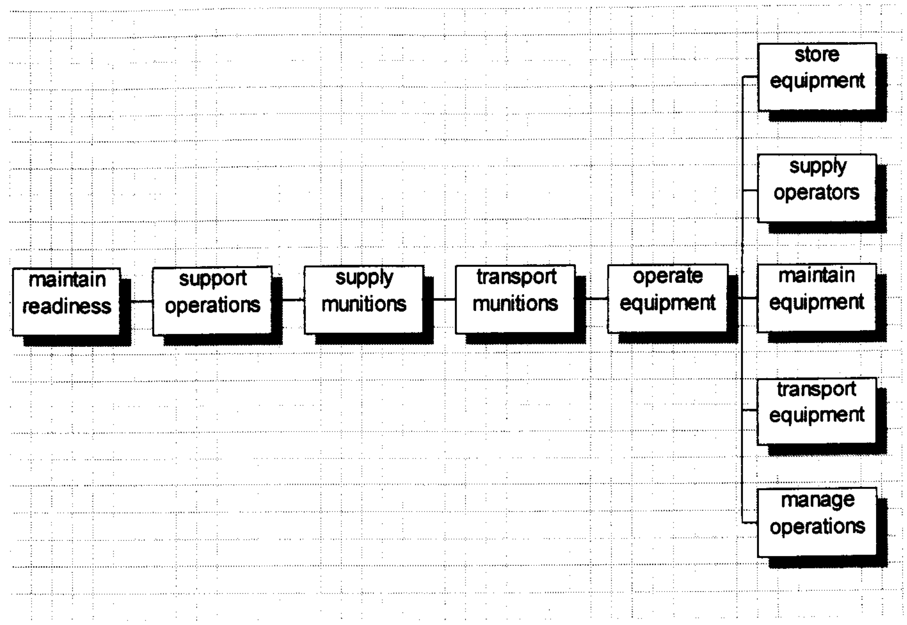


Figure 16

What is the next step in development of the diagram? Each logic line (manage operations, transport equipment, etc.) should be expanded until it validates or invalidates the facility construction identified in the programming document. For example, how do you maintain equipment? The expanded diagram shown in Figure 17 says that you "maintain forklifts" and "maintain batteries". Expanding the diagram further to the right you ask the questions, "How do you maintain batteries?" There are a number of functions that have to be accomplished. You have to "charge batteries" and "replace batteries". How do you charge batteries? You need to "park forklift", "connect charger", "energize charger" , "monitor charging" and contain spills. The facility construction needed to support these functions are: construct forklift parking, install charger, provide power, and install spill containment. This is sufficient information to proceed with the design and it probably isn't necessary to expand the diagram further. The diagram also expands "maintain forklifts" as shown on the diagram. The facility construction required to support "maintain forklifts" is construction of a maintenance work bay and mechanic lockers, showers and lunchroom. The other functions required to operate equipment, i.e., store equipment, supply operators, manage operations and transport equipment are also expanded to the right by asking how that function can be provided. As was shown in Figure 15, the facility construction that is required to support these functions are a operation office, drivers office, forklift drivers office and a forklift storage building.

There are several all the time functions and design objectives to consider. All the time functions are "meet building codes, life-safety codes and environmental regulations." Design objectives are: "design for typhoons and corrosive atmosphere", "meet budget", "meet schedules" and "maintain operations."

Now that you've completed the FAST diagram, how do you use it? You've already benefitted from

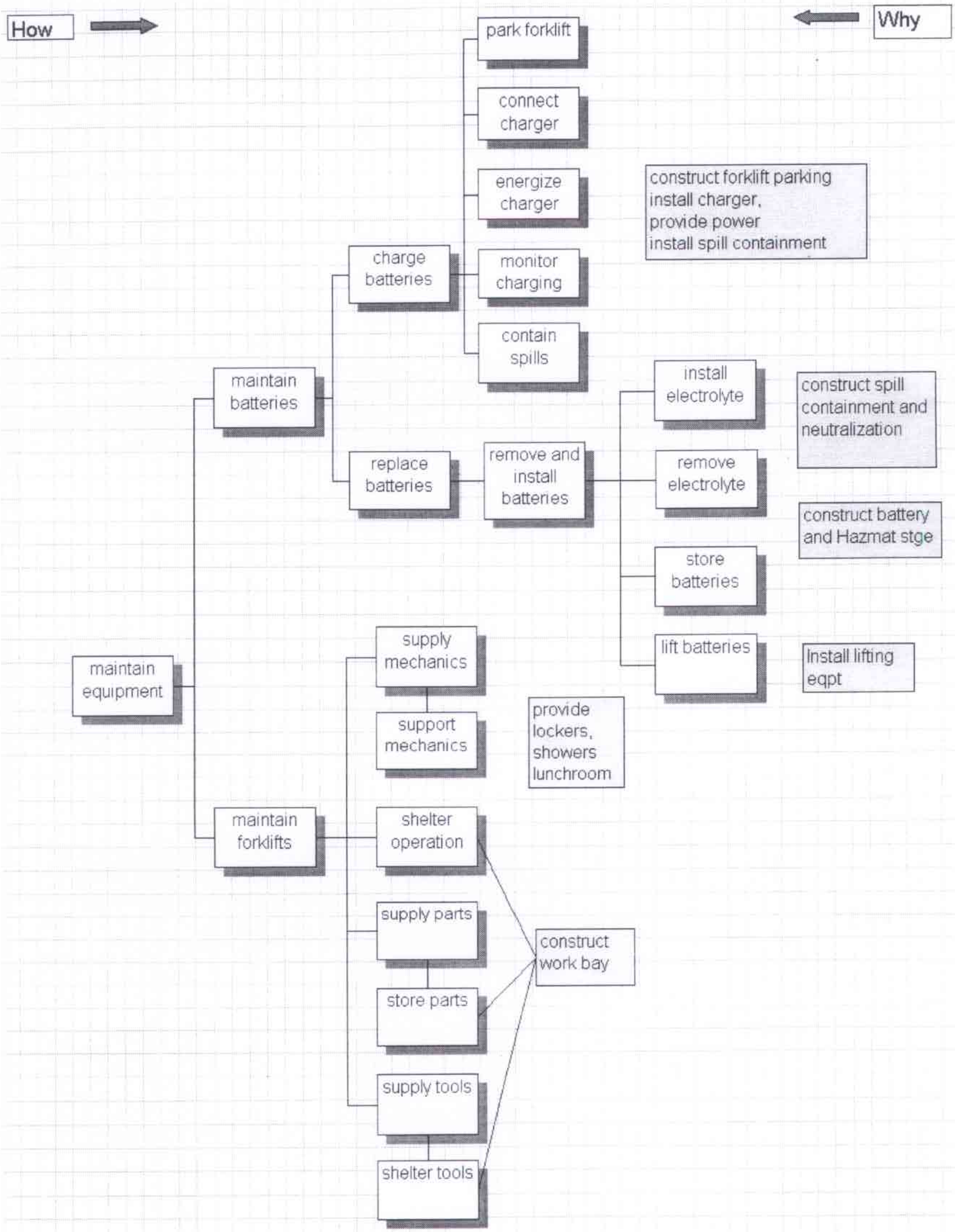

How
Why
park forklift
connect charger
energize charger
monitor charging
contain spills
construct forklift parking
install charger,
provide power
install spill containment
charge batteries
maintain batteries
replace batteries
remove and install batteries
install electrolyte
remove electrolyte
store batteries
lift batteries
construct spill containment and neutralization
construct battery and Hazmat stge
Install lifting eqpt
maintain equipment
supply mechanics
support mechanics
provide lockers, showers lunchroom
maintain forklifts
shelter operation
supply parts
store parts
supply tools
shelter tools
construct work bay

Figure 17

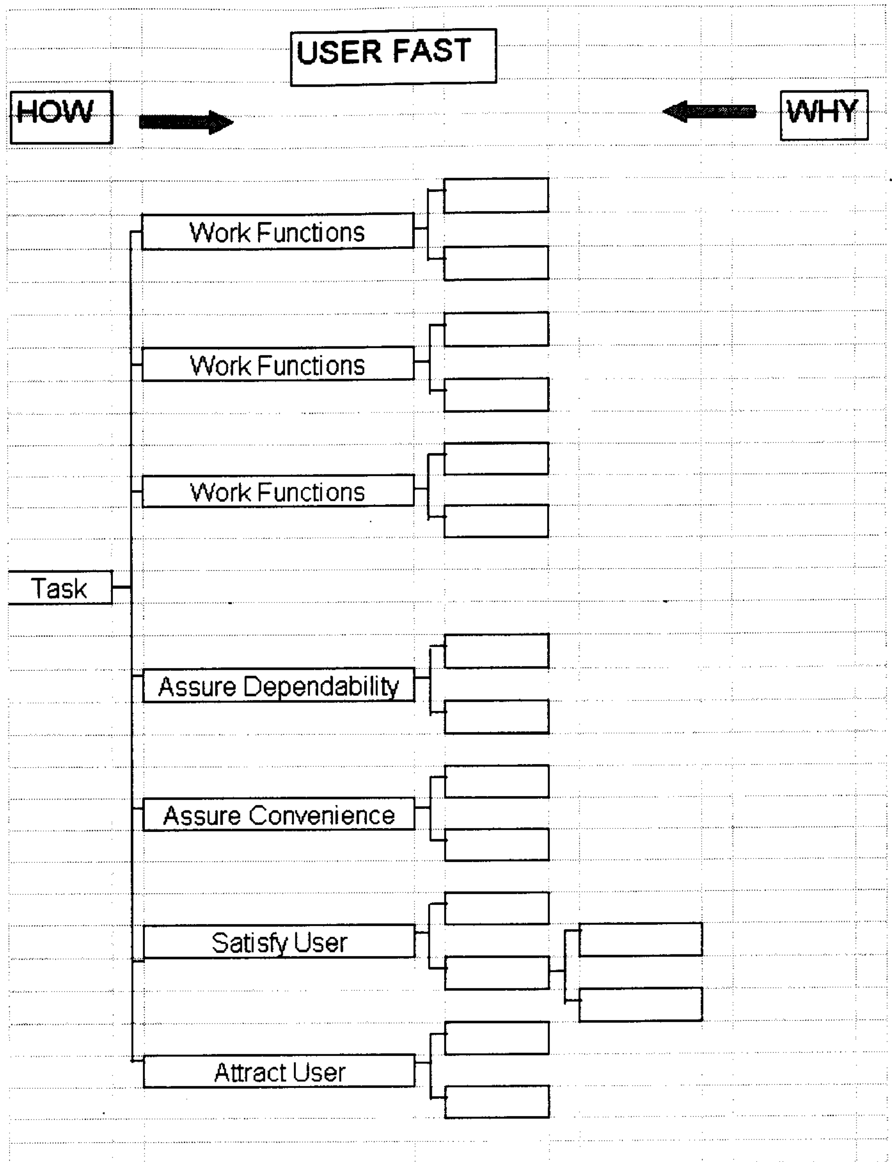
the thought process that went into its construction and that may be the extent of its use. If you are part of a design team it is beneficial for you to present the FAST diagram to the team to get their input and buy-in. If the team is well versed in FACD and can participate in its development, then it is beneficial for the team to develop the diagram. In this team setting it is always helpful for you to have done a FAST diagram on the project before you work with the team. This will allow you to help if the team runs into a roadblock. Your preparatory work will not overly influence the team if you facilitate the discussion rather than direct it. You can include the customer in preparation of the FAST diagram if he has a working knowledge of FAST, but customers generally do not have the necessary knowledge and skill to participate. Some customers are able to follow the logic in the FAST diagram. It is suggested that the diagram be used as a discussion tool with these customers. For example, on the Battery Charging project you could ask the facility operator how functions you've identified that are not included in the project will be accomplished, i.e., "maintain forklifts", "transport equipment", "manage operations" and "supply operators". Information on the diagram can also be used to guide the process of the work. Functions on the diagram can be used as criteria that can be used to test the developing work. It is also suggested that the FAST diagram and the resulting criteria be included in all meetings with the customer. This will reduce the incorporation of personal preferences into the developing work that are not compatible with the identified function.

When is the FAST diagram prepared? The FAST diagram should be prepared as soon as you have enough information to start. It is helpful if FAST can be done before the first meeting with the customer. The thought process required to develop the diagram can focus the discussion in the opening meeting. If insufficient information is available prior to the first meeting, then the FAST diagram should be done right after the meeting. The diagram can be presented at the next meeting with the customer to get feedback and verification. Input from the customer should be used to update the FAST diagram. The diagram should also be updated when additional insight or information changes the conclusions drawn from the diagram. These changes should be presented to the customer for verification.

User FAST

Another version of FAST is called User FAST. User FAST separates the work functions from the sell functions and is sometimes more effective when the project or product is primarily driven by sell functions. As shown in Figure 18, the sell functions addressed are: "assure dependability", "assure convenience", "satisfy user" and "attract user". It isn't necessary to address all of these sell functions unless they apply to the specific assignment. Work functions are placed at the top of the sheet. The task is the basic function and higher order functions. Each logic line is expanded by applying the how and why logic. One rule that is applied to expansion of the diagram to the right is to stop the expansion process when you can not identify two or more supporting functions. In that sense the diagram is a brainstorming tool.

Figure 19 shows a user FAST diagram for the Battery Charging facility.



USER FAST
HOW
WHY
Work Functions
Work Functions
Work Functions
Task
Assure Dependability
Assure Convenience
Satisfy User
Attract User

Figure 18

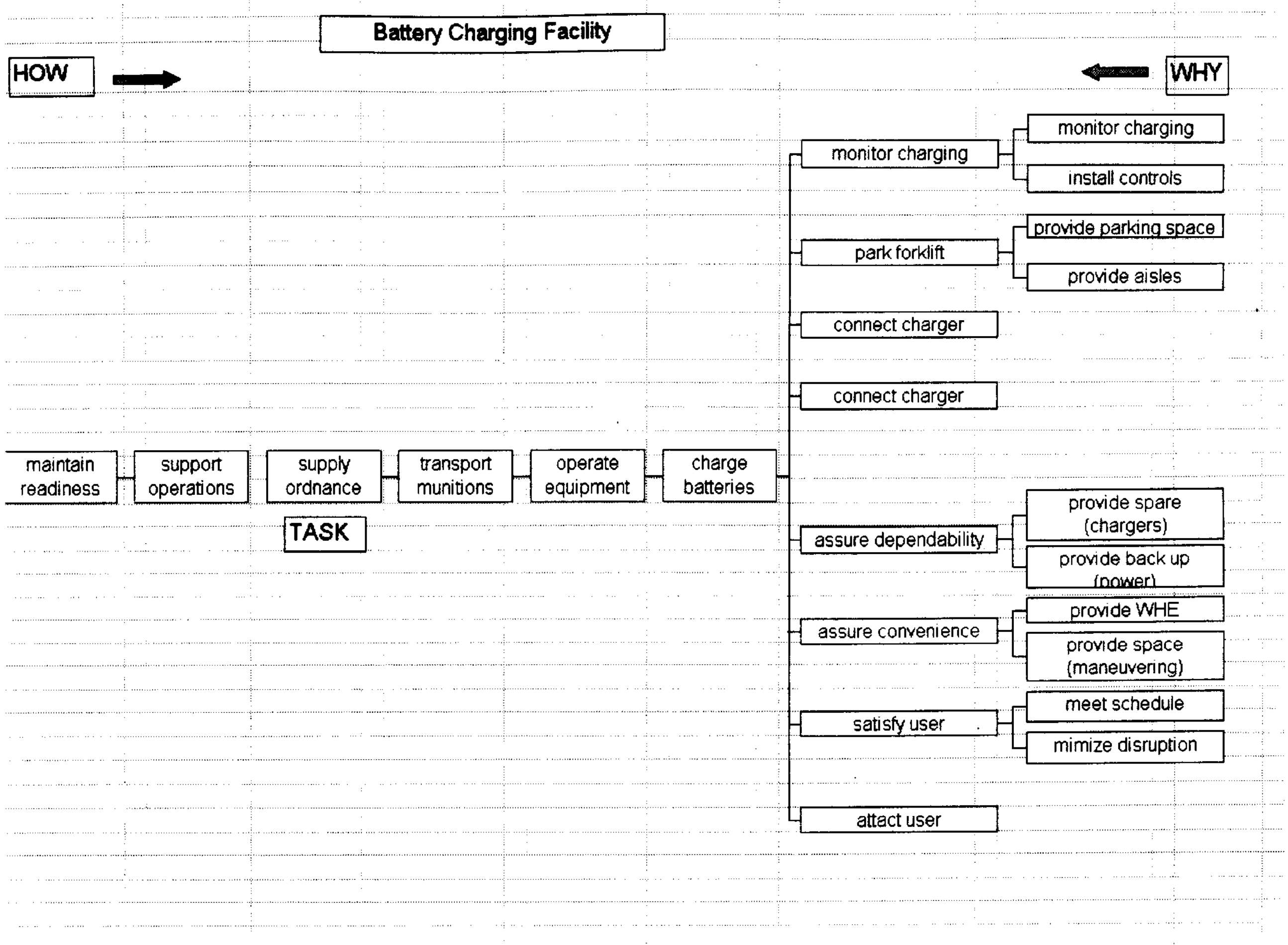


Figure 19

The project was to replace an aircraft hydrant fueling system that ruptured and spilled roughly 200,000 gallons of JP-8 fuel. The line was repaired and the hydrant system put back in service. A forensic examination of the pipe showed that a manufacturing defect caused the rupture. A project was programmed to replace the line, install new pump, modify controls, replace fuel outlets and install an emergency engine generator. Technical FAST was first attempted, but was difficult to develop because most of the items in the project were not related to the work function (fuel aircraft), but to meet current criteria. For example, the project called for replacing 1,800 gpm pumps with 1,200 gmp pumps to meet current criteria. When User FAST was used, the FAST diagram shown in Figure 20 quickly developed. Note that all of the construction items in the programming document are sell functions.

Another project where User FAST could have expedited preparation of the diagram was a project to replace two above ground fuel pipelines with below ground pipelines. Although not specified in the programming document, the facility operator wanted secondary containment and leak detection included in the construction for the roughly 16 miles of pipe which were being replaced. Two questions needed answering; 1) why were the two existing aboveground lines being replaced and 2) why was it necessary to install secondary containment and leak detection? The later two items would have exceeded the budget and there is no leak detection technology suitable for a cross-country pipeline.

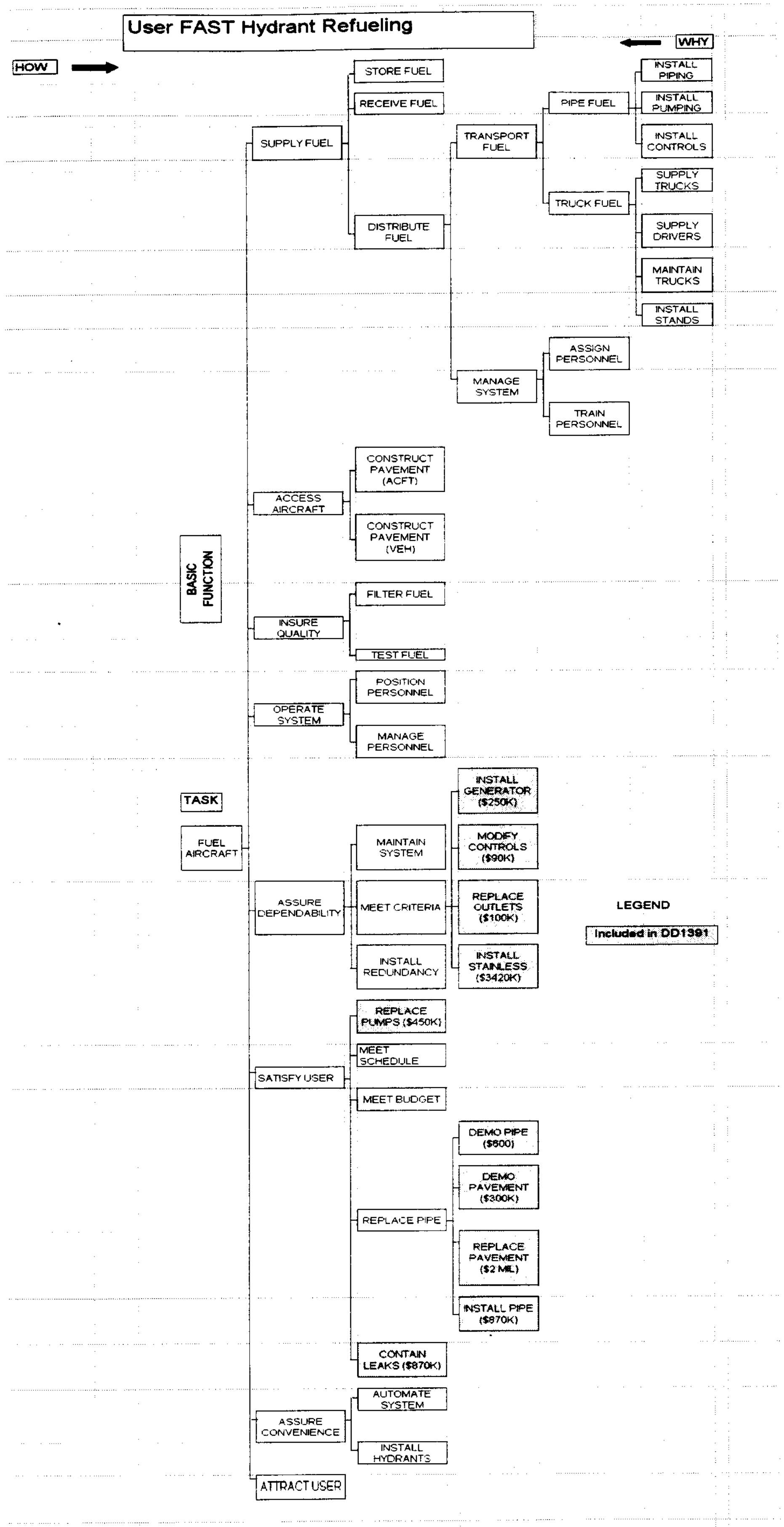

User FAST Hydrant Refueling
HOW
WHY
BASIC FUNCTION
TASK
FUEL AIRCRAFT
SUPPLY FUEL
STORE FUEL
RECEIVE FUEL
DISTRIBUTE FUEL
TRANSPORT FUEL
PIPE FUEL
INSTALL PIPING
INSTALL PUMPING
INSTALL CONTROLS
TRUCK FUEL
SUPPLY TRUCKS
SUPPLY DRIVERS
MAINTAIN TRUCKS
INSTALL STANDS
MANAGE SYSTEM
ASSIGN PERSONNEL
TRAIN PERSONNEL
ACCESS AIRCRAFT
CONSTRUCT PAVEMENT (ACFT)
CONSTRUCT PAVEMENT (VEH)
INSURE QUALITY
FILTER FUEL
TEST FUEL
OPERATE SYSTEM
POSITION PERSONNEL
MANAGE PERSONNEL
ASSURE DEPENDABILITY
MAINTAIN SYSTEM
MEET CRITERIA
INSTALL REDUNDANCY
INSTALL GENERATOR ($250K)
MODIFY CONTROLS ($90K)
REPLACE OUTLETS ($100K)
INSTALL STAINLESS ($3420K)
LEGEND
Included in DD1391
SATISFY USER
REPLACE PUMPS ($450K)
MEET SCHEDULE
MEET BUDGET
REPLACE PIPE
DEMO PIPE ($600)
DEMO PAVEMENT ($300K)
REPLACE PAVEMENT ($2 MIL)
INSTALL PIPE ($870K)
CONTAIN LEAKS ($870K)
ASSURE CONVENIENCE
AUTOMATE SYSTEM
INSTALL HYDRANTS
ATTRACT USER

Figure 20

The FAST diagram using technical FAST is shown in Figure 21.

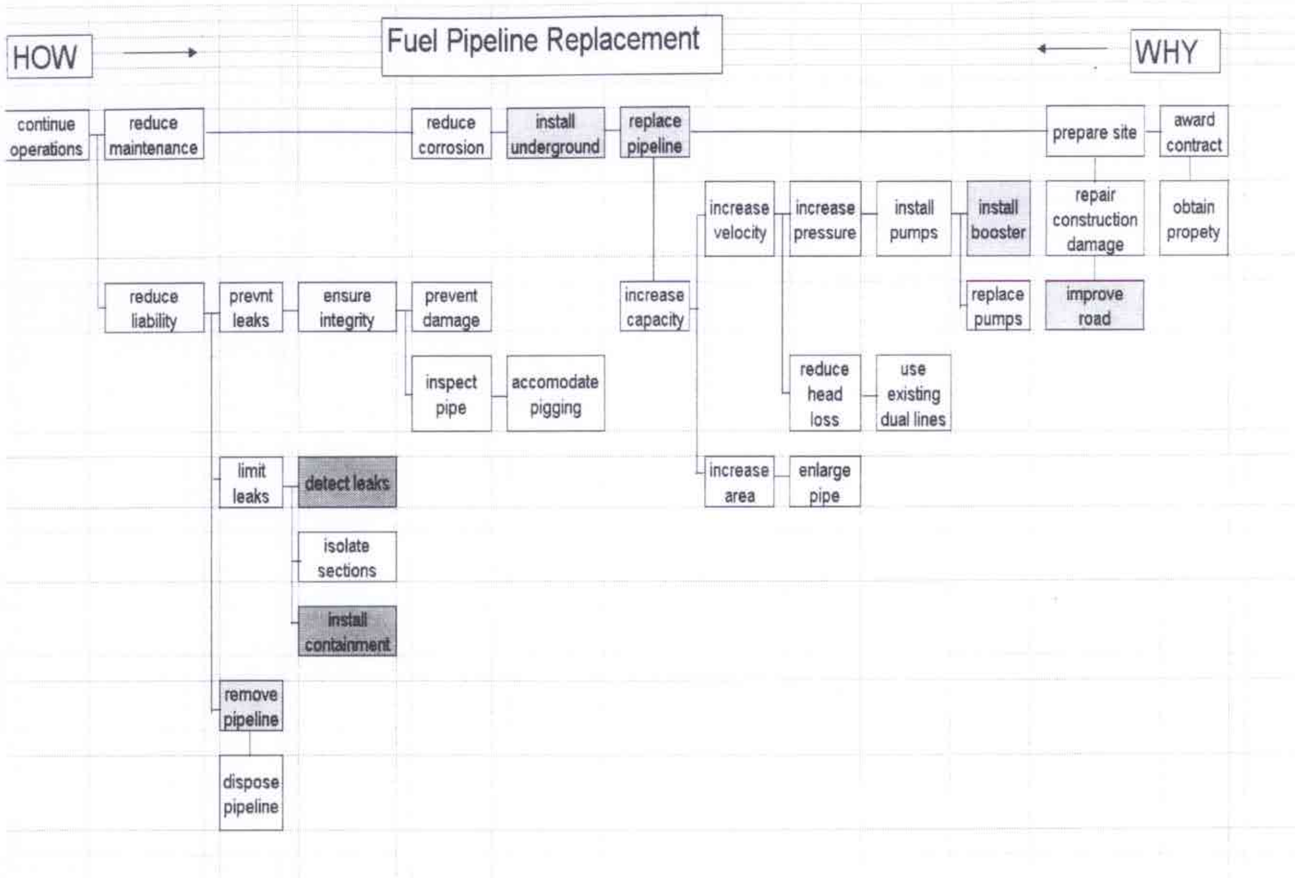


Figure 21

Note that the main critical path does not talk about transferring fuel, but addresses reducing maintenance. If User FAST was used to prepare a FAST diagram for the Hydrant project, the diagram may have looked like the one shown in Figure 22. The separation of work and sell functions and a format that forces brainstorming, facilitates further expansion to the right and the identification of specific design solutions. Development of the diagram was also much easier. User FAST can facilitate preparation of a FAST diagram where the assignment does include many work functions.

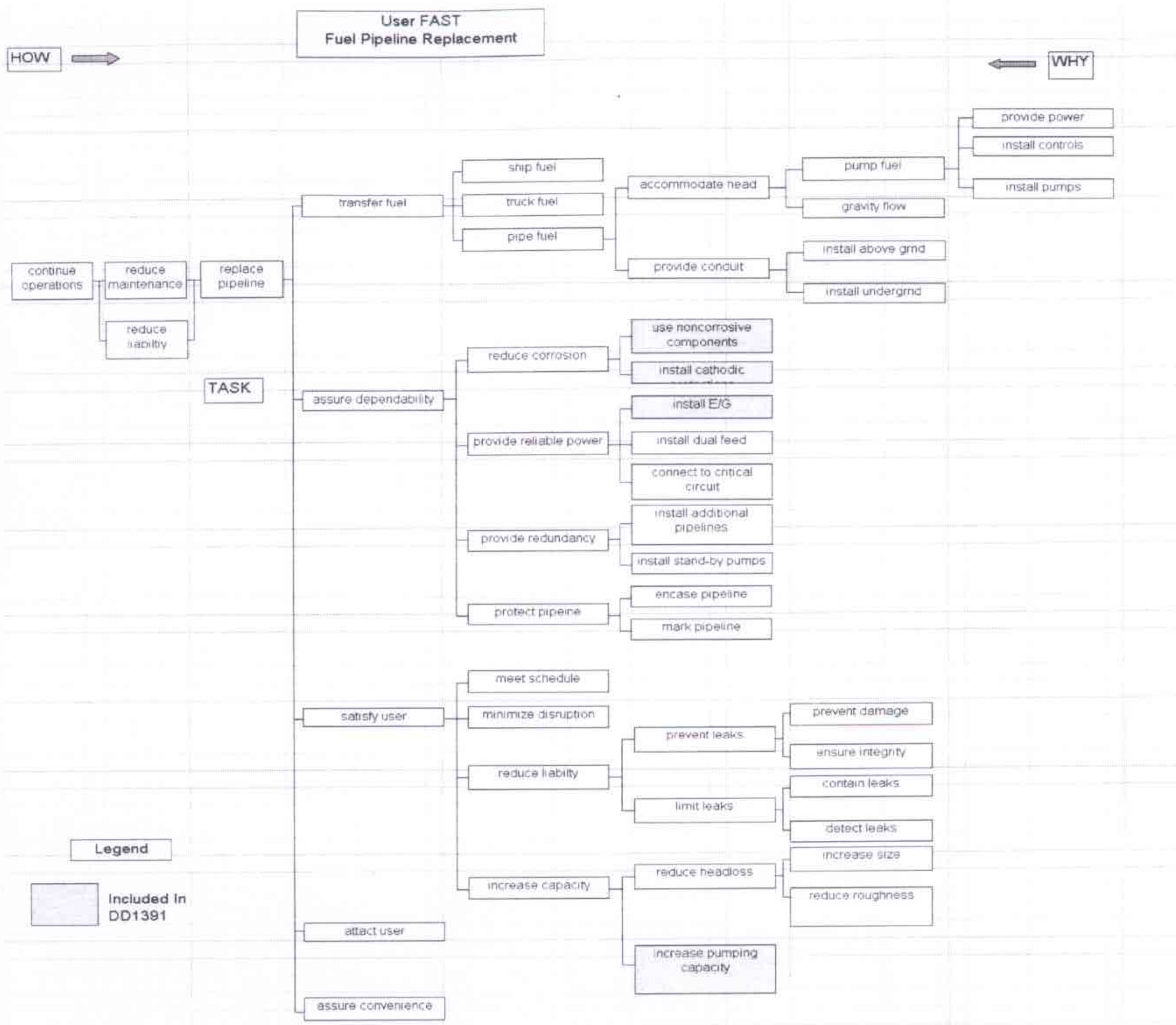


Figure 22

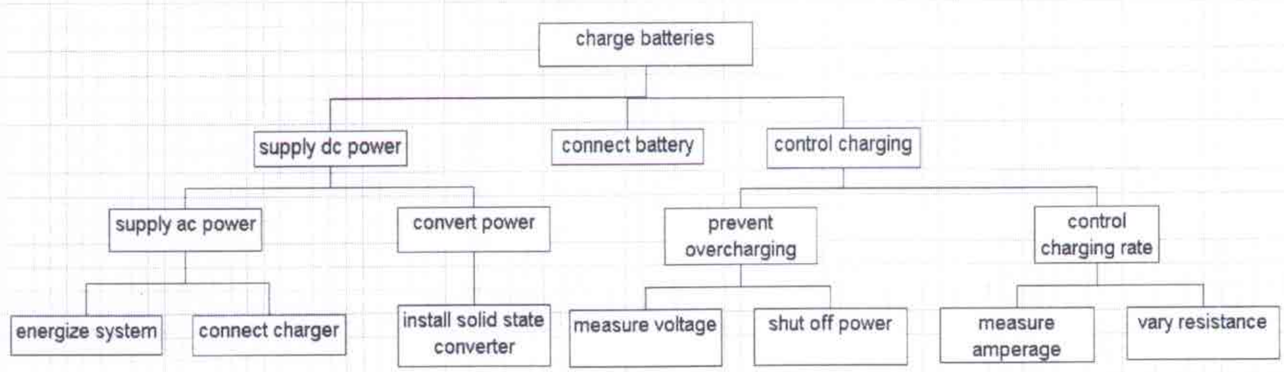


Figure 23

Function Hierarchy

Another function identification tool that may be easier for engineers and architects to understand is called the Function Hierarchy model. As shown in Figure 23, the top of the hierarchy is the output of the assignment or the basic function. The next level in the hierarchy are supporting functions that must be accomplished to achieve the basic function.

Each succeeding tier is composed of supporting functions that must be accomplished to achieve the function that they are linked to on the tier immediately above. For example, if the output for the battery charging facility is to "charge batteries" then what has to happen for that function to be achieved. The diagram says that you have to supply dc power, connect battery and control charging. What has to happen to supply dc power? You have to supply ac power and convert power. What has to happen to supply ac power? You have to energize system and connect charger. The other legs of the hierarchy are similarly expanded.

There are other formal thinking processes available that can help you clarify and communicate your understanding of the customer's functional requirements. The input-output diagram or Ishikawa fishbone diagram is one of these that comes from the quality program. It graphically presents the relationship of inputs (the fishbones) to the output (the fish head) so that the causes of the situation or problem are clearly identified. Having a working knowledge of tools such as FAST, function hierarchy model, fishbone diagrams and others is important to give you the flexibility to choose the best tool for the specific application and customer.

FACD TEAM MEMBERS

The FACD team members should be well versed in the use of functional terms and FAST diagraming. The team members should be able to listen to the customers' needs and assist in developing an overall concept to meet those needs. To do this the team member must ferret out what exists (utilities, availability Base master plan, environmental impacts, etc.) and determine how all will be addressed in the overall plan.

Project Type and Team Members

FACD team members' requirements will vary based upon the type of project (design, planning, programming or workshop project) required. The following is a suggested team member listing based upon project type and can vary based upon individual circumstances.

Project Type	Team Members
Design	Team Leader/CVS, Architect(s), Civil, Structural, Mechanical, Electrical, Fire Protection, Environmental, Geologist and Cost Estimator
Planning	Project Manager, Team Leader/CVS, Architect(s), Civil and Electrical Engineer and Cost Estimator
Workshop	Project Manager, Team Leader/CVS, Project Sponsor, Branch of Service - Command, Base Command and Project Area Specialists

FACD Team Members

The following is a listing of the typical FACD team members and their responsibilities on a typical MILCON project.

Project Manager (PM)

Responsible for project scope, budget and any changes thereto.

Project Design Engineer (PDE)

The PDE is responsible for the project design, execution, construction, coordination and follow up.

A-E Design Team or In-House Design Team

Architect(s), Civil, Structural, Mechanical, Electrical, Fire Protection, Environmental, Geologist, Cost Estimator or other mix of disciplines depending upon the particular project. All are responsible for the overall project scope and maintaining the agreed-upon project cost and schedule. Keep minutes of meetings not attended by the Team Leader or Project Manager. Provide inputs to the Draft Partnering Agreement. Prepare all drawings, presentation graphics, participate in an analysis of project functions, creative sessions to identify alternative materials and systems to provide the required functions, evaluations of the high-potential creative ideas, contribute to the Draft Partnering Agreement, conduct summary briefings, respond to review comments on the Draft Partnering Agreement, obtain approval signatures and distribute the Final Partnering Agreement.

Team Leader/CVS

The Team Leader/CVS is the outsider between NAVFACENGCOM, the customer, base personnel and the A-E design team responsible for resolving differences. A CVS background should be considered due to the FACD process being dependent on function, function analysis, FAST diagraming, functional relationships and alternate documentation.

Responsible for leading the A-E design team through an analysis of project functions, creative sessions to identify alternate materials and systems to provide the required functions, guide the design team through evaluations of the high potential creative ideas, coordinate all meetings, keep minutes of all meetings that he attends, type the Draft Partnering Agreement, help the A-E design team during the summary briefings, assist the designer obtain approval signatures and assist the designer in distributing the Final Partnering Agreement. The Team Leader/CVS (customer, Base, A-E design team, NAVFACENGCOM or other) provides an appropriate conference room for use by the A-E design team during the on-site work sessions. The conference room must be provided with adequate lighting, 24 hour a day availability, xerographic reproduction services, telephone for local and long distance calls, facsimile transmission and availability of drawing reproduction services near the conference room.

The Team Leader/CVS will produce a concept report which is called Volume I of the Project Engineering Report and includes:

1. Final Partnering Agreement

2. Supporting Project documentation: Data to support the development of the project scope, layout and special features. Items included: 1) written reports of all site investigations and fact finding; 2) minutes of meetings, discussions and list of attendees; 3) functional analysis worksheets including site analysis diagrams (showing relationships to adjacent structures, major vehicular/pedestrian circulation patterns, utilities, site topography, climatic factors, major vegetation and other factors impacting facility siting and building orientation), internal building functional relationships (depicting interrelation-ships and required proximity between spaces, work flow, circulation, etc.), material flow and other functional diagrams prepared on-site; 4) list of creative ideas with economic impact and quality rating; 5) summary of alternates developed; 6) economic and technical analyses prepared during the on-site work sessions; 7) listing of all creative ideas incorporated in the design concept with an estimate of the cost impact of implementation and 8) copies of the initial parametric cost estimate and the final cost estimate.

The report is indexed and bound in standard size (8 ½" by 11" page) 3-ring binder with the project title and other pertinent information shown on the front cover and binding edge.

Cover information and color of same are coordinated between the A-E design team and the Team Leader/CVS, so that the Volume I and Volume II appear as a set on the shelf.

Value Engineering/Manager

Sets initial FACD schedule with Base Facilities Engineer, A-E design team, Team Leader/CVS, Project Manager and Project Design Engineer. Insures availability of project funding for the project design. Insures coordination of all parties required to participate in the FACD process.

Base Facilities Engineer

Insures that all required personnel are informed and available for participation in the FACD work schedule period (Base Commander, unit commander, facilities technical staff [sewer, water, electric and communications] and Base security).

FACD PROCESS STEPS

The following are the steps elements of the "Functional Analysis Concept Development" (FACD) Process:

FUNCTIONAL ANALYSIS CONCEPT DEVELOPMENT PROCESS

IDENTIFY REQUIRED FUNCTIONS

↓

IDENTIFY ALTERNATES

↓

EVALUATE ALTERNATES

↓

DECISION MAKING

↓

INCORPORATE APPROVED ALTERNATES

↓

WRITE SCOPE AND DESIGN CONCEPT (DRAFT PARTNERING AGREEMENT)

↓

RESPOND TO REVIEW COMMENTS

↓

GET APPROVALS (FINAL PARTNERING AGREEMENT)

↓

PREPARE PE/PD PACKAGE (PROJECT ENGINEERING/PROJECT DEFINITION)

The FACD Team starts with no design, just user-required functions and function analysis. The team develops iterative designs and iterative alternatives to meet user-functional requirements, adjacencies, circulation (both internal and external) and building systems within project budget (cost) requirements.

ON-SITE WORK PLAN SCHEDULE

The following shows a typical On-Site work plan schedule which details when meetings are planned and who is required to be in attendance. This actual schedule typifies the milestones and the time frame for achievement.

ON-SITE WORK PLAN SCHEDULE
MUNITIONS MAINTENANCE FACILITY

WORK ITEM	MON 9/28	TUE 9/29	WED 10/1	THU 10/1	FRI 10/2	SAT 10/3	SUN 10/4	MON 10/5	TUE 10/6	WED 10/7	THU 10/8
INFORMATION MEETING MUNITIONS MAINTENANCE	*, B X										
SITE INVESTIGATION	X, +										
FUNCTION ANALYSIS	X, +										
PREPARE FLOOR PLAN		X, +									
BRAINSTORM AND EVALUATE ALTERNATES		X, +	X, +	X, +	X, +						
PROGRESS MEETING			*, X B								
PREPARE GRAPHICS						X	X				
PREPARE SCOPE & DESIGN CONCEPT (PA)						X	X				
PRESENT SCOPE & DESIGN CONCEPT (PA)								*, B X			
DISTRIBUTE DRAFT PA								X			
CO EXECUTIVE OUT-BRIEF									*, B X		
REVIEW COMMENTS, RESOLUTION & SIGN-OFF										*, B X	
DISTRIBUTE FINAL PARTNERING AGREEMENT											X

***** AAFB AND PACAF INVOLVEMENT REQUIRED

B BCE INVOLVEMENT REQUIRED

X DESIGN TEAM ACTION REQUIRED

+ AAFB, PACAF AND BCE INPUT MAY BE REQUIRED; FULL TIME PARTICIPATION OPTIONAL

TYPICAL MEETINGS

MEETING NAME	HOW/WHEN SCHEDULED	SCOPE
Opening Meeting	Usually scheduled by PDE in AM of first day at user's facilities.	Attended by everyone involved. This meeting usually generates a lot of user group information. It is used to establish subsequent meetings, site visits, points of contact, and etc. User will identify key issues and concerns.
Site Visit Meeting	Held right after Opening Meeting.	Attended by all FACD Team members to gain visual understanding of facilities and equipment requirements.
Executive In-Brief Meeting	PDE usually schedules prior to the FACD, but sometimes during Kick-Off Meeting.	Limited attendance by PDE, Value Manager, Team Leader/CVS and one or two of the A-E team representatives. The purpose of this meeting is to give the Base C.O. and his executive staff an overview of the project and FACD process. **Note: Do not ask the C.O. to sign attendance sheet. The Team Leader fills it in.**
FACD Team Meetings	Scheduled with all FACD Team members by the Team Leader/CVS for each day at 1700 Hours.	These meetings are used to review, aloud, what each team member has accomplished throughout the day and plans to accomplish the following day. They are also used for developing the FAST diagram, brainstorming, cost cutting, review of developing design and planning for working sessions.

FACD Team Member Meeting with Others	Member schedules with contact person.	Documents conclusions and understandings reached.
Working Session Meetings	Scheduled by Team Leader/CVS or FACD team. Multiple meetings (2-4) are required. One needs to occur right before the weekend so that productive work can continue.	These are critical meetings for the project development process. These are used for or to get decisions from the user on alternates or issues involving scope or budget problems.
OICC (Office in Charge of Construction) Meeting	Scheduled by Team Leader/CVS for A-E team before Formal Presentation Meeting and completion of Partnering Agreement.	Usually to get any special concerns that need to be addressed in the Partnering Agreement. This is attended only by the Team Leader/CVS, the PDE and an A-E team representative.
Formal Presentation Meeting	Scheduled by Team Leader/CVS and FACD team.	Everyone usually attends. The A-E should make a formal presentation of the design (color, graphics, etc.). The Draft Partnering Agreement should be distributed at this meeting and a heads up copy to the Base C.O Each person is requested to review the Draft Partnering Agreement and fill out the comments page.
Executive Out-Brief Meeting	Scheduled to occur after Formal Presentation Meeting.	Limited attendance, usually same as In-Brief Meeting. The A-E presents overview of the project scope using color, graphics, etc. as in Formal Presentation Meeting. The Team Leader/CVS makes notes and fills out the comments sheet for the C.O.

Review Comments and Sign-Off Meeting	Scheduled by Team Leader/CVS.	Everyone that reviewed the Draft Partnering Agreement should bring their review comments to the meeting. The Team Leader/CVS usually reads each comment aloud and the A-E responds. The Team Leader/CVS records each response and incorporates the verbiage into the Final Partnering Agreement, reprints the Partnering Agreement and distributes same to all initial Partnering Agreement holders.

MEETING AND PROCESS SCHEDULE

WORK ITEM	DAY
GATHER INFORMATION	PRIOR
MEET WITH CLIENT FUNCTION ANALYSIS	1
MAKE FAST AND BUBBLE DIAGRAM	1
DEVELOP FLOOR AND SITE PLANS	2
COORDINATE UTILITY CONNECTIONS	2
INVESTIGATE ALTERNATES	2
MEET WITH CLIENT	3
REFINE CONCEPT REFINE COST	4
MEET WITH CLIENT REFINE CONCEPT	5
FINALIZE CONCEPT FINALIZE COST	6
PREPARE PARTNERING AGREEEMENT	7
FORMAL PRESENTATION	8
REVIEW REPORT	9
RESOLVE COMMENTS APPROVE CONCEPT DISTRIBUTE SUMMARY	10

CONDUCT OF MEETINGS

WHEN?	**TIME AND DATE**
WHERE?	**SPECIFIC LOCATION**
WHY?	**PURPOSE OF THE MEETING**
WHAT?	**ITEMS TO BE PRESENTED**
WHO?	**WHO WILL PRESENT WHAT ITEMS**
HOW LONG?	**ANTICIPATED LENGTH OF MEETING**
EXPECTED RESULTS?	**WHAT IS HOPED TO BE ACHIEVED**

CONDUCT OF MEETINGS

BASED UPON WHAT IS TO BE PRESENTED AND
WHAT IS EXPECTED TO BE ACHIEVED,
"WHO SHOULD BE INVITED?"

WHO'S SCHEDULE SHOULD DETERMINE
WHEN THE MEETING SHOULD BE HELD?

WOULD A MINI-MEETING SUFFICE?

USE PEOPLE'S TIME WISELY.

THE MEETING LOCATION SHOULD BE
CONVENIENT FOR WHOM?

WHO SHOULD ATTEND? DECISION MAKERS!
CHOSE A RECORDER TO TAKE NOTES!

Opening Meeting
for
FY00 MILCON REPLACE POL HYDRANT FUEL SYSTEM, PH 1
ANDERSEN AFB, GUAM

TIME AND DATE: 4 May 1998 at 0900

LOCATION: As determined by Andersen AFB

PURPOSE:

1. Introduce stakeholders
2. Discuss project scope, budget and acquisition schedule
3. Present projected FACD schedule and verify times and locations for formal meetings
4. Open discussion on project functions
5. Present notional hydrant schematics, facility siting and parametric cost estimate
6. Get stakeholder feedback on FACD schedule, meetings, project functions and notional schematics.
7. Discuss required design data and best method to obtain this information
8. Schedule follow on informal meetings

AGENDA

Agenda Items	Presented by
Opening comments and introductions	George Moribe
Authorized Project Scope, Budget and Acquisition Strategy	Ed Kwock/Clarence Kubo/Gordon Tang/Sanford Oda
FACD Process, schedule and discussion on project functions	Mike Koga
Present notional hydrant schematics, facility siting and parametric cost estimate	Robert and Company
Discuss design data and best method to obtain information	Robert and Company
Schedule follow on informal and formal meetings	Jim Dziekonski/Robert and Company
Site Visit to follow meeting	

EXPECTED RESULTS:

1. Concurrence on time and location of formal meetings
2. Concurrence on authorized scope and ECC
3. Team understanding of Andersen AFB priorities and concerns
4. Stakeholder input on notional schematics, siting and parametric cost
5. Andersen AFB input on desired exterior building appearance, materials, building systems and environmental considerations
6. Scheduling of separate meetings on utilities, environmental, planning, constructibility issues, etc.

PRESENTATIONS

COVER EVERYTHING THAT IS IN THE FINAL PRODUCT AND WHAT WILL BE READ IN THE PARTNERING AGREEMENT

ANSWER QUESTIONS

RECORD COMMENTS & DECISIONS

ALLOW TIME TO REVIEW PARTNERING AGREEMENT

SCHEDULE REVIEW COMMENTS MEETING

A-E RESPONDS TO COMMENTS

INCORPORATE CHANGES IN FINAL PARTNERING AGREEMENT

THE FINAL PRODUCT

MILCON DESIGN

DESIGN BUILD

WORKSHOPS

MASTER PLANNING

PROGRAMMING

MINIMAL PROJECT

FACD WORK ITEMS

The typical FACD Work Plan details each of the incremental steps that occurs throughout the process. Completion of Work Items ensure that all items get reviewed and disposition of each is included in the Partnering Agreement.

The following pages depict a typical MILCON FACD Work Item listing, to whom items are typically assigned and a column for the date completed. This listing will cover the following:

1. Involve the customer.
2. Identify functions to be provided.
3. Identify functions required to satisfy the requested needs.
4. Identify all functional relationships.
5. Identify utilities, permits, environmental, architectural and ownership requirements.
6. Brainstorm, evaluate systems and analyze alternates.
7. Present and explain alternates to the customer including cost impact.
8. Gain customer's concurrence on all systems and prepare Draft Partnering Agreement (PA).
9. Respond to review comments and obtain signatures.
10. Publish Final Partnering Agreement.

SUSTAINABLE DESIGN ISSUES

Sustainable Building Technical Manual, Public Technology, Inc., 1996

Building and Site Requirements

1. Develop previously disturbed sites where available in lieu of developing virgin land.
2. Avoid stream channels, flood plains, wetlands, steep erodible slopes and mature vegetated areas.
3. Plan site layout to consider site clearing and planting to take advantage of solar and topographic conditions.
4. Orient building to take advantage of solar energy and passive and active solar systems.
5. Minimize solar shadows.
6. Minimize earthwork and clearing by aligning long buildings and parking lots with landscape contours.
7. Adjust building footprint and floor elevations to take advantage of excessive slopes.
8. Provide a building entrance orientation that maximizes safety and ease of access.
9. Harness solar energy, airflow patterns, natural water sources and the insulating quality of land forms for building temperature control.

10. Avoid siting building downwind of heat sinks or use heat sinks to heat specific areas.
11. Use existing vegetation to moderate weather conditions and provide protection for native wildlife.
12. Design access roads, landscaping and ancillary structures to channel wind toward main building for cooling or away from them to reduce heat loss.
13. Modify microclimates to maximize human comfort in the use of outdoor public amenities such as plazas, siting area and rest areas.
14. Use plants to mitigate climate zones.
15. Select building entrance orientation to maximize safety and ease of access.

Materials of Construction

1. Consider use of sustainable or renewable materials for construction.
2. Evaluate recycle or reuse capability when selecting materials.
3. Consider the total energy required to manufacture and install materials when selecting materials.
4. Reduce material use, reuse and recycle in that order of priority.
5. Use new materials only when reusable or recyclable materials are not suitable.
6. Select materials based on life cycle considerations including the total cost of manufacture, demolition and disposal.

Construction Methods

1. Specify sustainable site construction methods.
2. Specify sequential phasing of construction to minimize site disruption.
3. Protect soils on site during construction.
4. Require erosion protection considerations during construction.
5. Stabilize soil during and after construction.
6. Protect existing plants to remain during construction.

Watershed Protection

1. Emphasize preservation of mature vegetated soils and lowland areas.
2. Minimize pavement areas to the strict minimum required for their intended purpose.
3. Install silt fences to hold sediment on-site during construction.
4. Minimize use of landscape irrigation, herbicides, pesticides and fertilizers to support landscaping.
5. Consider use of permeable pavement material.
6. Use vegetated surfaces for areas occasionally used for vehicle travel.
7. Use permeable material such as gravel, wooden decks and paving stones for pedestrian surfaces in lieu of impermeable pavement.
8. Design paving to serve dual purposes such as covering over a gravel reservoir.

Reclaim Water

1. Consider routing roof drainage and other site drainage to natural permeable drainage ways, ponding areas or dry wells to allow water to infiltrate into the aquifer.

2. Reduce flow velocity, treat runoff and return it to its natural path in the soil.
3. Use infiltration basins and ponding areas in lieu of manmade or natural drainage channels to maximize groundwater recharge.
4. Install a rain water harvesting system to collect and use rainwater.
5. Install gray water collection, treatment and use systems.
6. Consider use of dual water systems.
7. Install black water treatment system to use treated effluent on site.

Landscaping

1. Use native or well adapted plant species in landscaping.
2. Preserve native plants through careful site planning and sustainable construction practices.
3. Restore native plant species.
4. Minimize use of high maintenance lawns.
5. Minimize use of annual plants.
6. Use xeriscape principles when selecting landscaping.
7. Use integrated pest management against insects and weeds.
8. Use mulching, alternative mowing and composting to maintain plant health.

Water Conservation

1. Reduce overall water use by installing water efficient systems.
2. Prepare a water budget analysis to determine baseline consumption for use in life cycle analyses.
3. Install drip irrigation where irrigation is required.
4. Increase efficiency of irrigation with controllers and sensors.
5. Maintain irrigation systems to maintain maximum efficiency.

Utility Corridors

1. Design site plant to minimize road length, building footprint, and the actual ground area required for intended improvements.
2. Use gravity sewer systems.
3. Consolidate utility corridors.

Transportation

1. Use existing transportation infrastructure where feasible.
2. Consolidate service, pedestrian, and automobile routes.

Site Lighting and Electrical Systems

1. Light the minimum area for the minimum time.
2. Identify the actual purpose of lighting to determine the lowest lighting level that will fulfill that purpose.
3. Use energy efficient lamps and ballasts.
4. Use low voltage lighting.

5. Use renewable energy sources for lighting and outdoor power.

Daylighting

1. Avoid direct sunlight on critical tasks and excessive brightness.
2. Bring daylight in at a high elevation.
3. Filter daylight.
4. Bounce daylight off of surrounding surfaces and select wall surfaces to enhance reflectivity.
5. Use clerestories, skylights, roof monitors, light shelves, light pipes, and innovative side lighting techniques to bring daylight into interior spaces.
6. Use sloped or curved ceilings to distribute light efficiently.
7. Maintain a favorable room aspect ratio to bring daylight into interior spaces.
8. Use baffles, louvers, and reflectors for solar control.
9. Integrate daylighting with luminous ceiling systems.
10. Consider use of heliostats, reflectors, or other light collectors.
11. Integrate lighting controls to respond to available daylight.
12. Install spectrally selective or special glazing.

Building Envelop

1. Select the most compact building footprint and shape that work with requirements for daylighting, solar heating and cooling and function.
2. Size and position doors, windows and vents to enhance daylighting, heating and cooling.
3. Use the highest insulation value as possible considering life cycle cost considerations.
4. Use thermal mass to moderate interior temperature swings.
5. Enhance the reflectivity of the exterior building skin.
6. Use construction materials and details that reduce heat transfer.
7. Consider use of earth berms to reduce heat transmission and radiant heat loads.

Heating and Cooling

1. Use passive heating techniques.
2. Install shading devices.
3. Maximize natural ventilation.
4. Use thermal storage strategies.
5. Use solar heating.
6. Consider solar cooling.
7. Consider use of reject heat for heating and cooling.
8. Design HVAC using advanced design methods.
9. Consider efficiency for the entire system vice individual components.
10. Design for flexibility.
11. Design equipment for greatest efficiency at the most probable load.
12. Select equipment for good part load efficiency.
13. Install an energy monitoring and control system as required by 10 CFR.
14. Use variable air volume systems.
15. Avoid use of re-heat for zone temperature control.
16. Reduce duct system pressure losses.

17. Reduce duct leakage and thermal losses by specifying low-leakage sealing methods and good insulation.
18. Consider proper air distribution to save energy and improve comfort.
19. Use low face velocity coils and filters.
20. Deliver cooling air at lower temperatures.
21. Specify ductwork with smooth interior surfaces.
22. Select the highest efficiency chillers.
23. Use variable speed drives and multiple compressor unloading for greater efficiency.
24. Consider desiccant dehumidification.
25. Consider use of absorption cooling.
26. Consider thermal energy storage.
27. Evaluate hydronic pumping systems.
28. Use heat recovery systems.
29. Use direct digital controls.
30. Consider direct drive motors in lieu of belt or gear driven equipment.
31. Consider diffuser selection to include energy efficiency.
32. Consider underfloor air distribution systems.
33. Consider use of evaporative cooling.
34. Recalculate cooling loads at final design stage to insure that original design assumptions are realized.
35. Reduce hot water system standby losses.
36. Consider hot water heating options and base selection on life cycle cost.
37. Evaluate central vice localized heating systems based on life cycle costs.
38. Reduce hot water distribution temperatures.
39. Install hot water system controls to optimize energy efficiency.
40. Use solar hot water heating.
41. Design efficient plumbing systems including selection of pumps considering part load flow conditions.

Power

1. Consider user of photovoltaic.
2. Use high efficiency motors.
3. Consider the most energy efficient lighting source.
4. Consider all lighting sources when designing lighting systems.
5. Use sophisticated lighting design analysis.
6. Lighting should specify illumination levels and luminance ratios to achieve uniform lighting levels and avoid over-illuminating areas.
7. Design lighting levels for specific visual tasks.
8. Consider use of task lighting.
9. Specify high efficiency lamps and ballasts.
10. Improve optical control to place light where it is needed and reduce spill lighting.
11. Include lighting control in energy monitoring and control systems.
12. Use energy efficient exit signs.
13. Install high efficiency task lighting.
14. Specify energy efficient office equipment and appliances.
15. Consider higher voltage distribution.

16. Use proper selection of electrical equipment and power factor correcting equipment to improve power factors.
17. Use K rated transformers.
18. Size conductors correctly.
19. Install equipment to turnoff equipment such as computers when they are inactive.

Indoor Air Quality (IAQ)

1. Use dedicated ventilation systems.
2. Use separate exhaust systems to reduce spread of pollutants.
3. Regulate quantities of ventilation air based on specific occupancy needs.
4. Provide adequate ventilation rates.
5. Select building materials considering impact of selection on indoor air quality. Get MSDS for all materials.
6. Consider building sealing on IAQ.
7. Establish acceptable limits for total volatile organic compounds and determine probable levels based on emissions test data.
8. Specify materials that are resistant to microbial growth.
9. Consider building flushout.
10. Consider the following items for HVAC: locate intakes away from contaminants, locate intakes away from bird pollution, install high efficiency filtration, use positive building air pressure in humid areas, provide adequate access for maintenance, and include carbon monoxide and VOC detectors.

Acoustics

1. Determine the acoustic impact of building equipment on surrounding area.
2. Specify STC rating between spaces.
3. Select appropriate criteria for noise levels.
4. Locate noise sensitive areas away from noise producing areas.
5. Consider acoustical properties when selecting interior finishes.
6. Use acoustical ceiling materials and carpets.
7. Consider white noise or sound masking system to maintain speech privacy.
8. Consider use of active noise control systems when necessary.

FACD Work Items Schedule

	Work Item	Assigned To	Date Completed
1.	Schedule on-site work.	NAVFACENGCOM	
2.	Prepare agenda for opening meeting.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
3.	Prepare calendar, FACD handout, announcement letter and transmit to Customer.	NAVFACENGCOM	
4.	Formally notify Customer of schedule.	NAVFACENGCOM	
5.	Notify participants of opening meeting.	Customer	
6.	Coordinate logistics.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
7.	Schedule and notify Client, Customer and Architect of pre-FACD team meeting.	Team Leader/CVS	
8.	Review programming documents.	All Team Members	
9.	Obtain existing site information, i.e. master plan, general development maps, base topographic maps, geotechnical information, utility drawings and other published information.	A-E Team	
10.	Prepare parametric cost estimate.	A-E Team	
11.	Prepare presentation size concept	A-E Team	

	sketches, a maximum of 22 x 34 and include Anti-terrorism/Force Protection requirements.		
12.	Prepare draft function model.	Team Leader/CVS, A-E Team	
13.	Conduct opening meeting, confirm title of the property and if ADA requirements apply.	All parties	
14.	Review meeting minutes.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
15.	Conduct function analysis.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
16.	Identify functional relationships.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
17.	Prepare block plan "bubble diagram."	A-E Team	
18.	Prepare floor plan.	A-E Team	
19.	Prepare site plan.	A-E Team	
20.	Brainstorm floor and site plan.	Team Leader/CVS, A-E Team	
21.	Evaluate potential floor and site plan alternates.	A-E Team	
22.	Develop structural system.	A-E Team	
23.	Brainstorm structural system.	A-E Team, Team	

		Leader/CVS	
24.	Evaluate potential structural system alternates.	A-E Team	
25.	Develop architectural systems.	A-E Team	
26.	Brainstorm architectural systems.	A-E Team, Team Leader/CVS	
27.	Evaluate potential architectural systems alternates.	A-E Team	
28.	Develop mechanical systems.	A-E Team	
29.	Brainstorm mechanical systems.	Team Leader/CVS, A-E Team	
30.	Evaluate potential mechanical systems alternates.	A-E Team	
31.	Develop fire protection systems.	A-E Team	
32.	Brainstorm fire protection systems.	Team Leader/CVS, A-E Team	
33.	Evaluate potential fire protection systems alternates.	A-E Team	
34.	Develop electrical systems.	A-E Team	
35.	Brainstorm electrical systems.	Team Leader/CVS, A-E Team	
36.	Evaluate alternate electrical systems.	A-E Team	

37.	Check topo and geotechnical.	A-E Team	
38.	Confirm environmental clearances have been obtained.	Team Leader/CVS, A-E Team	
39.	Identify and resolve potential environmental roadblocks.	Team Leader/CVS, A-E Team	
40.	Coordinate utility connections.	A-E Team	
41.	Confirm conformance with applicable master plans.	Team Leader/CVS, A-E Team	
42.	Identify required permits.	A-E Team	
43.	Confirm conformance with BEAP.	Team Leader/CVS, A-E Team	
44.	Confirm real estate ownership.	Team Leader/CVS	
45.	Review applicable conforming documents.	Team Leader/CVS, A-E Team	
46.	Refine cost estimate.	A-E Team	
47.	Prepare for 1st working session.	Team Leader/CVS, A-E Team	
48.	Prepare agenda.	Team Leader/CVS	
49.	Conduct 1st working session.	NAVFACENGCOM, Team Leader/CVS, A-E Team	

50	Revise design.	A-E Team	
51.	Refine cost.	A-E Team	
52.	Brainstorm cost-cutting items.	Team Leader/CVS, A-E Team	
53.	Evaluate alternates.	A-E Team	
54.	Obtain constructibility comments and review sustainable design issues.	Team Leader/CVS, A-E Team, ROICC	
55.	Prepare for 2nd working session.	Team Leader/CVS, A-E Team	
56.	Prepare agenda.	Team Leader/CVS	
57.	Conduct 2nd working session.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
58.	Incorporate changes.	A-E Team	
59.	Refine cost.	A-E Team	
60.	Prepare presentation graphics, 22 x 34 maximum and 11 x 17 maximum for book.	A-E Team	
61.	Prepare Partnering Agreement.	Team Leader/CVS, A-E Team	
62	Conduct formal staff presentation and distribute Draft Partnering Agreement.	NAVFACENGCOM, Team Leader/CVS, A-E Team	

63.	Schedule receipt of review comments, comment resolution and sign-off meeting.	Team Leader/CVS	
64.	Executive briefing.	NAVFACENGCOM, Team Leader/CVS, A-E Team	
65.	Comment resolution and sign-off meeting.	NAVFACENGCOM, Team Leader/CVS, A-E Team, Customer Representatives	
66.	Revise Draft Partnering Agreement.	Team Leader/CVS	
67.	Distribute Final Partnering Agreement.	Team Leader/CVS	
68.	Prepare Concept Study Report.	Team Leader/CVS	
69.	Distribute Concept Study Report.	NAVFACENGCOM	

NOTE: Items #68 and #69 are completed after the FACD process and document all significant occurrences during the FACD process.

CREATIVE THINKING

What is Thinking?

The word "think" comes from the Latin "cogitare" (co-agitare, to turn in mind, consider, agitate). Hence when you think hard and fast you are probably shaking bits of data together mentally in your hope of making a relevant connection. For example, if you are trying to *think* of an acquaintance's name, you might shake loose a variety of thoughts related to the person - past occasions when you were together, associations you had made with him/her etc. - hoping that something would suddenly connect with the correct name in your mental storage bin.

If you are thinking about a new use for a paper clip, you might associate it with a tie clip and thus generate the idea of using it as a tie clasp - maybe even gold-plating it for novelty jewelry. Or you might picture it opened to its full length and then associate it mentally with dry-cell batteries, as a connecting wire. You might even make the visual association to a racetrack and then manipulate the material in your data bank until you come up with the appropriate absurdity of using it as a racetrack for fleas. Nothing earth-shaking, but rather a crude example of what is often called "creative" thinking. Fran Cartier, once joked, "There is no such thing as creative thinking; there is only thinking, but it happens so seldom that when it does we call it creative!"

Creativity

The creativity process starts early in life for every individual and maximizes at 4 or 5 years of age (Figure 2-33). From then on, creative thinking is restricted by parental and school controls and social and legal requirements until many lose their inherent ability to be creative. In fact, one can lose creativity by narrowing work experience as shown in Figure 2-33.

What can be done? For one thing, it must be recognized that the creative process requires an alert mental attitude and a responsiveness to change. Also, it must be recognized that regeneration of creativity can definitely be enhanced through training. This phenomenon is indicated by the dotted loop on the curve. By training and practice, creative ability can be improved by learning to recognize and overcome barriers to creativity. In addition, one can broaden his/her experience by other means, such as adopting a creative hobby.

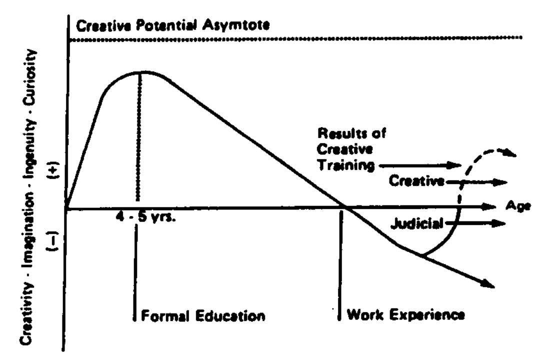


Figure 2-33. Creativity process.

One aspect of training is very important.
Emotional blocks, such as the fear of making a mistake or of appearing foolish, must be removed in order to maintain a positive approach to creativity. A general law is that a positive attitude begets positive results while a negative attitude invariably ends up with negative results.

If we look for creativity in individuals, their personal status of needs must be analyzed. For example, if an individual is hungry he will hardly be creative. So the individual has to have his basic needs satisfied (e.g., job security is also quite important and must be satisfied before one can be really freewheeling and creative). An analogy can be applied to the project status. Figure 2-34 graphically portrays the hierarchy of needs as developed by Maslow, and modified by the author to apply to projects. This figure indicates that the project must meet the following needs in order of priority: program, budget, codes and standards; esteem values, such as acceptance, awards or recognition; and lastly, after all else is satisfied, the owner/designer/user/public critical evaluation. Critical evaluation sometimes called actualization is the highest order of needs. The hierarchy of needs indicates that the lower needs must be satisfied first before proceeding up the ladder.

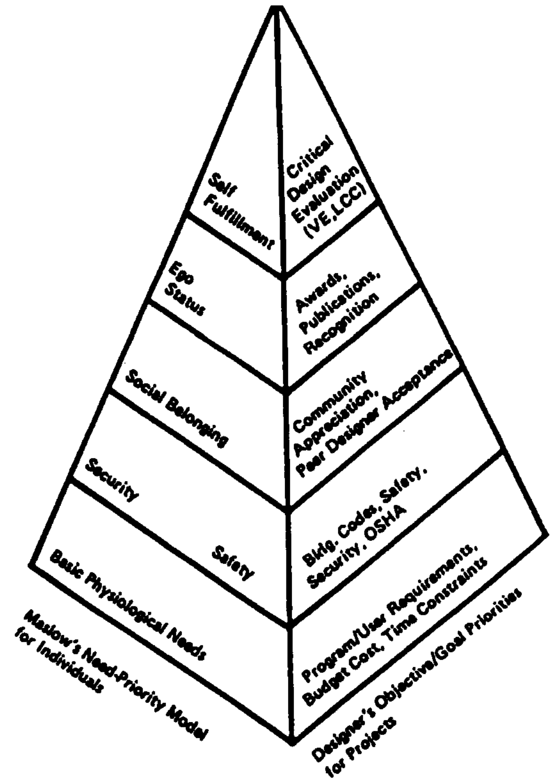


Figure 2-34. Hierarchy of Needs.

Creativity involves generating a wide variety of ideas. This helps to optimize the solution by increasing the probability of selecting the best idea during the evaluation phase of the FACD job plan.

Brainstorming

The foremost approach to creativity is the brainstorming technique. A brainstorming session is a problem-solving conference wherein each participant's thinking is stimulated by others in the group. A brainstorming session consists of a group sitting around a table and spontaneously producing ideas related to the performance of the required function. During the session the group is encouraged to generate the maximum number of ideas. No idea is criticized. Judicial and negative thinking are not permitted.

To insure that all ideas are accepted, ground rules are established prior to opening the session. These rules are: no criticism of ideas is allowed; "free wheeling" is encouraged; a large quantity of ideas is wanted; combining and improving ideas is sought; and all ideas are recorded. Thus, the pressures that normally exist in an ordinary conference are removed. Since time is not devoted to criticism or evaluation, a great many more ideas per unit of time are generated. This approach is known as the principle of "deferred judgement".

Brainstorming can be applied to many aspects of problem solving, ranging from definition of the problem to implementation and follow-up on the solution of the problem. Avoid functional rigidity in thinking that brainstorming can be applied only to finding possible solutions for the problem.

Criteria for Selecting Leader and Recording Secretary for the Group - The group leader should be unbiased, have interest in the subject being brainstormed and be a good communicator. This person should attempt to keep all discussions on track, draw people out when necessary, curtail discussions when necessary, allow others to contribute to the discussion and observe time constraints. In addition, this person should be knowledgeable and able to apply brainstorming techniques; he should get the group to observe the rules of brainstorming, especially the "withhold judgement" rule. The group recording secretary should be unbiased and a good note taker. This person should consider his work an important contribution to the group effort.

Possible Group Sizes:

- One person or two people - the advantage of one or two-person brainstorming is that it is a good warm-up for developing checklists for discussion in a larger group.

- Three to eight people (optimum size) - this size group is good for stimulating discussion because people interact and build on ideas of others. A wide variety of ideas can result from group brainstorming with groups of this size.

- Nine or more people - groups of this size offer the advantage of being able to consolidate and elaborate on ideas from smaller size groups.

The quantitative result of a multi-disciplinary group in generating ideas has no parallel. The team concept not only results in a large number of ideas, but also improves the creative ability of the participants. There are many reasons for the high quantity of group ideas obtained, but perhaps the most important one is the aspect of interdisciplinary communication. Many times, one member's idea motivates the associative processes of the other group members. This phenomenon produces a chain reaction, triggering many ideas and the cycle repeats itself. Research tests conducted by the Creative Education Foundation at the University of Buffalo, NY have demonstrated that groups generate 65% to 93% more ideas than individuals working alone.

The Gordon Technique

This technique forces people to talk about a situation differently. It does it by not telling the group what the specific problem is. It merely states the general problem or area of discussion. Very often the two word function definition does this. For example, "fasten material" is not limited to bonding by a specific process. The premise is that if the group knows the specific problem it is highly apt to talk about it in the same habitual fashion and be curbed by preconceived notions.

Rules:

1. Group must be highly diverse.
2. Tape the general discussion.
3. Extended effort is needed, the general discussion may last for hours
4. After the general discussion the specific problem is defined and the group correlates the appropriate ideas.

The Gordon Technique can be highly profitable but highly frustrating since creative people usually instinctively strive for leadership when none is provided. When no specific direction towards a specific problem is provided, creative, goal-seeking people attempt to establish it. Fortunately, with only a broad area to discuss, they go in circles around and around talking about the problem, but never getting there. The profitable thing is they usually cover aspects which would never have dawned on them to discuss if they had known the specific problem. This is the power of the technique. It does not allow people to get into a verbal rut and be roadblocked by words.

Catalog Technique

This technique is handy when looking for certain types of words applicable to a problem. For example, if working on an electrical circuit it might be profitable to look through a catalog of electrical components in order to find many uses for the circuit. A catalog of household non-electrical gadgets might supply some more unique uses for the circuit. Catalogs are used to find ideas for such questions as:

1. In what product might we use this unique material?
2. What professional groups might be interested?
3. What products might be combined?
4. What products might need the features/attributes of this material?

Morphological Approach

The morphological procedures applies the notion of attribute listing together with forced relationships, in a matrix approach. It speeds the production of countless ideas.

In meal planning, we might list some of the following attributes: people involved, places, times, foods, special effects, etc. Under each heading we would list a number of alternatives. For "people" we might jot down family, friends, strangers, needy people, celebrities, etc....for "places" we might list different parts of the house, outdoors, picnics, campgrounds, etc....for "times" we might list breakfast, lunch, dinner, snack-time, etc.... for "foods" we could list all kinds of different food items....for "special effects" we might have music, TV, odors, incense, etc.

Then we would take items at random from each of the headings (attributes) and connect them into a novel meal idea. For example, we might randomly select celebrity, basement, breakfast, hamburger, incense and put them together or adopt them in different ways: "incense" the "head of the house" by serving the kids hamburger for breakfast in the basement game room.

Bionics

This is another way to generate unique ways of talking about functions. It studies nature to ascertain how plants and animals perform functions. The whirling seed of the maple leaf has been copied to encase seedling trout and drop them gently into lakes from aircraft. The womb of a cat was copied to encase large transformers for shipment. The way animals change colors to adapt to heat/cold has been used for roofing shingles to absorb heat at night and reflect during the day. Bats sonic system, navigation capabilities of sand fleas and dolphins ability to communicate are just a few of the bionic analysis.

Synectics

By using other descriptive words this technique forces talk about the problem in another manner. Repeated analogies or metaphors are used as mechanisms for making the familiar strange and the strange familiar. It goes beyond the commonplace descriptive terminology of the experts releasing the team from the functional fixedness of everyday behavior.

Synectics uses three different types of analogies to develop material for possible use in connecting idea elements.

1. Personal Analogy: This is an individual objective mental concentration which makes you part of the thing you are designing. "I am a radar — what do I do?" This approach was a favorite of Charles Kettering, the great American inventor.

2. Direct Analogy: This is an actual comparison of parallel facts which identifies one element with another element of knowledge, function or method. It also involves the use of one idea for another application, such as when an inventor used the forked handle on a doughnut maker for the idea of combining a fork with a truck to make a material handling truck.

3. Symbolic Analogy: This technique attempts to capture the essence of a key word in the problem and describes it as a metaphor. For example, the key work might be "flame." The question would be, "What is the essence of flameness?' Ghostly/thereness could be a response. "Why so?' A flame seems unsubstantial and wavering, but if you put your finger in its path you know it's there!

The 66 Buzz Session

The participants are divided into a number of groups, usually six groups of six people each. Each group has a team leader and recorder who should be briefed and appointed ahead of time. Using the group brainstorming method each group develops alternatives to the function being studied. As the noise level starts to decline, the overall course leader asks each group for one or two ideas from their list and the leader encourages the other groups to expand on the characteristics of those ideas. For example, if studying the function "Remove obstruction," one buzz group may say "explode" - the leader would then encourage all the other groups to develop as many ideas as possible to "explode." A second team may say "melt it." Again, how many ways can you melt it? Both large quantities and diverse ideas can be quickly generated from these interactive sessions.

Input-Output

This technique was developed by General Electric Company for its creative engineering course. It consists of listing either the input to or the output from an adequate solution to some proposed need. If listing the desired output, you would list the inputs desired and available. Between these two extremes, the limitations of the specific "need area" should be listed. For example, suppose the general aim is to develop a satisfactory combination space heater and hair dryer. A listing similar to below might be developed.

Input
1. Electric power for heating element and fan
2. Manual or automatic controls
3. Controls for independently varying temperature and flow of air

Limiting Conditions	1.	Small Size
	2.	Low cost
	3.	Light weight
	4.	Minimal noise
	5.	Adaptable to 120/240 volt AC or DC
	6.	Reliable (X years of trouble free operation)
	7.	Maintainable
	8.	Easy to clean
	9.	Attractive
Output	1.	Sufficient quantity of warm, dry air for heating room or drying hair
	2.	Meet all requirements of users
	3.	Meet all requirements of UL and CSA.

Then the question is asked, "How can we perform this better?"

Crawford Slip-Writing

This is a form of individual brainstorming. Each person is given slips of paper on which they write one idea per slip. The slips are collected and read one at a time. The team then attempts to expand the idea by hitch hiking off of it. This technique overcomes the frequent initial reluctance of brainstorming since the ideas are anonymous.

Attribute Listing

Another commonly used process to aid the flow of ideas is called "attribute listing". It involves taking specific aspects of an object or situation and then focusing particularly on the aspect selected. The checklisting or the forced-relationship processes can then be applied to whatever specific aspect is the subject of focus.

In the meal situation, we might look at the question of dessert and examine everything we know about it - the shapes, colors, tastes, etc., of each specific dessert that we might think of. Then we might vary any one of those attributes or connect something else to that specific attribute.

Suppose we selected orange jello, cut into squares. One attribute might be that it was "soft and shimmery." If we focused on a brick in the fireplace and applied the hardness of the brick to the soft and shimmery quality of the jello, it might lead to the idea of freezing the jello and making it into a semi-icy dessert.

Can You Manipulate Your Images?

New relationships can frequently be forced by manipulating observations that we make, or images that we form in our minds. The inventor of the fork-lift truck reputedly conceived the initial idea while observing (and magnifying) the mechanism that lifts donuts into a donut oven.

Another inventor is said to have achieved his synchronization of the machine gun with the airplane propeller by visualizing how he threw rocks through windmill blades as a boy. His childhood experience suddenly became very relevant to his problem.

A final idea or product might not always evolve from one simple step, but from many channels of connections that open up after the initial forced relationship is made between seemingly unrelated items.

Forced Relationships

Another fundamental procedure involves taking anything in our awareness and attempting to relate it to the problem at hand. For example, in the previous meal situation, suppose the family focused on a tree outside the window. Someone might notice the leaves and suggest serving some element of the meal on attractive leaves; still another person might see highly-textured bark which might suggest small ice-carvings as table decorations.

Want a Few Idea-Stimulation Techniques?

The deferred-judgement principle might be thought of as the "environmental turnpike" that allows free flow to ideas that come to your mind. But what do you do when ideas aren't flowing? While the "turnpike" concept allows and encourages you to express ideas as they occur, you may often need to use other procedures which help to bring the ideas to mind in the first place, so that you do not become stranded on the turnpike, out of gas. The following are some of the more productive techniques for triggering new ideas.

Checklists - In his classic text, "Applied Imagination", Alex F. Osborn explains an effective checklist consisting of a series of verbs used to change mental set as one contemplates a problem or a challenge. For example, three of the verbs are: "magnify", "minify" and "rearrange".

Suppose a family were trying to generate ideas on ways to enjoy their meals together more fully. If they were to think about the situation and apply "magnify", they might come up with ideas like: (1) inviting diverse people - foreign students, teachers, local artists, etc.; or (2) lengthening an occasional dinner by combining it with a favorite record album between courses. "Minify" might suggest: (1) decreasing the size of the portions in each dinner course, but increasing the number of courses, so as to provide more variety and interest to the dinner; or (2) eating around a very small table so as to make the whole dinner much more intimate; or (3) eliminating the meal and feeding a needy family instead. "Rearrange" might suggest eating in the living room or on the porch, or having a reverse meal with the dessert first.

What About Our Automatic Reactions?

It is often difficult not to have some kind of reaction to the spontaneous new ideas that enter our minds while deferring judgment. Whether this reaction is positive or negative, it need not prevent us from considering or simply listing the ideas. Although we may react to a new idea, we need not make any evaluation during the idea finding stage. We might even jot down our momentary reaction as an additional idea. For example, if our unavoidable and immediate reaction to an idea is "too costly", we might note, "reduce cost," or "get some extra funds" as additional ideas.

Try your hand at deferring judgment for five minutes while listing as many ideas as you can regarding the challenge. Let your ideas flow as rapidly as they pop into your head. Later, you can look them over and see what you produced or where they led you. But, for five minutes, just let them flow, as though automatically, from your head, through your fingers, onto the next page.

If we are to break habit-sets and move into new, original ways of viewing our problems and challenges, we must find ways to break old mental associations or connections and form new ones.

What is Deferred Judgment?

Deferred judgment is a fundamental principle that can open us to the greatest flow of associations or connections of new ideas. It frees us from anxieties about the worth and acceptability or appropriateness of raw ideas as we conceive them.

This principle has been extensively researched. When used by groups in the idea-generating stage of the problem-solving process. It is commonly called "brainstorming". The term was coined by its originator, Alex F. Osborn, and popularized in the 1950's.

The fundamental basis of deferred judgment, however, goes back as far as Ecclesiasticus in the Old Testament Apocrypha. One of its pithy saying states: “Think first, criticize afterward.” The great poet-philosopher Frederick Schiller expanded on this in 1788:

> "Apparently, it is not good - and indeed it hinders the creative work of the mind - if the intellect examines too closely the ideas already pouring in, as it were, at the gates. Regarded in isolation, an idea may be quite insignificant and venturesome in the extreme, but it may acquire importance from an idea which follows it. In the case of the creative mind, it seems to me, the intellect has withdrawn its watchers from the gates, and the ideas rush in pell-mell and only then does it review and inspect the multitude."

The essence of deferred judgment is to allow a given period of time for listing all the ideas that come to mind regarding a problem, without judging them in any way. Forget about the quality of the ideas entirely and stretch for quantity. Combine or modify any of the ideas which have already been listed in order to produce additional ideas. Quantity and freedom of expression, without evaluation, are the key points which allow free reign to the imagination. Many of the psychological blocks caused by habit and past experience are broken down by the strange associations that take place during the “free wheeling” process of deferred judgment.

For additional information on creativity and free materials available, the reader might want to contact the Creative Education Foundation. The address is:

> Creative Education Foundation, Inc.
> 1050 Union Rd., #4
> Buffalo, NY 14224
> (716) 675-3181
> (716) 675-3209 FAX

WHAT ELSE WILL DO THE JOB ?

In the Information Phase, the function was identified and checks were made to see if the function(s) were absolutely required. If not required, actions are taken to implement the change. However, in most studies, this will not be the case. The function will be required. Next is speculation on alternate ways to perform the function.

In this phase, the use of creative talents come into play. Attention is initially focused on the "action verb" in our defined function. This verb may be rotate, transmit, store, move, retard, inject, explode, cut, mark, etc.

The powers of the mind are focused on this ONE action being performed ... or to be performed. Several techniques are used to develop ideas that will "do the job".

BLAST - CREATE - REFINE - TECHNIQUE

BLAST the item out of your mind. Concentrate on the function. One way to do this is to remove the drawing or item from view. Think only of Function.

CREATE - write down as many ideas as possible on how to perform the function. Do not discuss the merits of the idea at this time. The ideas will be REFINED during later stages of the analysis.

BRAINSTORM TECHNIQUE

Use the "brainstorm technique". Piggy-back on the ideas of others. Use no negative thinking. Jot down as many ideas as possible. Check lists are available in a number of books on creativity; use these lists to jog your creative talents.

IMAGINATION - use it freely.

Repeat the above creativity process, now using the Two-Word function definition. It will not be unusual if the function definition is changed at this stage.

Write down all ideas no matter how "wild" or far out they may seem. Do not eliminate any ideas at this stage. What is needed now is a <u>lot</u> of ideas . . . quantity counts!

All of us are creative if we will just believe it . . . .

<u>BE POSITIVE IN YOUR MANNER AND ATTITUDE</u>

NOTES ON CREATIVITY

Decision Making - Falls in Four Major Steps

1. Diagnosis of Problem
2. Creative Element
3. Comparing Courses of Action
4. Picking a Course to Follow

Don't rely too heavily on past experience; it is probably outdated.

Do use it as a guide - what are others doing? Reference published articles.

Do rely on current practices.

Sound Diagnosis Requires Answers to the Following Questions:

What is the real problem?

What do we want to accomplish?

Within what limits must we find a satisfactory solution?

Pattern for Creativity - There Are Five Phases to be Considered

Saturation - Soak up all information you can on the subject.

Deliberation - Mull over the ideas - analyze them - listen to all sides of the idea.

Incubation - Relax for a while.

Illumination - When you get the idea jot it down.

Accommodation - Put ideas to work for you - use brainstorming.

BRAINSTORM SESSION POINTERS

SESSION LEADER

Team Captain to act as leader ... and/or appoint an alternate ... to keep session moving in an "informal" atmosphere.

RECORDING SECRETARY - Unbiased and a good note taker.

PROBLEM . . . OPPORTUNITY

"WHAT ELSE WILL DO THE JOB?"

Stick with the FUNCTION . . . how can the FUNCTION be performed? Is it required? Concentrate on that "active" verb first.

KEY FACTORS

Judicial thinking is ruled out

Wildness is welcomed

Quantity is wanted

Combinations and improvements are sought

WRITE down all ideas

AND . . .

Idea of hitchhiking is encouraged
Don't break into splinter groups

THE IDEAL CONCEPT

Let's assume that your project (part-procedure-report-form-organization, etc.) has never been designed, produced, implemented or used. What would be the best way...The Ideal Way...to accomplish this FUNCTION? Think along these lines without any restrictions due to the requirements of specifications, procedures, precedence or any other impeding factors. What we are striving for - as the goal - is the ideal way to do the function under the ideal conditions.

Try it. It may sound impractical but remember - ideal is an idea and ideas are what we are seeking now.

One MILCON project, BEQ & BOQ Facilities, was to be sited in areas with poor soil conditions and the major cost driver was found to be a pile foundation system. Once cost drivers were identified brainstorming was instituted. Many alternatives were considered, analyzed and rejected. Finally, a combination of ideas did the trick. Four separate steel frame buildings with an Exterior Finish System (EFS) were connected by walkways and were provided in lieu of the traditional "Marine proof" Concrete Masonry Unit (CMU) or Cast In Place (CIP) concrete structure. The structure was lightened enough that a spread footing system could be used after over excavating and recompacting with select fill.

FACD studies break the mold on definitive designs due to new quality of life, energy conservation requirements, climatic conditions and other such issues.

Prior to a FACD study the A-E did a design and parametric cost estimate for a dining facility based upon the requirements detailed in the DD 1391. At the opening meeting of the FACD process, function and function analysis was explained to the customer and Government food service representatives. During the function analysis of the project it became obvious that the traditional 1950s design was not the vision for today or the future: one-line feeding system versus the food court concept. Brainstorming ideas found another twist beyond the food court concept. It identified that pay stations (cashier/s) could be utilized to move large quantities of people through in a hurry (more turns per hour) which reduced the sit-down seating requirement. Maybe the definitive designs will catch up to changing military requirements for downsizing, increased efficiency and reducing life cycle costs.

The FACD achievements do not depend on a gifted few. RATHER -- they will represent the sum of contributions of each and every one of the FACD team members.

"WHAT ELSE WILL DO THE JOB?"

Your imagination -- your ability and desire to create something new and different is the only answer to this question.

Don't Be Afraid To Work Alone

Creative thinking doesn't necessarily have to be a group process. Many a good idea came from the individual person. Have the courage to put your ideas to the test of critique. You can use criticism for more stimulation.

Schedule Practice Sessions

With yourself, that is. Unless you drill your mind regularly to produce a bagful of ideas, you haven't really decided to be creative.

Build An Idea Reservoir

Ideas don't often pop out of the blue. You have to keep flooding your mind with ideas by studying related information, by experimenting constantly and by hypothesizing.

Beware of Self-Satisfaction

The president of a large corporation credits his company's success to the "inquiring mind" approach to problems. He says, "This point of view is never satisfied with things as they are," "We assume that anything and everything - product, process, method, procedure or human relations - can be improved."

Be Enthusiastic, Confident

Your willpower controls your imagination and is affected by your emotions. Build faith in yourself by scoring successes on little problems before you tackle the big ones.

Don't Worry About Waste

Accept the fact that much of what you produce will be chaff. But it's always wasteful to wait around for the big, flawless idea.

Be Ready for the Hot Flash

Relax your mind. Keep a pad of paper and a pencil available, even on your night stand.

Don't Worry About Opinions of Others

A couple of bicycle mechanics named Wright never would have gotten their airplane off the ground if they had accepted the "lift" formulas thought up by physicists of their day.

Split Your Problem Into Pieces

It was a milestone in the design of typesetting machines when the problem was broken down into three steps - **composing a line, adjusting line length and redistributing type.** As a whole, the problem would have been overwhelming - if not impossible.

Try the Input-Output Scheme

State the solution of your problem by listing the desired output of the new method and what it should do for you. Then, list all the things that go into the process that are desirable, necessary and available. Between the two extremes, list the limitations of the "need area." Example: Cut the cost of metal ashtrays. For input you have electric power, hand labor and sheet metal. For output you have an ashtray that meets weight, design and appearance specs. Limiting factors are cost limitations, delivery dates and money for equipment. Now cast about among your choices. Specifications may not limit your choice of metal. Other options might be making ashtrays by machine or by hand, with punch presses or draw presses, in your own plant or by sub-contractor. Also, you can spray, dip, chemically treat or polish for a finish.

POWER AND INNOVATION

Innovative accomplishments stretch beyond the established definition of a "job" to bring new learning or capacity to the organization. They involve change, a disruption of existing activities, a redirection of organizational energies that may result in new strategies, products, market opportunities, work methods, technical processes or structures. Change, no matter how desired or desirable, requires that new agreements be negotiated and tools for action be found beyond what it takes to do the routine job and to maintain already established strategies and processes.

Though innovators are diverse people in a diverse circumstance, they share a mode of operating which produces innovation: seeing problems not within limited categories, but in terms larger than perceived wisdom; they make new connections, both intellectual and organizational; and they work across boundaries, reaching beyond the limits of their own jobs-as-given. They are not rugged individualists as in the classic stereotype of an entrepreneur, but good builders and users of teams, as classic creators have to be. They are aided in their quest for innovation by an environment, in which ideas flow freely. Resources are attainable rather than locked in budgetary boxes. Support and teamwork across areas are the norm.

To initiate and implement an innovation, people need that extra bit of power to move the system off the course in which it was heading automatically, like the extra muscle thrust to turn a boat or the extra engine power to turn an airplane. As long as people are merely the custodians of already determined routines and directions, they too can operate automatically, staying within their segment and working with the resources or information handed down to them. But innovation, in contrast, requires that the innovators get enough power to mobilize people and resources to get something non-routine done.

Innovative accomplishments differ from merely doing one's basic job, even if the person does it well, not only in scope and long-run impact but, also in what it takes to carry them out. This is why power is so important. Power, as defined, is intimately connected with the ability to produce; it is the capacity to mobilize people and resources to get things done. But people who are "just doing their jobs" do not need to "mobilize" anyone. Little is problematic. They have a job to do; they are told in detail how to go about it or they already know, from past experience with identical assignments; they use existing budget or staff; they do not need to gather or share much information outside their unit and they encounter little or no opposition. So they can act on their own authority and do not need to seek or use additional power. At the same time, they do not produce innovations; they repeat what is already known, though sometimes a little faster or better. Often they get so good at repeating it that they find it hard to stop even when conditions change.

The accomplishments, for example, generally involve beating their own record, advancing their own careers, smoothing friction with subordinates, or adding incrementally to an ongoing process, rather than introducing anything, changing anything, redirecting or reorienting their area. They rarely describe orientation to a specific goal, a drive toward a concrete achievement or a tangible project. There is only an ongoing stream of organizational events in which these managers have a clearly delineated territory and rather unchangeable activities; sometimes they cannot even single out achievements from this ceaseless flow.

It is also for this reason that non-innovators lack the excitement about their work characteristic, are dull and lifeless. Routine jobs, after all, lack the adventure associated with carrying out specific projects and watching results pile up - a clear "something" where there was "nothing," order out of chaos. There is none of the drama and even romance inherent in overcoming obstacles, in proving something or in jumping hurdles. Managers whose accomplishments were basic ones coming directly out of routine jobs had little to say about what they had done; their achievements were modest and there was no real story.

The term "innovation" makes most people think first about technology: new products and new methods for making them. Typically the word "innovation" creates an image of an invention, a new piece of technical apparatus or perhaps something of a scientific character. If most people were asked to list some of the major innovations of the last few years, microprocessors and computer-related devices would be mentioned frequently. Fewer people would mention new tax laws or the creation of enterprise zones, even though those are innovations, too. Fewer still, if any, would be likely to mention such innovations as quality circles or problem-solving task forces. This is unfortunate, for our emerging world requires more social and organizational innovation. Indeed, it is by now a virtual truism that if technical innovation runs far ahead of complementary social and organizational innovation, its use in practice can be either dysfunctional or negligible. The advanced technology incorporated in nuclear plants clearly needs more organizational innovation to prevent the frequent breakdowns of both components and human controls. Even many "productivity improvements" rest, at root, on innovations that determine how jobs are designed or how departments are composed.

Innovation refers to the process of bringing any new idea into use. Ideas for reorganizing, cutting costs, putting in new budgeting systems, improving communication or assembling products are also innovations. Innovation is the generation, acceptance and implementation of new ideas, processes, products or services. It can thus occur in any part of an organization and it can involve creative use as well as original invention. Application and implementation are central to this definition; it involves the capacity to change or adapt. And there can be many different kinds of innovations, brought about by many different kinds of people. A person can find opportunities for innovation in nearly any setting.

Early in an organization's growth, there will typically be many innovations. Most people will be concerned with the design of new systems and services or with incorporating rapid technological advances into current products - as in both financial services and personal computers today.

As an organization "matures" and both its products and its technologies become older and more stable, innovations are more likely to center around saving costs and improving performance, thus encouraging creative effort in efficiencies, work methods or quality control - a very different realm for innovation, one that "smokestack" industries like steel and autos are currently emphasizing.

Innovations in management methods and organizational practices thus constitute a broad range of opportunities. In resource-rich environments, when working capital, expert staff and hungry customers are all abundant, emphasis is likely to be placed on potential breakthroughs in technology and extensive research and development activities because the organization can afford them. But, when resources are in short supply, potential innovators need not and do not give up. In resource-lean time, the domain for innovation simply shifts to managerial procedure and organization practice, as in the design of new ways to engage employees in solving problems.

RULES FOR BRAINSTORMING

QUANTITY IS WANTED

NEGATIVISM IS RULED OUT

CHOSE A RECORDER

RECORD EVERYTHING

ALL CONTRIBUTE

MINIMIZE SIDE CONVERSATIONS

CONCENTRATE ON THE PROBLEM

Roadblocks

"... Negative responses based upon

Irrelevant Assumptions ..."

"We don't do it that way."

"It won't work in our operation."

"It's been done this way for years."

"Let's think about it some more."

"They won't hold still for that."

"Let's try it on another job."

"We don't have enough time."

COST DRIVER ANALYSIS

Cost driver analysis is looking for those elements in a project which greatly effect project cost and determining why the costs are high. The primary reason for identifying cost drivers is to identify those areas where cost cutting efforts would be most effective. Each project is different and each must be fully analyzed to determine if the cost drivers are in structural, mechanical, electrical, architectural or even civil. Rules of thumb, such as, watts/SF for electrical, hundreds of SF/ton of air conditioning, pounds of rebar per cubic yard of concrete and etc. are used as a starting point to find where the disproportions lie. Each design discipline is familiar with these quantity rules of thumb. Once identified the cost drivers should be reviewed to see how else the systems may be provided.

Titles of project sometimes direct an erroneous approach. One MILCON project was titled as a Munitions Maintenance Facility in the DD 1391 and in reality it was a trailer maintenance facility. The trailers, however, were used only for the delivery of munitions from the magazines to the flight line. No munitions ever entered the maintenance facility. The original DD 1391 site selected along the roadway from the magazines to the flight line was a high permafrost area and remote from the main Base. Cost driver analysis showed that well over 60% of the project cost was in utilities infrastructure and a sewage waste collection tank which would have to be pumped out weekly. Recognizing that no munitions would enter the facility made it apparent that the facility could be located near the flight line where permafrost was not encountered and utilities were readily available thus allowing the construction of a quality facility with all required built in equipment and offices.

Working with cost models the Team Leader/CVS might ask questions of the entire team, such as, "Why is the structural system so expensive?" The structural engineer's response might be, "Because we are using piles, pile caps and a structural slab." Team members brainstorming responses usually are as follows: "Could we use less piles and place them only at the corners of each module?"; "How about using a floating slab?"; "How about making smaller modular buildings?"; "How about using a waffle slab?"; and "How about reducing the weight of the super structure by going to lighter systems, such as a steel structure, steel studs and "Dryvit" on the exterior?

Cost-Cutting and Cost Modeling

Certain projects (workshop, planning or projects with sufficient funding) do not normally require cost-cutting efforts.

Cost-cutting can be done at any time, but in the FACD process it should be done only when the team has identified the functional needs of the customer and can relate their systems cost to functions being provided in the project.

Cost-cutting relies on a cost estimate for a particular type of project. Cost estimates are furnished in many formats. Whatever the format, the A-E design team, Team Leader/CVS and VE Manager can work with them and turn them into a Cost Model. The Cost Model is used as a focal point to hone in on questioning which systems are being provided and brainstorming what alternates might be proposed.

Cost models can be produced based upon design discipline (Figure 24), building systems (Figure 25) or functions (Figure 26). All three have their place in the FACD process and each can be used effectively.

The cost model based upon design discipline (Figure 24) is usually computer based for ease of modifying numbers and recalculation, and can be broken down into sub-systems or elements under each discipline. This type of cost model can be made to reflect the various entries, in any units, such as, dollars, dollars/SF, dollars/SM, percentage or any other measurement that might apply.

The building system model (Figure 25) probably gives the greatest visibility in the shortest amount of time and doesn't have too much overlap of trades as the other two cost models do.

The function cost (Figure 26) model is a tougher one to use as costs are assigned to functions, not finite elements. As an example, "Enhance Exteriors" has a whole new meaning. It could include, exterior painting, "Dryvit", plaster finish, burlap rub, tile roof and etc. The function model does offer more opportunity for brainstorming as the participants concentrate on two words only and not the familiar terminology they use every day.

Cost models based upon design discipline are used primarily as a focal point for eliciting inputs when trying to understand the various components of the project, how functions are being satisfied. Building system cost models are effective because they can easily be related to how functions are being provided in the project.

A cost estimator is very important to a MILCON FACD study, as a full-time team member, because he is the only person completely familiar with all the data in the construction cost estimate. While an overall cost of construction, which is based upon a cost per square foot (SF) or cost per square meter (SM), may be fine from a parametric cost estimator's point of view for a particular type of construction, it is not a good starting point for cost-cutting with the A-E design team who is not familiar with what systems are in the cost estimate. Each team member needs to know what assumptions the cost estimator made in determining cost.

The Team Leader/CVS and A-E design team should review each cost element of the cost estimate, so that the entire team has a complete understanding of the project and can question why certain systems or capacities are being provided. Once there is a clear understanding of what functions are required and what systems are being provided to satisfy those functions the team is ready for cost-cutting, to meet the FACD target of 90% Estimated Cost of Construction (ECC) which leaves room for the unforseen items at this point in project development. A break should be taken to allow the cost estimator to revise his cost estimate based upon the new information gained in the previous discussion and allow the cost estimator and Team Leader/CVS to produce a cost model.

The Team Leader/CVS and Project Manager should set a cost-cutting target. It is suggested that this cost-cutting target be the difference in cost between the revised cost estimate and the budgeted (DD 1391) ECC plus 20%. Shown, as follows:

Revised Cost Estimate - DD 1391 ECC x 1.2 = Cost Cutting Target

The reason for setting the target higher than required is that upon developing the alternates some will drop out entirely, some will produce larger than expected cost reductions and others will produce lesser amounts. Further, it is better to have more alternates and let the customer make informed choices to arrive at the ECC target.

AVIATION SUPPLY - FIGURE 24

CIVIL	ARCHITECTURAL	STRUCTURAL	MECHANICAL	ELECTRICAL	FIRE PROT.	MISC.	TOTAL
$406,375	$546,581	$885,685	$172,110	$162,932	$119,232	$95,889	$2,388,804
17.01%	22.88%	37.08%	7.20%	6.82%	4.99%	4.02%	100%
Sewer	Drywall	Foundation	Plumbing	Lighting	Fire Sprinkler	Arch. Mon.	
$17,623	$26,000	$184,521	$48,655	$104,513	$99,215	$40,000	
4%	5%	21%	28%	64%	83%	42%	
AC Pavement	Ceiling	Slab on Grade	Air Conditioning	Power	Fire Alarm	Pallet Racks	
$49,676	$12,300	$171,014	$64,435	$24,776	$20,017	$55,889	
12%	2%	19%	37%	15%	17%	58%	
PCC	VCT	Low Roof	Ventilation	Exterior Elect.			
$23,512	$6,000	$1,004	$59,020	$33,643			
6%	1%	0.11%	34%	21%			
Grading	Doors	Pre-Engineered Bldg					
$189,399	$34,600	$511,788					
47%	6%	58%					
Demolition	Windows	CMU Wall					
$19,371	$46,632	$17,358					
5%	9%	2%					
Water Dist.	Specialities						
$53,270	$24,554						
13%	4%						
Fencing	Roofing						
$23,633	$148,237						
6%	27%						
Drainage	Precast Conc. Walls						
$29,891	$248,258						
7%	45%						

AVIATION SUPPLY - FIGURE 25

COMPONENT	SUBTOTAL	NOTES						
Foundation	$184,521	176 CY	$1,048	CY				
Slab on Grade	$171,014	20,000 SF	$8.55	SF				
Low Roof	$1,004	2,500 SF	$0.40	SF	0.1408	#/SF		
Pre-engineered Bldg	$511,788	17,500 SF	$29.25	SF				
Roofing	$148,237	21,525 SF	$6.89	SF				
Precast Conc. Walls	$248,258	13,300 SF	$18.67	SF				
CMU Wall	$17,358	1,604 SF	$10.25	SF				
Drywall	$26,000	3,066 SF	$8.48	SF				
Ceiling	$12,300	2,054 SF	$5.99	SF				
VCT	$6,000	2,095 SF	$2.86	SF				
Doors	$34,600	20 ea	$1,730	ea				
Windows	$46,632	41 ea	$1,137	ea	5.08%	FA		
Specialities	$24,554	LS	$4,092	fixture				
Plumbing	$48,665	13 fixtures	$3,743	fixture				
Air Conditioning	$64,435	8 Tons	$8,054	Ton				
Ventilation	$59,020	48,000 CFM	$1.23	CFM				
Fire Sprinkler	$99,215	20,000 SF	$5	SF				
Fire Alarm	$20,017	20,000 SF	$1	SF				
Lighting	$104,513	20,000 SF	$5.23	SF				
Power	$24,776	20,000 SF	$1.24	SF				
Exterior Electrical	$33,643	75 KVA	$449	KVA	20.6	W/SF	$1.68	SF
Pallet Racks	$55,889	484 pallets	$115	pallet				
Water Distribution	$53,270	364 LF	$146	LF				
Sewer	$17,623	193 LF	$91	LF				
AC Pavement	$49,676	1,244 SY	$40	SY				
PCC	$23,512	2,589 SY	$9.08	SF				
Grading	$189,399	2 AC	$94,700	AC				
Demolition	$19,371	LS						
Drainage	$29,891	186 LF	$161	LF				
Fencing	$23,633	462 LF	$56.00	LF				
Arch. Mon.	$40,000							
	$2,388,804							

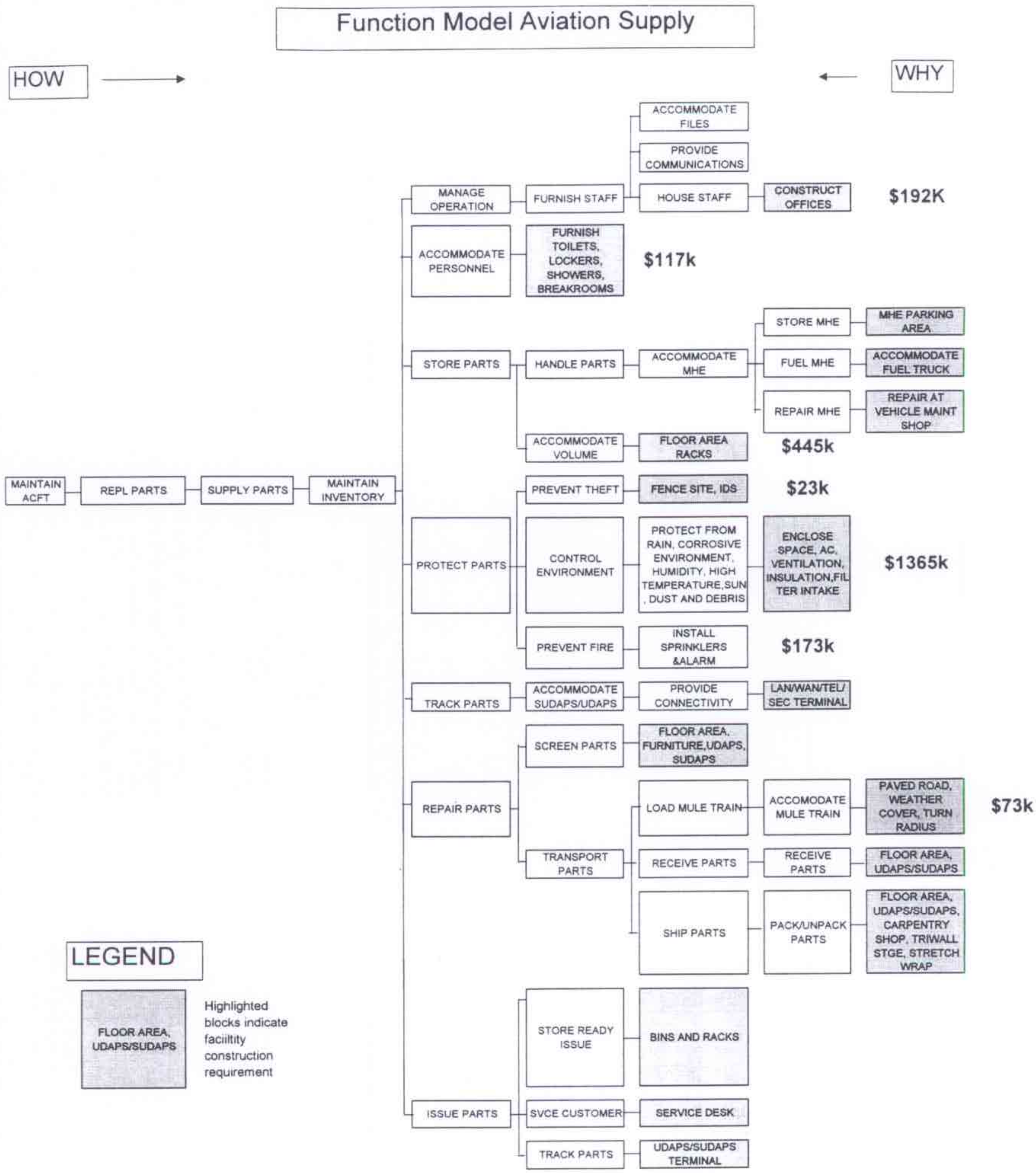

Function Model Aviation Supply
HOW
WHY
ACCOMMODATE FILES
PROVIDE COMMUNICATIONS
MANAGE OPERATION
FURNISH STAFF
HOUSE STAFF
CONSTRUCT OFFICES
$192K
ACCOMMODATE PERSONNEL
FURNISH TOILETS, LOCKERS, SHOWERS, BREAKROOMS
$117k
STORE MHE
MHE PARKING AREA
STORE PARTS
HANDLE PARTS
ACCOMMODATE MHE
FUEL MHE
ACCOMMODATE FUEL TRUCK
REPAIR MHE
REPAIR AT VEHICLE MAINT SHOP
ACCOMMODATE VOLUME
FLOOR AREA RACKS
$445k
MAINTAIN ACFT
REPL PARTS
SUPPLY PARTS
MAINTAIN INVENTORY
PREVENT THEFT
FENCE SITE, IDS
$23k
PROTECT PARTS
CONTROL ENVIRONMENT
PROTECT FROM RAIN, CORROSIVE ENVIRONMENT, HUMIDITY, HIGH TEMPERATURE,SUN, DUST AND DEBRIS
ENCLOSE SPACE, AC, VENTILATION, INSULATION,FILTER INTAKE
$1365k
PREVENT FIRE
INSTALL SPRINKLERS &ALARM
$173k
TRACK PARTS
ACCOMMODATE SUDAPS/UDAPS
PROVIDE CONNECTIVITY
LAN/WAN/TEL/ SEC TERMINAL
SCREEN PARTS
FLOOR AREA, FURNITURE,UDAPS, SUDAPS
REPAIR PARTS
LOAD MULE TRAIN
ACCOMODATE MULE TRAIN
PAVED ROAD, WEATHER COVER, TURN RADIUS
$73k
TRANSPORT PARTS
RECEIVE PARTS
RECEIVE PARTS
FLOOR AREA, UDAPS/SUDAPS
SHIP PARTS
PACK/UNPACK PARTS
FLOOR AREA, UDAPS/SUDAPS, CARPENTRY SHOP, TRIWALL STGE, STRETCH WRAP
LEGEND
FLOOR AREA, UDAPS/SUDAPS
Highlighted blocks indicate faciltity construction requirement
STORE READY ISSUE
BINS AND RACKS
ISSUE PARTS
SVCE CUSTOMER
SERVICE DESK
TRACK PARTS
UDAPS/SUDAPS TERMINAL

Figure 26

The Team Leader/CVS should write all of the brainstorming ideas down on a flip chart so the ideas are visible to all participants. The Team Leader/CVS proceeds through all systems and high cost elements of the project, taping all idea sheets to the conference room wall. This is a no-holds-barred session where anything goes.

The team takes a short break and reconvenes for an evaluation, expansion of ideas and to access the worth of each idea as compared to other ideas. Each idea is evaluated on its own merits or combined with other ideas to form new concepts. Questions are asked of each idea. Is the idea feasible? Yes, or no? Is another idea better, or very similar? Is what is proposed an increase or decrease in quality and to what extent? FACD strives to provide quality facilities and systems, therefore, rating each idea will assist in selecting quality alternates. The following is an example of the Quality Rating system used.

Quality Rating System

This rating system has been developed by the NAVFACENGCOM to improve the overall performance of the FACD study and to ensure that quality systems have been seriously considered during the study process. The rating system is a five point system with a maximum of a plus two (+2) points and a negative two (-2) points. (Note: *Any recommendation with a negative two (-2) will not be developed or presented unless directed by NAVFACENGCOM due to very serious budget problems).* The rating system used is as follows:

+2	Greatly improved quality, major criteria change/challenge, improved functional requirements or greatly decreased life cycle cost (LCC).
+1	Improved quality, slight modification to criteria, some change in functional requirements or slight decrease in LCC.
0	Same quality, same criteria or same functional needs.
-1	Slightly reduced quality, criteria are outdated or overstated functional needs. More of a customer want than need. Might be a challenge to base engineering and architectural plans (BEAP) (subjective) and appears to have same LCC.
-2	Greatly reduced quality, LCC increased or has drastic negative effect on mission and function.

Feasible ideas are identified and cost impact is sought (guesstimate only) from each of the disciplines for each idea. The ideas are then assigned to the specific disciplines for further development. If one discipline is overloaded and another is under loaded, the Team Leader/CVS should assign the under loaded person to assist the overloaded one.

As the ideas are developed into specific alternates the designer should determine if it is worthwhile to pursue. Each alternate should be given to the cost estimator for review.

Presentation of Alternates to the Client

A suggested method to present this information is on a separate piece of flip chart paper the Team Leader/CVS would prepare with columns with headings of "Alternates," "FACD Team Recommends," "FACD Team Does Not Recommend," "Customer Accepts Idea," "Customer Rejects Idea" and "Cost Impact." At this time each alternate will have an "X" placed within the column marked "FACD Team Recommends" or "FACD Team Does Not Recommend" and a cost will be placed in the "Cost Impact" column. Each figure from the "Cost Impact" column, which is associated with the "FACD Team Recommends" column, is totaled. Hopefully, this total exceeds the cost-cutting target. If not, more brainstorming and evaluation must be done until the target is met, even if it means drastic downscoping. The list of alternates, with a clear description of each, is presented to the user when the "Cost Impact" total equals or exceeds the cost-cutting target. The user can follow the team recommendation or can choose an alternate which the FACD Team rejected. But the customer must explain why and give reasons that are not or were not obvious in prior sessions. The team will answer questions, explain the advantages and disadvantages of each alternate to help the customer make informed decisions. At this time each alternate will have an "X" placed within the column marked "Customer Accepts Idea" and a cost will be placed in the "Cost Impact" column. Each figure from the "Cost Impact" column, which is associated with the "Customer Accepts Idea" column, is totaled. From this point on, the team will work with the "Cost Impact" figures from the "Customer Accepts Idea" column. When subtracting the "Customer Accepts Idea" cost impacts from the revised cost estimate, the difference can not exceed the ECC. If a team and customer can not find a common ground to meet the ECC target, more cost-cutting or a different approach will have to be taken, such as, a Blast and Refine method (Like Figure 13B) which looks at the least expensive approach to providing all the required systems or additional Cost Driver Analysis. Life Cycle costs should also be considered in selecting alternates.

Life Cycle Cost Analysis and Terms

Life Cycle Cost (LCC) analysis should be performed on building systems which have differing initial cost, varying maintenance schedules, energy consumption and replacement schedules. After completing the LCC analysis a rational decision can be made knowing the full long-term economic impact of that decision.

The following terms should become familiar to the individual doing LCC analysis:

> **Life cycle** is the total period of time over which a product, building, process or system is considered useful by the Owner, Developer or Manufacturer. MILCON projects are normally based on a 25 year useful life.
>
> **Life cycle cost** is the total cost of a product, building, process or system throughout its entire useful life. This includes <u>all</u> costs (development, implementation, initial cost, maintenance, repair, energy, operation, salvage, etc.).
>
> **Life cycle savings** (or additional expenditures) are calculated when the proposed alternate impacts the performance and costs of the item or system under consideration during its life cycle and affects items, such as energy consumption, heat gains or losses, operating cost, maintenance costs, replacement costs, salvage values, etc.
>
> When a comparative Life Cycle Cost Analysis is desired, extreme care must be taken to make sure that all affected costs are taken into consideration. For instance, when insulation in a building is changed (reduced or increased) the corresponding effect on the heating and/or cooling system should also be considered; this, in turn, can affect electrical system and utility cost.
>
> **Annual operating costs** should include as many aspects of maintenance and energy costs, as may be necessary to support the purpose, scope and intent of the analysis.

Replacement costs need to be considered only if the normal useful life expectancy of any major system or component is less than the Life Cycle Basis considered for the purpose of analysis.

Salvage value is the estimated value of the considered system or building at the end of the Life Cycle period.

Escalation - There is no simple or accurate method by which escalation rates can be predicted. Some items, such as energy, will probably escalate at a faster than normal rate. Other items could actually decrease in cost, due to advances in technology. Because of these considerations, most life-cycle cost evaluations are based on current costs.

U.S. Navy Life Cycle Costing does not normally include an inflation rate, except for energy rates.

Typical Life Cycle Cost Categories:

1. Initial Costs
2. Annual Recurring Costs, such as:
   a. Property taxes and insurance.
   b. Maintenance: Labor, materials and miscellaneous (oil, grease, refrigerant, chemicals, minor repairs, etc.).
   c. Operating Personnel.
   d. Energy and utilities (electricity, gas, fuel, oil, water, sewer, etc.).
   e. General administration.
3. Non-Recurring Costs, such as:
   a. Major repairs (overhaul).
   b. Replacement.
   c. Salvage value (credit).

Present Worth Calculations

Life Cycle Savings are usually in "PRESENT WORTH" dollars. Present Worth is the equivalent cost in "today's dollars" of future money disbursements.

Present Worth of Recurring Costs is usually calculated using factors from interest tables by the following formula:

Present Worth PW = A x PWA

Where: A = Uniform future cash flow at the end of a period.

PWA = Present Worth Factor for uniform payment series (P/A). To find PWA in compound interest tables you must establish the amortization period: "n" (number of years) and the interest rate "I" %.

Note: PWA is what $1.00 payable periodically is worth today.

<u>Example</u>:

1. Savings per year: $189.00 (A)
2. Number of years: 25
3. Interest rate: 10%
4. Present Worth Factor: 9.077 (PWA) from tables

Computation: PW = $189.00 x 9.077 = $1,715.55

The mathematical equation for calculating present worth from a given uniform annual recurring cost is:

$$PW = \frac{A[(1+I)^{n-1}]}{I(1+I)^{n}}$$

Present Worth of Non-Recurring Costs

Formula: Present Worth PW = S x P/S

Where: S = Amount of single expenditure at the end of "n" periods at an interest rate of "I" % per period.

PW = Present Worth Factor for single expenditure (P/S).

To find PW on the tables you must establish:

- The number of years: "n"
- The interest rate: "I" %
- PW is what $1.00 spent in the future is worth today.

<u>Example</u>:

1. Replacement cost at the end of 10 years: $10,000
2. Number of years: 10
3. Interest rate: 10%
4. Present Worth Factor: 0.3855 (PW) from tables

Computation: PW = $10,000 x 0.3855 = $3,855

The mathematical equation for calculating present worth from a single expenditure is:

$$P = \frac{S}{(1-I)^{n}}$$

An annualized cost analysis is usually performed when the project is based upon capital recovery from a capital investment.

An example of a life cycle cost analysis is shown in Figure #14 on the following page. This LCC analysis was done on a family housing project with 260 units and compares the use of heat pumps versus solar collectors to produce domestic hot water.

LIFE CYCLE COST ANALYSIS - SUMMARY SHEET

ALTERNATE NO. M-1

LIFE CYCLE PERIOD: 20 25a. YEARS **INTEREST RATE:** 7

FIGURE #27

ITEM/DESCRIPTION	AS DESIGNED HEAT PUMP	ALTERNATE SOLAR
A. INITIAL COST: (USEFUL LIFE)	$ 4,930 YRS	$ 9,210 YRS
B. RECURRENT COSTS PER YEAR:		
1. MAINTENANCE CHANGE FILTER - HEAT PUMPS	$ 60	$
2. OPERATING	$	$
3. ENERGY	$ 738	$ 216
4.	$	$
5.	$	$
6.	$	$
7.	$	$
TOTAL ANNUAL COSTS	$ 798	$ 216
PRESENT WORTH: $ T. A. C. X 10.594	$ 8,454	$ 2,288

C. SINGLE EXPENDITURES DESCRIPTION	YEAR	AMOUNT	PWF	P. WORTH	P. WORTH
5. ANODE ROD	5	$ 50/25	.713	$ 36	$ 18
2 TANKS/1 TANK	10	$ 50/25	.508	$ 26	$ 13
6.	15	$ 50/25	.362	$ 18	$ 9
7.		$		$	$
8. RECIRCULATING PUMP	10	$ 200	.508	$	$ 102
9.		$		$	$
HEAT PUMP	10	$ 4,930	.508	$ 2,504	$
10.		$		$	$
11.		$		$	$
12.		$		$	$
13. SALVAGE VALUE		$		$	$
TOTAL PRESENT				$ 2,584	$ 142
GRAND TOTAL (PW): B + C				$ 11,038	$ 2,430

INITIAL COST	$ 4,930	9,210 PW
TIMES 130 COMPARATIVE UNITS	640,900	1,197,300
RECURRENT COSTS & SINGLE EXPENDITURE	$ 11,038	2,430 PW
TIMES 130 COMPARATIVE UNITS	1,434,940	315,900
TOTAL LIFE CYCLE	$ 2,075,840	1,513,200 PW

SUBJECT: SOLAR WATER HEATING	PROJECT: FY96 FAMILY HOUSING PROJECT, WHOLE HOUSE REVITALIZATION, PEARL CITY PENINSULA,	SHEET NO.
CIMS, Inc. Golden, Colorado	PROJECT NO. HC/R-04-94	M-1.4
	BY L. ARAKAWA — DATE 12/06/94	

SUBMITTALS ON A MILCON PROJECT

The following elements are required for future reference and to ensure that the final design reflects the spirit, intent and general design features as initially agreed to in the Final Partnering Agreement.

Volume I - Submitted by Team Leader/CVS and contains the following to fully document the FACD process.

Final Partnering Agreement

Covers the design concept and systems narrative; floor, site and utility plans including points of connection; exterior building appearance, perspective and elevations; response to customer comments and signatures signifying agreement.

Minutes of Meetings

Minutes of all meetings and telephone conversations that transpired during the on-site FACD process are documented for future reference and clarification of future questions.

Design Alternates Investigated

All alternates are documented along with all forms and worksheets used in the analysis of each alternate. All alternates, whether accepted or rejected, are summarized and presented in a section of Volume I. This information is used to complete a portion of the NAVFACENGCOM VEDIS report.

List of Creative Ideas

List all ideas generated with indication of quality and cost impact, whether the idea was incorporated in the design or not and disposition of each.

Function Analysis Worksheets

Depicts all function worksheets used in coming to agreement with the customer on the functional requirements of the project.

Base Cost Estimate and Final Cost Estimate

Shows where the FACD team started from (Base Cost Estimate) and where the team ended in the final presentation (Final Cost Estimate) to the customer and other Base personnel.

Value Engineering Documentation

Value Engineering documentation is required to satisfy legislative requirements and, far more importantly, which alternates the customer accepted based upon informed decisions.

The systems alternates in the FACD study process should be documented in the same format as alternates are documented in a VE study, see Figures #15 through #18 for typical forms used. Following the typical forms are examples of actual FACD study alternates.

Basically if every decision were documented in the FACD process, the difference between the Base cost estimate and the Final On-Site cost estimate would be the total of all accepted design alternates - both cost increases and cost decreases.

In the FACD process the alternates get immediate attention and should either be incorporated into the progressing design or rejected.

All alternates and a summarization, whether incorporated or not, should be presented in the meeting minutes or in the Volume I - Concept Report.

The Facilitator/CVS should be responsible for producing the VEDIS (Value Engineering Data Information System) report and submitting same to the NAVFACENGCOM VE Manager.

VEDIS Report

Covers the listing of FACD team members, project description, Job Order Number (JON), the reporting division, Base and Final cost estimates, total scope, unit of measure and all alternates analyzed during the FACD process with description of change, disposition of alternate and dollar impact on the project.

SUMMARY SHEET	ALTERNATE NO. C-1
PROJECT: FIRE STATION NCTAMS EASTPAC, HI	IDENTIFICATION NO. P-155
ITEM UNDER STUDY: SITE DEVELOPMENT	FUNCTION SUPPORT CONSTRUCTION

BASE

Site development, including utilities, at Site #1.

FIGURE #28
(4 pages)

ALTERNATE

Site development, including utilites, at Site #2.

LIFE CYCLE COST SUMMARY	PRESENT WORTH COSTS		
	INITIAL COST	O & M COSTS	TOTAL
BASE	319,900		319,900
ALTERNATE	262,900		262,900
DIFFERENCE	57,000		57,000

TEAM MEMBER	DISCIPLINE	TELEPHONE	DATE
Keith Terada	Civil	808-521-5361	03/18/97
CIMS, INC. GOLDEN, COLORADO		UNIFORMAT NO. 820 CSI DIVISION 02	PAGE C-1.1

DISCUSSION SHEET

ALTERNATE NO. C-1

PROJECT: FIRE STATION
NCTAMS EASTPAC, HI

IDENTIFICATION NO. P-155

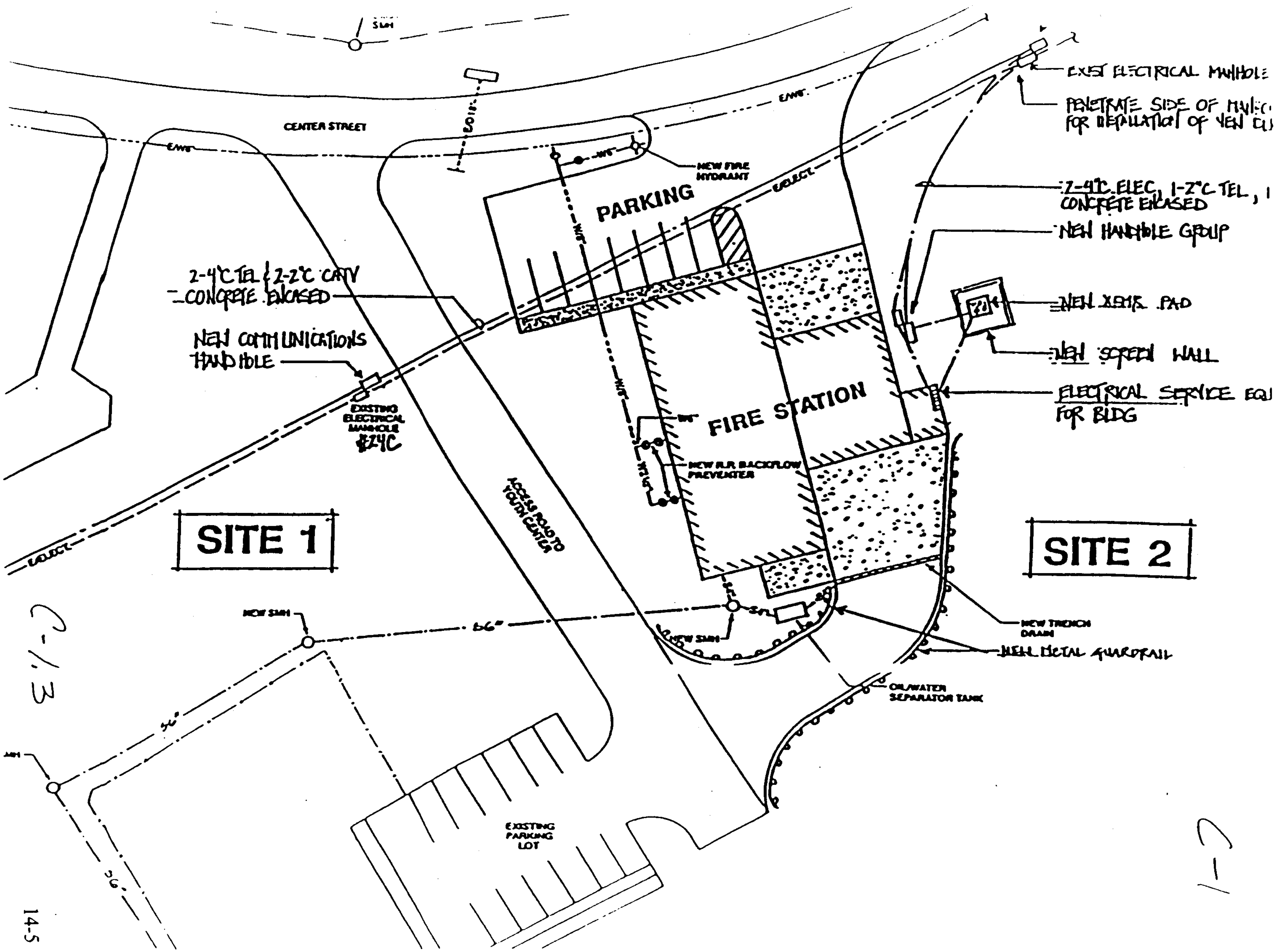
ITEM UNDER STUDY: SITE DEVELOPMENT

ADVANTAGES, DISADVANTAGES & DISCUSSIONS

ITEM	Site #1	Site #2
Move electrical ductline	YES	NO
Retaing wall required	YES	NO
Sewer line length	Shorter	Longer
Impact on CCC tot lot	YES	NO
Storm drainage length	Longer	Shorter
Water pressure at 20 psi residual	900 GPM	800 GPM
Move exercise yard	NO	YES
Impacts master plan	NO	YES
Road realignment	YES	NO

Development at Site #2 still allows for NEX Facility to be built between the fire station and the Child Care Center. Constructing the Fire Station at Site #1 would be too close to the Child Care Center and visually overpower the Center. Placing the Fire Station at Site #2 allows the Center more openness, corrects the storm drainage problem and doesn't impact it with noisy activities.

QUALITY IMPACT


EXIST ELECTRICAL MANHOLE
PENETRATE SIDE OF MANHOLE FOR INSTALLATION OF NEW
2-4"C ELEC, 1-2"C TEL, CONCRETE ENCASED
NEW HANDHOLE GROUP
NEW XFMR PAD
NEW SCREEN WALL
ELECTRICAL SERVICE EQU FOR BLDG
SITE 2
NEW TRENCH DRAIN
NEW METAL GUARDRAIL
OIL/WATER SEPARATOR TANK
CENTER STREET
NEW FIRE HYDRANT
PARKING
FIRE STATION
NEW R.P. BACKFLOW PREVENTER
2-4"C TEL & 2-2"C CATV CONCRETE ENCASED
NEW COMMUNICATIONS HANDHOLE
EXISTING ELECTRICAL MANHOLE #24C
ACCESS ROAD TO YOUTH CENTER
SITE 1
NEW SMH
EXISTING PARKING LOT
C-1
C-1.3

COST ESTIMATE WORKSHEET

ALTERNATE NO.	C-1
PROJECT	FIRE STATION, NCTAMS EASTPAC, HI
IDENTIFICATION NO.	P-155
ESTIMATED BY	KEITH TERADA
CHECKED BY	
DATE	03/14/95
REMARKS	LOCATE ENTIRE SITE EAST OF ACCESS ROAD SCHEME

DESCRIPTION		AS DESIGNED COST			PROPOSED COST		
ITEM	UNIT	NO. UNITS	COST/ UNIT	TOTAL	NO. UNITS	COST/ UNIT	TOTAL
SANITARY SEWER							
SEWER LATERAL	LF	210	30	6,300	440	30	13,200
SEWER MANHOLE	EA	1	3,000	3,000	2	10,500	21,000
FLEXIBLE PAVEMENT							
AC ACCESS RD./PARKING LOT	SY	1,100	35	38,500	600	35	21,000
EARTHWORK							
FILL & GRADING	CY	4,500	50	225,000	4,000	50	200,000
RETAINING WALL	LS	1	36,000	36,000	0	0	0
STORM DRAINAGE PIPING							
DRAINAGE MANHOLE	EA	1	3,000	3,000	0	0	0
STORM DRAIN LINE	LF	100	50	5,000	50	50	2,500
HEADWALL	EA	1	1,500	1,500	2	1,500	3,000
WATER DISTRIBUTION							
WATERLINE	LF	40	40	1,600	55	40	2,200
				319,900			262,900

CIMS, INC.
GOLDEN, COLORADO

PAGE C-1.4

PARTIALLY DEVELOPED IDEA # A-6

ITEM CONSIDERED: INTERIOR TREATMENT OF EXTERIOR WALLS

COMMENTS and RECOMMENDATIONS:

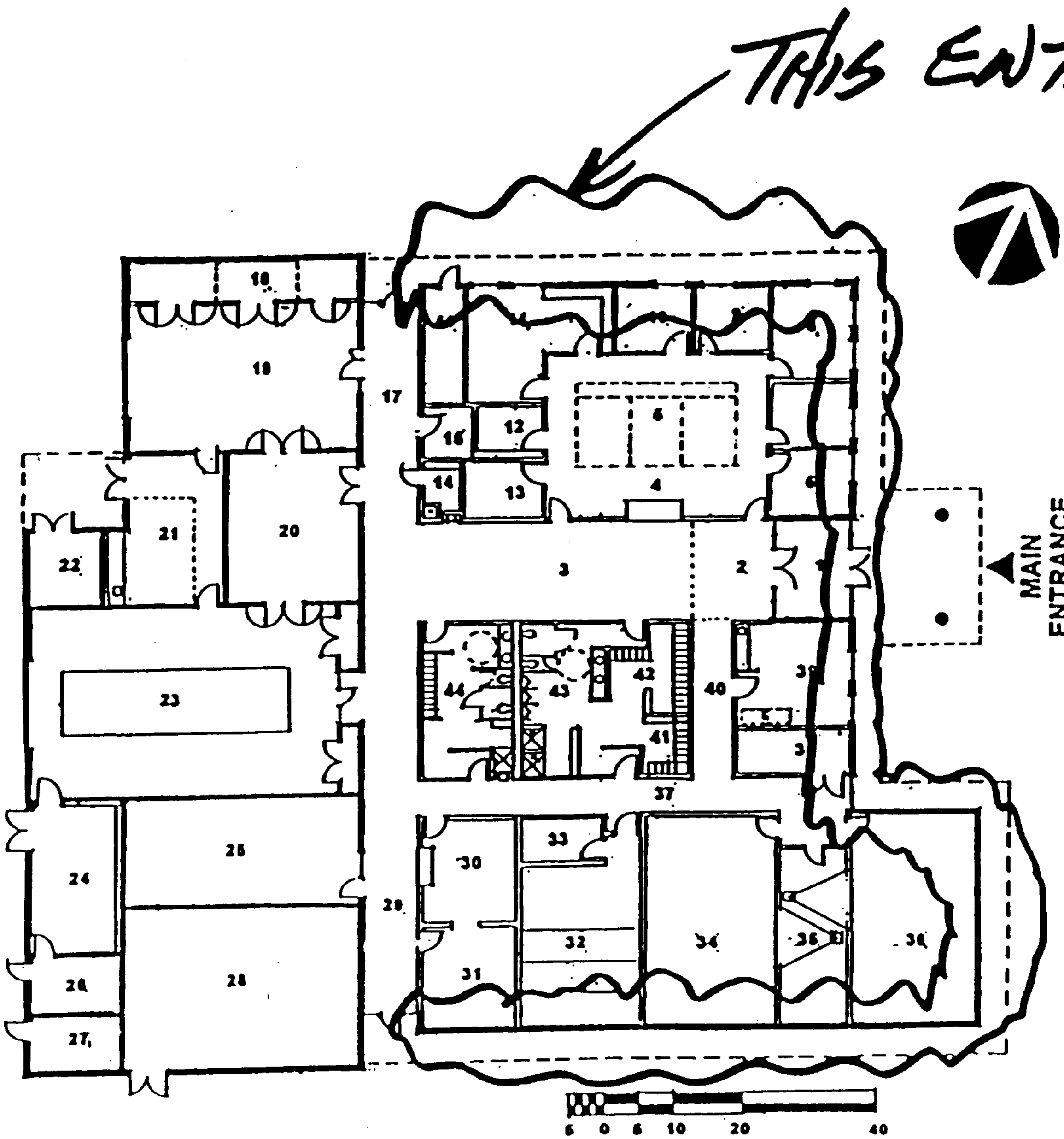
Furred and finished interior of exterior walls will provide a more finished look rather than painted concrete masonry units (CMU). The treatment would give a higher quality appearance to all interior occupied spaces.

FIGURE #29
(2 pages)

COST IMPACT: Adds $16,000

UNIFORMAT NO.	143	**CSI DIVISION**	09	**NAME**	DUANE BOX

A-6



ROOM IDENTIFICATION SCHEDULE

1. VESTIBULE
2. LOBBY
3. EXHIBIT CORRIDOR
4. RECEPTION/CONTROL
5. ADMIN OFFICE
6. AP OFFICE
7. LCPO OFFICE
8. OIC OFFICE
9. AP OFFICE
10. AP OFFICE
11. CONFERENCE/LIBRARY
12. COPY ROOM
13. RECORD SCREENING
14. JANITOR CLOSET
15. TELEPHONE/COMM
16. ELECTRICAL
17. CORRIDOR
18. EJECTION SEAT STORAGE
19. EJECTION SEAT TRAINER
20. MAINT. REPAIR SHOP
21. TREATMENT ROOM
22. GENERAL EQUIP STORAGE
23. HYPOBARIC CHAMBER
24. HYPOBARIC MECHANICAL
25. 4 LINE RELEASE TRAINING
26. CHAMBER OXYGEN STORAGE
27. HAZARDOUS STORAGE
28. MECHANICAL
29. CORRIDOR
30. TRAINING EQUIP ISSUE
31. TRAINING EQUIP STORAGE
32. SMALL CLASSROOM
33. CLASSROOM EQUIP STORAGE
34. NIGHT VISION TRAINING ROOM
35. REAR PROJECTION ROOM
36. MEDIUM CLASSROOM
37. CORRIDOR
38. CLASSROOM EQUIP STORAGE
39. STAFF/STUDENT LOUNGE/VENDING
40. CORRIDOR
41. MALE STUDENT LOCKERS
42. MALE STAFF LOCKERS
43. MALE TOILET/SHOWER
44. FEMALE TOILET/SHOWER/LOCKER

FLOOR PLAN

SUMMARY SHEET	ALTERNATE NO. M-1
PROJECT: FY96 FAMILY HOUSING PROJECT WHOLE HOUSE REVITALIZATION, PEARL CITY PENINSULA, HI	IDENTIFICATION NO. HC/R-04-94
ITEM UNDER STUDY: SOLAR WATER HEATING	FUNCTION HEAT WATER

BASE

Individual heat pumps and individual 60 gallon hot water storage tanks with resistance heating back-up for 260 family housing units.

FIGURE #30
(4 pages)

ALTERNATE

Solar collector to heat water with a 120 gallon hot water storage tank serving two housing units for a total of 260 family housing units.

LIFE CYCLE COST SUMMARY	PRESENT WORTH COSTS		
	INITIAL COST	O & M COSTS	TOTAL
BASE	640,900	1,302,860	1,943,760
ALTERNATE	1,197,300	315,900	1,513,200
DIFFERENCE	556,400	986,960	430,560

TEAM MEMBER Lori Arakawa	DISCIPLINE Mechanical	TELEPHONE 808-471-8418	DATE 12/06/94
CIMS, INC. GOLDEN, COLORADO		UNIFORMAT NO. 212 CSI DIVISION 15	PAGE M-1.1

DISCUSSION SHEET	ALTERNATE NO. M-1
PROJECT: FY96 FAMILY HOUSING PROJECT, WHOLE HOUSE REVITALIZATION, PEARL CITY PENINSULA, HI	IDENTIFICATION NO. HC/R-04-94

ITEM UNDER STUDY: SOLAR WATER HEATING

ADVANTAGES, DISADVANTAGES & DISCUSSIONS

ADVANTAGES:

Using a solar heating system would use less energy than a pump system, which is the main factor attributing to a lower life cycle cost.

Using a dedicated heat pump insures that each unit has its own water supply so that if a heat pump system is inoperative, only one unit is affected as opposed to two units. Initial cost of the dedicated heat pump system is considerably lower than that of a solar system.

DISADVANTAGES:

Based on the calculations and figures given, solar heating has a lower life cycle cost as compared to heat pumps. However, the initial cost of the solar system is almost double the cost of the heat pump system. The calculations were based on a solar heating system (one solar heating system serving two units) versus a dedicated heat pump system for each unit (heat pump and storage tank located in same interior space as existing).

The solar panels should have unobstructed southern exposure to sunlight for maximum efficiency. If there are adjacent trees in the area that obstruct exposure to full sunlight, the amount of hot water obtainable will be reduced. If solar systems are to be used in areas that have trees which interfer with the panel location, the trees should either be removed or trimmed. For the subject project, the cost for tree removal and trimming was not included in the life cycle cost analysis. If it is decided to use solar water heating, the tree removal and trimming costs need to be included in the life cycle cost analysis due to the abundance and location of trees in the area.

Heat pumps are relatively noisy, which may cause some concern from the tenants.

QUALITY IMPACT

Solar heating is a much quieter system.

COST ESTIMATE WORKSHEET

ALTERNATE NO.	M-1
PROJECT	FY96 FAMILY HOUSING PROJECT, WHOLE HOUSE REVITALIZATION, PEARL CITY PENINSULA, HI
IDENTIFICATION NO.	HC/R-04-94
ESTIMATED BY	L. ARAKAWA
CHECKED BY	
DATE	12/06/94
REMARKS	

DESCRIPTION		AS DESIGNED COST			PROPOSED COST		
ITEM	UNIT	NO. UNITS	COST/ UNIT	TOTAL	NO. UNITS	COST/ UNIT	TOTAL
INITIAL COST/TWO UNITS							
STORAGE TANK (120 GAL)					1	800	800
STORAGE TANK (60 GAL)		2	700	1,400			
SOLAR PANELS (3' X 8')					3	620	1,860
PUMPS AND CONTROLS					1	350	350
PIPING					350	4	1,400
HEAT PUMP		2	1,465	2,930			
LABOR (INSTALLATION)		2	300	600			4,800
				4,930			9,210
RECURRING COST:							
ANODE ROD (REPLACE EVERY 5 YEARS)		2	25	50	1	25	25
RECIRCULATING PUMP (REPLACE EVERY 10 YEARS)					1	200	200
FILTER (REPLACE ONCE A YEAR)		2	30	60			

CIMS, INC.
GOLDEN, COLORADO

PAGE M-1.3

LIFE CYCLE COST ANALYSIS - SUMMARY SHEET

ALTERNATE NO. M-1

LIFE CYCLE PERIOD: 20 YEARS — INTEREST RATE: 7

FIGURE #14

ITEM/DESCRIPTION	AS DESIGNED HEAT PUMP	ALTERNATE SOLAR
A. INITIAL COST: (USEFUL LIFE)	$ 4,930 YRS	$ 9,210 YRS
B. RECURRENT COSTS PER YEAR:		
1. MAINTENANCE CHANGE FILTER - HEAT PUMPS	$ 60	$
2. OPERATING	$	$
3. ENERGY	$ 738	$ 216
4.	$	$
5.	$	$
6.	$	$
7.	$	$
TOTAL ANNUAL COSTS	$ 798	$ 216
PRESENT WORTH: $ T. A. C. X 10.594	$ 8,454	$ 2,288

C. SINGLE EXPENDITURES DESCRIPTION	YEAR	AMOUNT	PWF	P. WORTH (AS DESIGNED)	P. WORTH (ALTERNATE)
5. ANODE ROD	5	$ 50/25	.713	$ 36	$ 18
6. 2 TANKS/1 TANK	10	$ 50/25	.508	$ 26	$ 13
	15	$ 50/25	.362	$ 18	$ 9
7.		$		$	$
8. RECIRCULATING PUMP	10	$ 200	.508	$	$ 102
9.		$		$	$
HEAT PUMP	10	$ 4,930	.508	$ 2,504	$
10.		$		$	$
11.		$		$	$
12.		$		$	$
13. SALVAGE VALUE		$		$	$
TOTAL PRESENT				$ 2,584	$ 142
GRAND TOTAL (PW): B + C				$ 11,038	$ 2,430

	AS DESIGNED	ALTERNATE
INITIAL COST	$ 4,930	9,210 PW
TIMES 130 COMPARATIVE UNITS	640,900	1,197,300
RECURRENT COSTS & SINGLE EXPENDITURE	$ 11,038	2,430 PW
TIMES 130 COMPARATIVE UNITS	1,434,940	315,900
TOTAL LIFE CYCLE	$ 2,075,840	1,513,200 PW

SUBJECT: SOLAR WATER HEATING	PROJECT: FY96 FAMILY HOUSING PROJECT, WHOLE HOUSE REVITALIZATION, PEARL CITY PENINSULA,	SHEET NO.
CIMS, Inc. Golden, Colorado	PROJECT NO. HC/R-04-94	M-1.4
	BY: L. ARAKAWA — DATE: 12/06/94	

SUMMARY SHEET	ALTERNATE NO. E-1
PROJECT: NAVY EXCHANGE DISTRIBUTION CENTER NAVAL STATION, PEARL HARBOR, HAWAII	IDENTIFICATION NO.
ITEM UNDER STUDY: ELECTRICAL SERVICE	FUNCTION SUPPLY POWER

BASE

Power is received from an existing manhole located approximately 900' from the proposed facility. Power is received from PWC's circuit "E9" located in Substation "E" in the shipyard.

FIGURE #31
(4 pages)

ALTERNATE

Receive power from HECo. (Hawaiian Electric Company). Electric service about 100' from the proposed building.

LIFE CYCLE COST SUMMARY	PRESENT WORTH COSTS		
	INITIAL COST	O & M COSTS	TOTAL
BASE	59,300	567,315	626,615
ALTERNATE	10,200	505,378	515,578
DIFFERENCE	49,100	61,937	111,037

TEAM MEMBER	DISCIPLINE	TELEPHONE	DATE
Y. Matsumoto	Electrical Engineer	808-941-4448	01/12/95

CIMS, INC. GOLDEN, COLORADO	UNIFORMAT NO. 311 CSI DIVISION 16	PAGE E-1.1

DISCUSSION SHEET	**ALTERNATE NO.** E-1
PROJECT: NAVY EXCHANGE DISTRIBUTION CENTER NAVAL STATION, PEARL HARBOR, HI	**IDENTIFICATION NO.**
ITEM UNDER STUDY: ELECTRICAL SERVICE	

ADVANTAGES, DISADVANTAGES & DISCUSSIONS

ADVANTAGES:

Lower initial capital cost and power cost.

Eliminates maintenance cost and maintaining of manholes.

Improves reliability with decreased number of splices and fewer primary cables.

Transformer will be supplied by HECo. and maintained by HECo.

DISADVANTAGES:

Activity will be billed by HECo.

Although the activity is billed by HECo. this is not a true economic disadvantage because the activity could also be billed by PWC for power consumption. Since HECo. will own the transformer, they will also maintain it. HECo. would be better equipped to maintain services if the transformer should fail, because they maintain a larger inventory of transformers and other power equipment.

QUALITY IMPACT

There is no impact on quality.

COST ESTIMATE WORKSHEET

ALTERNATE NO. E-1

PROJECT NEX FURNITURE WAREHOUSE/TOYLAND RETAIL FACILITY
NAVAL STATION, PEARL HARBOR, HI

IDENTIFICATION NO.

ESTIMATED BY Y. MATSUMOTO | CHECKED BY | DATE 01/12/95 | REMARKS

DESCRIPTION		AS DESIGNED COST			PROPOSED COST		
ITEM	UNIT	NO. UNITS	COST/ UNIT	TOTAL	NO. UNITS	COST/ UNIT	TOTAL
MANHOLES	EA	4	5,000	20,000			
DUCTLINES	LF	900	12	10,800	100	12	1,200
PRIMARY CABLE	LF	910	15	13,500	100	15	1,500
TRANSFORMER	EA	1	15,000	15,000			
FUSED CUTOUTS	EA				3	1,500	4,500
LIGHTNING ARRESTORS	EA				3	1,000	3,000
				59,300			10,200

CIMS, INC.
GOLDEN, COLORADO

PAGE E-1.3

LIFE CYCLE COST ANALYSIS - SUMMARY SHEET

ALTERNATE NO. E-1

LIFE CYCLE PERIOD: 25 YEARS   INTEREST RATE: 10

ITEM/DESCRIPTION	AS DESIGNED	ALTERNATE
A. INITIAL COST:	$ 59,300	$ 10,200
(USEFUL LIFE)	YRS	YRS
B. RECURRENT COSTS PER YEAR:		
1. MAINTENANCE	$	$
2. OPERATING	$ 62,500	$ 55,671
3. ENERGY	$	$
4.	$	$
5.	$	$
6.	$	$
7.	$	$
TOTAL ANNUAL COSTS	$	$
PRESENT WORTH: $ T. A. C. X 9.077	$ 567,315	$ 505,378

C. SINGLE EXPENDITURES DESCRIPTION	YEAR	AMOUNT	PWF	P. WORTH	P. WORTH
5.		$		$	$
6.		$		$	$
7.		$		$	$
8.		$		$	$
9.		$		$	$
10.		$		$	$
11.		$		$	$
12.		$		$	$
13.		$		$	$
14.		$		$	$
15. SALVAGE VALUE		$		$	$
TOTAL PRESENT				$	$
GRAND TOTAL (PW): B + C				$	$

INITIAL COST DIFFERENCE $ 49,100 PW

RECURRENT COSTS & SINGLE EXPENDITURE DIFFERENCE $ 61,937 PW

TOTAL LIFE CYCLE DIFFERENCE $ 111,037 PW

SUBJECT	PROJECT	SHEET NO.
ELECTRICAL SERVICE	NEX FURNITURE WAREHOUSE/TOYLAND RETAIL FACILITY, NAVAL STATION, PEARL HARBOR, HI	E-1.4
CIMS, Inc. Golden, Colorado	PROJECT NO.	
	BY Y. MATSUMOTO / DATE 01/12/94	

PRESENTATIONS

COVER EVERYTHING THAT IS IN THE FINAL PRODUCT AND WHAT WILL BE READ IN THE PARTNERING AGREEMENT.

ANSWER QUESTIONS

RECORD COMMENTS & DECISIONS

ALLOW TIME TO REVIEW PARTNERING AGREEMENT

SCHEDULE REVIEW COMMENTS MEETING

RESPOND TO COMMENTS - A-E

INCORPORATE CHANGES IN FINAL PARTNERING AGREEMENT

THE FINAL PRODUCT

MILCON DESIGN

DESIGN BUILD

WORKSHOPS

MASTER PLANNING

PROGRAMMING

MINIMAL PROJECT

SUBMITTALS ON A MILCON PROJECT

Volume II - Submitted by A-E Design Team

Updated DD 1391

A-E submits a revised DD 1391 based upon the Final Partnering Agreement and revised cost estimate after all comments have been included.

Revised Cost Estimate

The revised Cost Estimate is based upon incorporating all review comments into the "Final" cost estimate.

Project Drawings

These are usually the same drawings as shown in the Final Partnering Agreement. Others included could be additional mechanical, electrical or structural drawings or calculations for further refinement.

PE Forms

A-E firm completes and includes all PE forms required for the project.

Basis of Design

The expansion of the Final Partnering Agreement to minute detail that will be included in the final project design.

Collateral Equipment (CEO)

A-E provides the customer a CEO Budget List as part of the PE/PD documentation. A complete pre-final collateral equipment buy package would be submitted at the 100% design stage. The Collateral Equipment Buy List will indicate all furniture, furnishings and equipment required by the customer to perform the intended mission. The listing includes federal stock numbers for each item identified where applicable.