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OVERVIEW & ANALYSIS OF THE U.S. NAVY ELEVATED CAUSEWAY SYSTEM

by

HAROLD LAWRENCE GROFF, B.S.C.E.

REPORT
Presented to the Faculty of the Graduate School of
The University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of
MASTER OF SCIENCE IN ENGINEERING

THE UNIVERSITY OF TEXAS AT AUSTIN

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Chapter1: Introduction

Purpose

For the past few years, the Navy and the Naval Facilities Engineering Command have endeavored to adopt and implement the tenets of the Total Quality Management theory (called Total Quality Leadership by the Navy) into its functions and operations. Central to this theory is the idea that the people within the organization should make constant efforts to improve the quality of how that organization operates. To that end, the following report is an evaluation of the ELCAS system and provides recommendations for future resolution of existing problems.

Prior to coming to the University of Texas, the author was assigned as the Officer-in-Charge of the Elevated Causeway (ELCAS) team at Amphibious Construction Battalion TWO (ACB-2) in Little Creek, Virginia (for a complete listing of acronyms see appendix D). ELCAS is a temporary pier facility used to transfer containerized cargo and equipment ashore during the follow-on phases of an amphibious assault. The existing ELCAS system was introduced in the late 1970's and is nearing the end of its useful life due to structural deterioration. This problem became clearly evident during some of the planning for a possible amphibious assault on Kuwait during Operation Desert Storm in 1991.

ELCAS was developed to meet the requirement to provide expeditious and sustained transfer of containerized cargo from container ships to an undeveloped beach in a remote location. Container ships presently make up the majority of commercial shipping and provide the most readily available form of shipping to the Navy for overseas deployment of cargo. ELCAS is one part of the Container Off-loading and Transfer System (COTS) that was designed as a joint Army, Navy and Marine Corps system to provide a means to conveniently support the follow-on phase of an amphibious assault (NAVFAC 1981).

An improved ELCAS system has been proposed for several years and was actually contracted out in 1985 (Daley 1991-2). However, after a long history of difficulty in securing sub-contractors, the contractor defaulted. A second solicitation has run into problems regarding the criteria for qualifying bidders and the contract was terminated for the convenience of the government. The existing system, in its deteriorated state, is currently the only system available. This report will endeavor to provide a readily understandable overview of the existing and proposed systems, develop a realistic Critical Path Method planning document that could be used by the Operational Commander during the erection of ELCAS, suggest an alternative method for procuring a new system, and make recommendations for improvement in several problem areas.

Chapter 2 of this report will describe the existing ELCAS system in detail, including the history of its development, its function, a component and erection procedure description, crew size and training requirements, and provide some detail on the problems with the existing system. Chapter 3 presents a Critical Path Method planning document for the entire process of installing ELCAS in a remote location. This CPM includes activities for off-loading the system from a Seabee Barge Carrier, transporting the system to the beach, assembling the pier and making ELCAS operational. Durations for the activities necessary to erect ELCAS will be approximated based upon experience from several previous operations, and various factors for productivity degradation.

Chapter 4 describes the new Cantilever/Modular ELCAS System (also known as ELCAS (M)) which is scheduled to replace the existing system. This chapter also examines the difficulties that have been encountered in the procurement history, describes the differences and advantages of this system and looks at the outlook for future employment of this system.

Chapter 5 examines ELCAS component availability in the commercial sector. Finally, Chapter 6 will offer conclusions and recommendations as to the future of ELCAS.

A Brief ELCAS System Description

The existing ELCAS system is divided between ACB-1 in Coronado, California and ACB-2 in Little Creek, Virginia. Figure 1-1 is a picture of the existing ELCAS system in an elevated status. When ELCAS was initially delivered, it was intended to provide up to 3000 feet of temporary pier for the off-load of containerized cargo (NAVFAC 1981). During training, each ACB typically constructs an 810 foot pier with a "pierhead" that is two causeways wide. This training scenario involves the use of twelve 90 feet by 21 feet by 5 feet pontoon causeways.

In an actual scenario this system would be off-loaded from a sea-based carrier (Naval Ship, Seabee or LASH (Lighter Aboard Ship) barge carrier), assembled offshore, and inserted into the beach (Figure 1-2 is a picture of a Seabee Barge Carrier (SBC)).

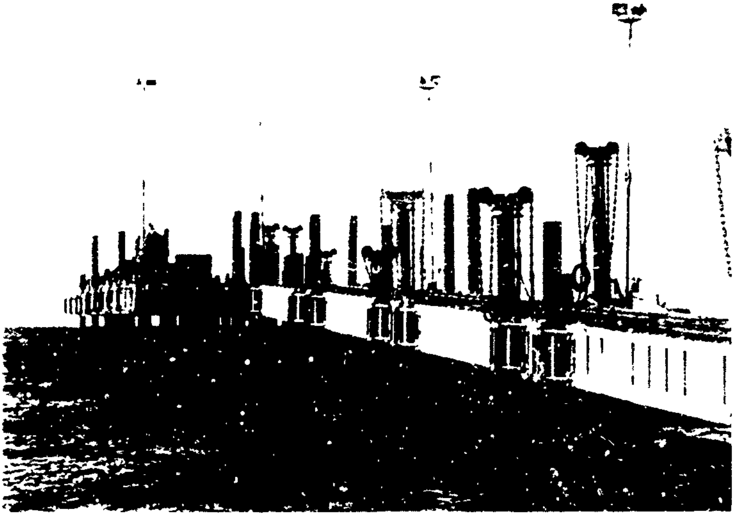


FIGURE 1-1 Picture of the Existing ELCAS System

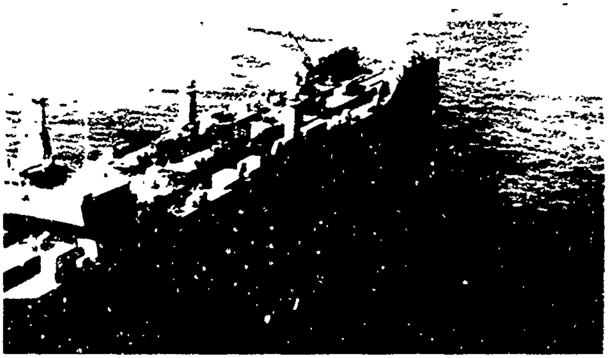


FIGURE 1-2. Picture of a Seabee Barge Carrier

Once inserted, several hydraulic cranes are used to pick up lengths of 20 inch diameter hollow steel pile and "stab" them into holes (called spudwells) which are either internal or external to the causeways. These pile are then driven with diesel pile hammers (that are placed by the cranes) to varying degrees of bearing depending upon their position in the causeway string and what they will have to support. Hydraulic jacking units (50 ton capacity each) are placed on top of some of the pile and are used to lift the ELCAS out of the water to a deck height of 20 feet above mean low water (15 feet to the bottom of the causeways). When the ELCAS is jacked to just above the required height, holes are cut into the pile and metal pins are inserted. The ELCAS is then lowered to rest on the pins. Piles on the pierhead that would interfere with truck and crane traffic are cut off at deck level and capped.

A 140 ton lattice boom crane is driven into position on the pierhead and a turntable is also set up on the pierhead. Once operational, the 140 ton crane is used to pick up containers from lighterage that docks alongside the ELCAS and transfer them to flatbed tractor-trailer trucks that drive out to the ELCAS from shore and are turned around on the turntable. When loading is complete, the truck drives off the ELCAS and another is loaded. The 21 foot causeway width allows two trucks to pass each other on the roadway leading up to the pierhead to permit faster operation.

Research Methodology

The research methodology followed in this report included reviewing available literature pertinent to ELCAS, interviewing knowledgeable persons regarding different elements of the chapters that will be covered, and conducting a literature and telephone search of available marine construction technology that will aide in the development of an alternate contracting strategy. For much of the background information, and to fill in the gaps, this researcher relied on past experience to estimate what was required (see resume of experience in Appendix A).

A large part of the research involved contacting several civilian personnel who have been involved with the ELCAS program since its inception and several people who were a part of the ELCAS construction and operation team for either ACB-1 in Coronado, California or ACB-2 in Little Creek, Virginia. For the history of ELCAS, personnel from the Navy Civil Engineering Laboratory (NCEL) in Port Hueneme, California were contacted and interviewed. NCEL is responsible for the testing and evaluation of the ELCAS system and was also the developmental organization for the system. Personnel at the Civil Engineering Support Office (CESO), which is responsible for the acquisition of all Civil Engineering Support Equipment, including the Elevated Causeway System were also interviewed (Daley 1991-2). (Pat Daley from the Sealift Support Branch of CESO, has been involved with the ELCAS system since its inception and is presently involved with the solicitation of the ELCAS (M) system). The David Taylor Research Center (DTRC) was also contacted and is involved with the testing of Joint Logistics Over the Shore system, of which ELCAS is a part. (Art Ra[illegible] from DTRC provided a bevy of information regarding the history, developmental tests and the performance of ELCAS under a variety of conditions. He was working at NCEL when ELCAS was first introduced).

Chapter 2: Existing ELCAS System

History

The U. S. Navy's involvement with major logistical support to amphibious operations essentially began in World War II. Pontoons (a hollow steel box used as a building block for floating structures) were utilized in a variety of ways, including break waters during the Normandy invasion. "Warping tugs" (a type of powered pontoon section) were used in both the Pacific and Mediterranean theaters of World War II. Pontoon causeways were also used as bridges to allow the Landing Ship Tanks (LSTs) to discharge their equipment and cargo over the shore (NAVFAC 1981). A causeway section is a floating structure made up of several pontoons designed to carry cargo or equipment over the water.

The LST (shown in Figure 2-1) was designed to beach itself and discharge rolling equipment through doors in its bow.

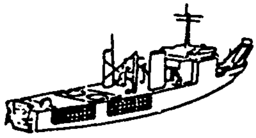


FIGURE 2-1: Drawing of an LST with pontoon causeways side-loaded

Compared to most other Navy ships the LST has a shallow draft that allows it to get in close to shore so that the equipment can be driven off through as little water as possible. However, many of the beaches in Mediterranean had very shallow gradients that would force the LST to ground too far out to effectively off-load of the equipment. Pontoon causeways (see Figure 2-2), because of their very shallow draft, were designed to bridge the gap between where the LST could land and the shore. This development made many areas accessible that the Germans had assumed were impregnable. Causeways and causeway ferries (strings of causeways used to ferry equipment from the Amphibious Assault Force into the shore) were well suited for transporting equipment which carried break-bulk cargo.

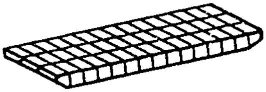


FIGURE 2-2: Drawing of a pontoon causeway.

The limitations of this system became evident during the Vietnam War. The advent and increasing utilization of containerized cargo transport modes (ships, trains and tractor-trailers) in the 1960's and 70's made containerization the transport mode of choice (Figure 2-3 shows a standard container).

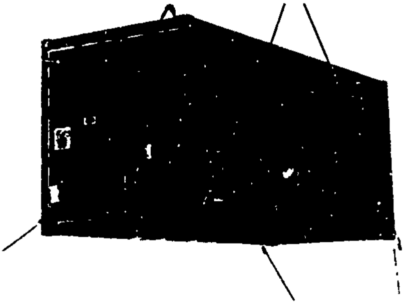


FIGURE 2-3: Picture of a standard container.

However, a lack of proper port facilities to handle containers and difficulties in handling and moving containers over a floating causeway pier due to their size and weight were an impetus in the development of a different means to move containers ashore (Rausch and Skaalen 1977). Bulk containers (pallets and small boxes) can be easily loaded onto trucks by the variety of forklifts that make up part of the standard equipment complement for the Armed Forces. However, standard containers are either 20 by 8 by 8 feet, or 40 by 8 by 8 feet, and exceed the lifting capacity of most of these forklifts. These containers require handling by a specialized, higher lifting capacity forklift called a Rough Terrain Container Handler (RTCH) which are much larger and more expensive than a standard forklift and are not as commonly available in the allowances of amphibious units (NAVFAC 1981).

This problem led to a major research effort by the Navy and the subsequent development of the Container Off-loading and Transfer System

(COTS) of which ELCAS is an important part. This system requires that Department of Defense (DOD) planning for the logistics support to sustain major contingency operations rely extensively on the utilization of U. S. Flag commercial shipping.

This planning was clear during preparations for deployment for Operation Desert Shield and Desert Storm, when reserve and auxiliary shipping were activated as quickly as possible to move cargo and equipment overseas. Military Airlift Command flights were rapidly booked and were limited in their ability to carry heavy or large cargo. The available break-bulk and barge-carrier shipping was also quickly obligated for use, moving tanks and other oversized cargo to the Persian Gulf. This brought home the need for a way to containerize as many assets as possible that were needed in the theater. In the Persian Gulf Conflict, off-loading containers from shipping was not a problem because of the numerous state-of-the-art port facilities available. However, if this conflict had occurred in one of the under-developed portions of the world, the COTS and ELCAS, in particular, would have been very valuable for transferring the cargo from the ships to where it would be needed on shore.

Amphibious assaults are typically conducted over undeveloped beaches. The handling of containers in this environment is a difficult problem to solve. Initially an overall DOD Over-the-Shore Discharge of Cargo (OSDOC) research effort was commissioned which involved contributions by the Army, Navy and Marine Corps. In July, 1975 the COTS Navy Development Concept was promulgated and the Navy Material

Command was tasked with its development (NCEL 1976). Control was later passed to the Naval Facilities Engineering Command (NAVFAC) with assistance from the Naval Sea Systems Command (NAVSEA). The concept of ELCAS was developed as part of the Ship-to-Shore sub-system of COTS.

However, other ideas had been considered before ELCAS was adopted. One idea that was evaluated in the late 1960's was to construct two towers to support a high wire for pallet transfer (Rausch 1991-2). However, the towers took too long to erect and the construction process was too manpower intensive to be feasible. Another method tried was to use a large balloon on a wire to transfer containers. This system was tested in 1978 (Rausch 1991-2) but was also proven unworkable because it was unstable in winds over 10 knots. Container transfer by helicopter was also not feasible because of the relative high fuel consumption of the helicopters and the large volume of containers that would have to be moved.

The first ELCAS causeway sections were constructed by the the Navy Civil Engineering Laboratory (NCEL) by modifying some of Amphibious Construction Battalion One's (ACB-1's) Navy Lighter (NL) pontoon causeways in 1975 (Rausch and Skaalen 1977). The system was first erected and tested by the NCEL at Point Mugu, California in June and July, 1975. Figure 2-4 is a drawing of an operational ELCAS system. Just prior to this test, two sections were assembled and evaluated in the harbor at the Port Hueneme Construction Battalion Center in California to make sure that the equipment fit together before it was barge-ferried to Point Mugu for the

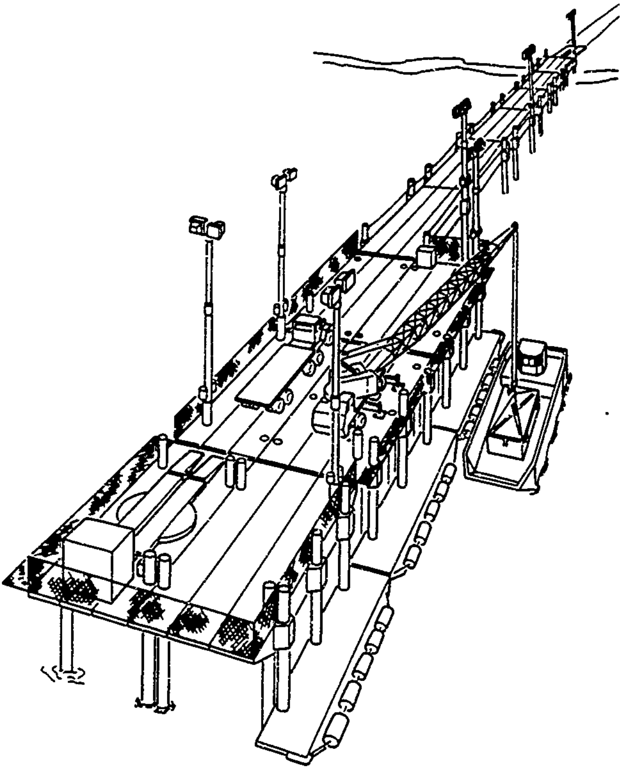


FIGURE 2-4: Drawing of an operational ELCAS.

erection test. This test was designed to investigate the operational and structural capabilities of the NL ELCAS and to develop operational procedures as a basis for the NAVFAC publication P-460 (ELCAS Manual) and did not involve container handling. The second test was conducted at Silver Strand Beach, Coronado, California with military operators from ACB-1 performing the construction. This exercise was conducted in November 1975. Container handling operations were conducted in December and the pier was left in place until 5 January 1976 in order to check for pile settlement and to provide an opportunity for the pier to encounter rough seas.

Two deployment scenarios were subsequently evaluated with this system. The first involved loading the 810 foot ELCAS system configuration onto three LSTs and an Amphibious Transport Dock (LSD) and deploying from Little Creek, Virginia to Onslow Bay, North Carolina, where the ELCAS was successfully erected and operated as part of Operation Solid Shield 79 (COMOPTEVFOR 1979). This operation was conducted from April to June 1979. Upon completion of the exercise ELCAS was dismantled and returned to Little Creek. This exercise proved that ELCAS was deployable aboard USN amphibious shipping, but required an enormous amount of well deck/tank deck space (40,900 sq. ft. net not including the causeways that were side loaded). It was noted in the evaluation report after the exercise that this space requirement would be in direct competition with USMC assets which would also require transport by Naval shipping and would most likely have a higher priority for shipment. This was a driving force towards the development and test of means to transport ELCAS by commercial shipping.

The erection itself went quite well. Despite encountering soft-bottom conditions, the elevation and outfitting were accomplished in 69.6 hours of working time. "Working Time" only accounts for the actual time the crews are working at the tasks, not including any delays that may be encountered. This should not be confused with the total amount of time it takes from pier insertion to the pier being operational. (Note: in most of the previous ELCAS exercises, construction activities have only been performed during daylight hours, utilizing one working shift.) This measurement method artificially enhanced the work efficiency because adverse conditions were avoided. Starting and stopping the clock when desired meant that the crews were always properly briefed and equipped prior to performing the construction activities, and avoided having crews work at night, which significantly degrades performance.

One particular problem encountered in this operation was difficulty in handling, storing, and transporting the pile. The causeway sections that are side-loaded onto the LST's rest flush against the sides of the ship, thereby not permitting any cargo or equipment to be loaded on their deck. Pile were stored on trailers inside the tank-deck of the LST. However, the weight (up to 7500 lbs.) and length (40 to 70 feet) of the pile, coupled with difficulty in maneuvering the pile trailer, precluded loading/unloading by way of the bow ramp (the bow ramp is a steep ramp that extends from the main deck of the LST forward to the beach or to a causeway ferry). Loading by way of the stern gate is the only other alternative. This is difficult even under ideal conditions.

The second ELCAS system transport evaluation was conducted in 1983 (Rausch 1991-2). It involved the test loading and unloading of the system onto a LASH (Lighter Aboard Ship) type barge carrier in the Chesapeake Bay. The LASH Ship has a gantry crane that spans the beam of the ship and can roll longitudinally from bow to stern and a large hold that allows for storage of the individual ELCAS sections without stacking. This allows the sections to be pre-loaded with a large portion of the ancillary gear that is required to construct the ELCAS pier before they are brought onboard the barge carrier. The construction cranes, jacking systems, external spudwells and most of the pile can be pre-loaded onto a position on top of a causeway section that will facilitate system erection. This provides a big advantage over the causeway storage procedures that are required in the use of the Seabee Barge Carrier (SBC) ship that will be discussed later. Additionally, the causeways can be pre-loaded in such a manner that they can be assembled in their proper order next to the side of the LASH ship and taken to the shore as one large barge unit (another significant time savings versus the SBC). This evaluation was successful and demonstrated that the system could be deployed by commercial shipping. However, no attempt was made at that time to erect and operate the system and the operation of the LASH crane was limited to calm water conditions.

In July and August 1990, ELCAS was erected at Fort Story, Virginia with the purpose of evaluating the use of Lightweight Modular Multi-purpose

Spanning Assembly (LMMSA) as a means to span from the seaward end of the ELCAS pier to a floating, 3 causeway wide by 2 causeway deep, Roll On/Roll Off (RORO) platform. This platform provided a means for causeway barge ferries to discharge rolling stock onto the RORO, drive up to ELCAS and then to the beach. This operation had never before been attempted and was highly successful despite side currents in excess of 2 knots.

In September, 1991 the Joint Logistics Over-the-Shore exercise number three (JLOTS III) was performed, also at Fort Story (CNBG-2 1991). This exercise involved the loading and unloading of the complete 810 foot ELCAS system and supporting gear onto a SBC. After discharge from the SBC, all equipment was taken to the beach and ELCAS was assembled and erected. The operation included a successful demonstration of the system's container off-load capabilities and another demonstration of LMMSA as a bridge between ELCAS and a RORO platform. The results of this exercise provides important data for the next chapter of this report.

Technical Aspects of ELCAS

As previously stated, ELCAS's primary function is to provide cargo handling capability over the surfline to connect to a shoreside transportation network. Previously, cargo off-load had been attempted by using a 250 ton crane (see Figure 2-5) on a built-up area of the beach to directly off-load containers (NAVFAC 1981). However, the lifting radius was very long and hence the lifting capacity was small even with a crane of this capacity.

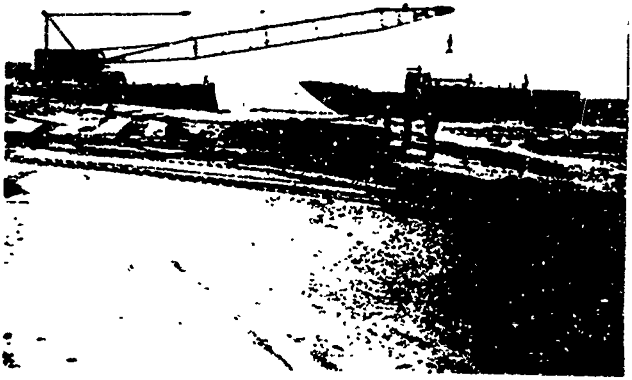


FIGURE 2-5: Picture of a 250 ton crane off-loading containers from shore. The craft is an LCU.

Using ELCAS, a 140 ton crane can be used to lift heavier containers and avoid having to pass through the surf zone. The Navy Civil Engineering Laboratory in Port Hueneme, California has been designated by NAVFAC as the responsible laboratory for the Ship-to-Shore system. The original specifications for ELCAS are given in Appendix B (Rausch and Skaalen 1977).

Components and Erection Procedure

ELCAS consists of standard NL pontoon causeway sections configured with specially developed components for elevation and cargo handling/pier operations. The ELCAS system is composed of a roadway, pierhead, fender system, beach ramps, jacking and pinning gear, 20 inch diameter pile and spudwells. Figure 2-6 is a diagram of an ELCAS pier.

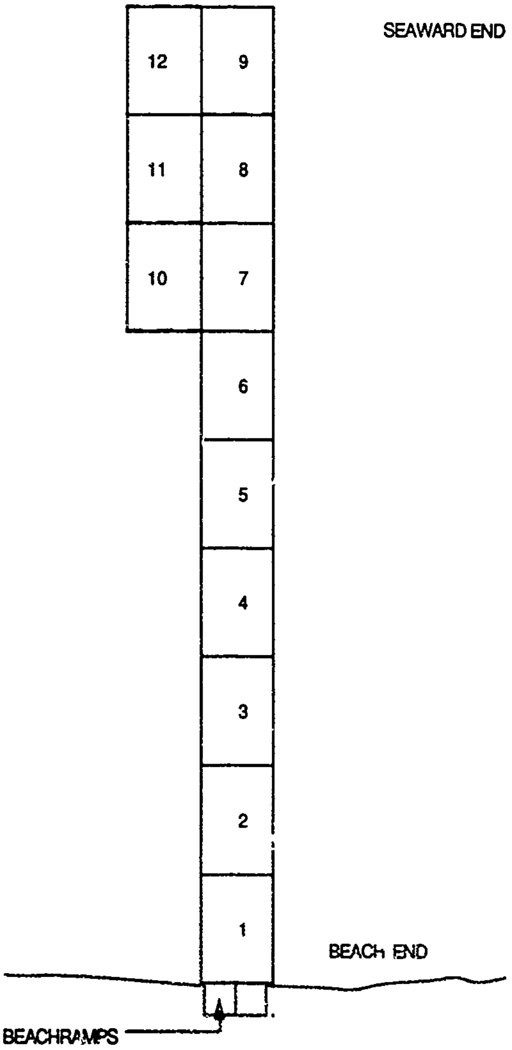
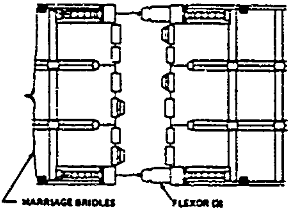
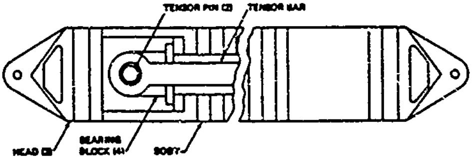


Figure 2-6: Plan Diagram of an ELCAS pier

Each causeway section is 90 feet long, 21 feet wide, 5 feet deep and weighs approximately 75 tons (NAVFAC 1981). It is constructed of 45 pontoons connected by flat and angled braces (3 by 15 configuration). Each pontoon is a welded steel module 5 by 5 by 7 feet and has a wall thickness of 3/8 inches and internal structural bracing. In a floating state each causeway is designed to carry a load of 110 tons. The causeways are end connected by the use of two "flexor pins" which have steel ends and a steel core wrapped by hard rubber. This design provides a large amount of structural strength while retaining flexibility. Figure 2-7 shows a descriptive drawing of flexor pin construction and shows how causeway sections are end connected.



MATING CAUSEWAY SECTIONS
USING FLEXOR END CONNECTORS



FLEXOR CONSTRUCTION

Figure 2-7: Flexor Pin Construction and Causeway End Connection

In addition to the flexor pins there are male and female connectors on the end of the causeways (that are structurally integral to the end pontoons) that fit into their opposite connector on the causeway with which they will marry.

For a typical ELCAS training mission an 810 foot, two-causeway-wide, pierhead arrangement is used (see Figure 2-6). This includes a roadway of six causeway sections in a row attached to a pierhead of six sections made up of two, three-section-long strings which are side-connected to provide a two-causeway-wide platform for the operation of the container handling crane. There are two side-connectors per section. These are solid steel pins that are deployed between the sections using a hydraulic ram. The system was originally designed to be expandable to a length of 3000 feet to allow for the required 20 foot water depth at the pierhead. This would permit lighterage access in areas where the sub-surface beach gradient is very shallow.

ELCAS is different from a floating causeway pier in that it is elevated out of the water to a height to the bottom of the causeways of 15 feet above mean low water (20 feet to deck level). This provides for protection from tidal ranges of 8 feet and swells of 7 feet.

Twenty-inch diameter pile of varying lengths are used to support the ELCAS pier when it is elevated. These pile are stabbed into spudwells (a hole in or attached to the causeway which is designed to accept the pile) and driven to required bearing at a minimum of four locations per causeway.

There are two types of spudwell, internal and external. Figure 2-8 shows a drawing of an external spudwell.

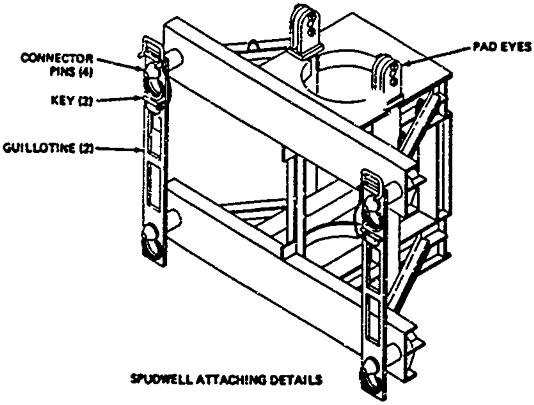


Figure 2-8: Drawing of an External Spudwell.

The internal spudwells are specially designed causeway cans that have structurally reinforced holes that allow the pile to be placed through them. These are found on the pierhead and incorporate a manhole for workers to perform pinning operations under the top deck of the causeway. Internal spudwells allow the pierhead sections to be side-connected flush to each other. Additional internal spudwells are found in the pierhead section (section number 11 of figure 2-6) that supports the outriggers of the 140 ton crane. External spudwells are attached to the outside of the roadway sections and to the pierhead for attachment of the fender string. The external spudwells are attached to the causeways by means of four projections that fit into holes in the side of the causeways which are secured by a locking device that slides down into a depression in the projection called a guillotine. Both external and internal spudwells have compensator rods that are used as attachment points for the jacking system. These compensator rods help to overcome the shock that may be encountered on the causeways and jacking systems due to swells. The compensator rods consist of a 1 inch diameter steel rod that extends the depth of the causeway (5 feet) where it is welded to a circular steel plate that bears against hard rubber packing to act as a shock absorber.

The fender string is designed to provide a convenient place for lighterage to moor while resisting the forces that such lighterage impose on the ELCAS (see Figure 2-9). The fender strings are the same length as causeway sections but only one pontoon wide (compared to three pontoons wide for the causeway sections). Three fender string sections are attached end-to-end and positioned adjacent to the pierhead after the ELCAS pier has been elevated. Each fender string section has two internal spudwells. Piles are placed into external spudwells on the elevated pierhead and down through the internal spudwells in the fender string. The fender piles have specially designed pointed ends to provide superior penetration without driving (compared to the hollow design of the standard pile). Standard operating procedures (NAVFAC 1981) call for driving these pile to a 55 blow-count-per-foot bearing, and pinning them at the pierhead to provide additional support in the vicinity of where the 140 ton crane will operate. However, in typical training evolutions the fender pile are only stabbed and not driven due to the conservation of time and pile splices that would be expended if this procedure were followed. Commercial shipping fenders are

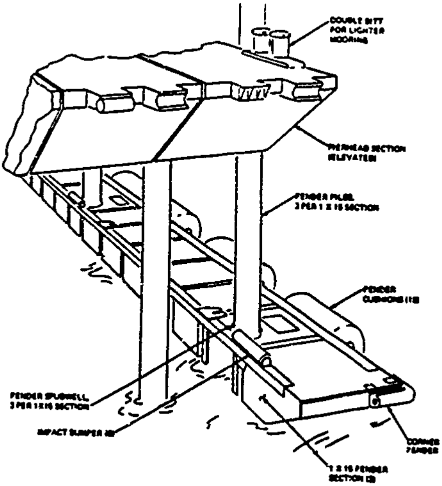


Figure 2-9: Detail of Fender-String Attachment

attached to the fender string to provide a cushion for the lighterage to bear against when they are moored at the pierhead.

The Beach Ramps are 30 feet long by 10 feet wide steel ramps used to bridge the transition between the roadway section closest to shore and the beach. A set of two are placed side-by-side to provide a ramp for the 21 foot wide causeway section. Figure 2-10 shows a picture of an ELCAS pier under construction with the beach ramps in the foreground.

Figure 2-10: ELCAS Pier Showing Beach Ramps

One variety of NL pontoon causeway is the inshore or "A" section. This section is designed with 5 ramps that can be manually deployed to provide a transition for vehicular traffic to transit from the causeway to the beach. However, the inshore section provides a transition that is too steep and doesn't have the requisite strength to allow transit of the 140 ton crane. The ELCAS beach ramps are specifically designed to provide a very strong, stable and easy transition between the beach and the pier.

The ELCAS system turntable (Figure 2-11) facilitates rapid container loading onto tractor-trailer trucks by turning the trucks around so that once they are loaded they can drive straight to the beach. The turntable consists of a top and a bottom section. During the ELCAS construction process, the bottom section is welded to the deck of section 9. The top section is supported by a ring of air bearings. These air bearings are inflated by a 750 cfm air compressor and lift the top section up so that it can be turned.

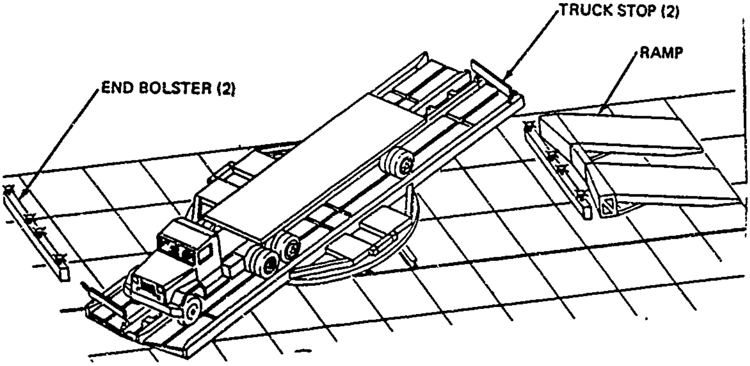


Figure 2-11: ELCAS Turntable

The ELCAS erection process is very susceptible to bad weather, particularly while the causeway sections are still floating in the water. Standard operating limits for pontoon causeway systems are typically stated (NAVFAC 1981) as Sea State 3 which is roughly defined as winds up to 20 knots and three foot seas. However, ELCAS has been erected in the past in 6 to 8 foot seas. This is more common at ACB-1 in Coronado, California where such waves heights are common at the ocean-side exercise area. During one ELCAS exercise at ACB-1 in 1989, a storm developed before the pier could be elevated. This resulted in the system being ripped apart and the various parts scattered down the beach. Because of this danger, it is imperative that the planners of ELCAS operations have accurate weather data and that the early stages of the operation be completed as quickly as possible in order to have the pier elevated and out of harm's way at the earliest time.

ELCAS Erection Equipment

ELCAS was initially designed to be assembled using a 50 ton crane (NAVFAC 1981). However, the typical complement of assembly cranes is now two 65 ton hydraulic all-terrain cranes, two 30 ton hydraulic all-terrain cranes and an 8 ton crane (cherry picker). These cranes are highly maneuverable (have the ability to turn all 4 wheels or crab steer) for mobility around the pile and other obstructions.

The 8 ton crane is used for the lighter lifts, allowing the other cranes to operate at more productive tasks. Additionally, it is positioned on the causeways that are being elevated to provide crane-lift capability for moving jacks or whatever else is required on the elevated sections. The much heavier weight of the larger capacity cranes would overtax the lifting capability of the hydraulic jacks. The 8 ton crane is also quite useful for transferring jacks from section 10 through 12 when they are elevated down to the water-level sections (1 through 9 see figure 2-6). The 8 ton is the primary crane used to set the external spudwells in place on the roadway, and also is used to remove the cutoff splice ends from the elevated pierhead and place them onto the administrative support barge (or "admin barge" which is usually a 3-causeway-section string that is tied up alongside sections 7 to 9). Alternatively, ACB-1 has been issued a 15 ton crane that retains the capabilities of the 8 ton (including the ability to be on the sections being jacked up) while having some of the capabilities of the 30 ton crane (like stabbing the shorter length forty to fifty foot long pile on the roadway).

The 30 ton cranes are used for all the activities in assembling ELCAS except for those involving the heaviest lifts. This includes picking up the pile from the causeway deck and stabbing them into spudwells, setting external spudwells, picking up pile and jack boxes from the "admin barge" and driving pile. The 30 ton crane is performing a near capacity lift when it places a DE-30 pile driver (with an approximate weight of 14,000 lbs) on top on a pile under rough conditions (by convention the load charts for the cranes are cut in half when operating from a floating platform). The standard operating procedure at ACB-2 was that the 30 ton cranes would only be used for pile driving up to the end of the roadway, where the movement of the causeway under the crane would typically be less and there would hence be less stress on the crane. In a contingency situation this constraint could be ignored, but there would be a risk of damaging the crane's boom.

The 65 ton cranes are used primarily on the pierhead sections, where because of the double-causeway-width their outriggers can be fully extended. They are used to place the turntable and to install the beach ramps, although these procedures can also be performed by two 30 ton cranes acting in tandem.

The 140 ton crane does not generally participate in the construction of ELCAS. However, its off-load from the causeway section which carries it on the Seabee Ship and the erection of its boom and installation of the counterweights are all activities that consume a considerable amount of time and must be completed prior to having a working ELCAS pier. The 140 ton crane's primary mission is to lift containers from lighterage (primarily Utility Landing Craft (LCUs) and causeway ferries) and place them onto tractor-trailer trucks for further movement ashore. Because of its bulk and the width of its outrigger spread, the 140 ton cannot operate effectively from ELCAS while it is still floating. This crane is rubber-tired and must be raised on its outriggers to perform lifts. It has very limited mobility in the sand and has suffered frequent tire punctures during ELCAS operations. An idea under consideration with the Civil Engineering Support Officer (CESO) is to replace this crane with a crawler crane which would not require the use of outriggers to perform lifts and would be much more mobile in the sand.

Rough terrain forklifts play a critical role in the erection of ELCAS. There are a variety of items that are too heavy to be moved by hand that can be quickly picked up and moved around by forklift. Tractor-trailer rigs are also very useful in the erection process. A large quantity of material can be moved from the beach out to the pierhead on one tractor-trailer load, saving numerous loads by forklift. They are particularly useful for the transport of additional pile or pile splices, which because of their length are cumbersome to handle with a forklift.

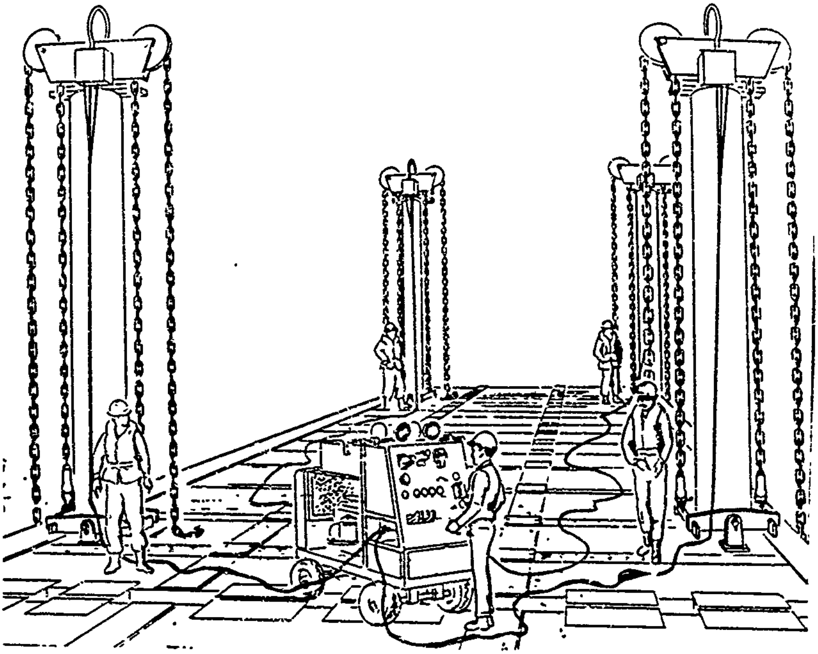


FIGURE 2-12: Drawing of the ELCAS jacking system.

The jacking system (see Figure 2-12) consists of hydraulic power units, 50 ton capacity hydraulic jacks, jacking chain, gimbals and hydraulic lines. This system is used to raise the ELCAS out of the water up to the position where it can be pinned. An operator is required at each jack, at each power unit and as a jacking captain who signals to the jack operators. Each power unit has a small diesel engine that provides hydraulic pressure to each of the jacks and has individual controls for each of the jacks. Each jack is controlled by its operator from causeway-level by means of three quarter inch diameter lines that are attached to levers on the jacks (on top of the pile approximately 20-25 feet above causeway-level). These levers control jack engagement and up or down movement of the dogs. The jacks' "dogs" are hardened steel pins that fit into the holes in the jack chain and actually provide the lifting motion. A complete cycle of the jack involves a movement of only 2 to 3 inches. Figure 2-13 is a drawing of a jack assembly mounted on a pile.

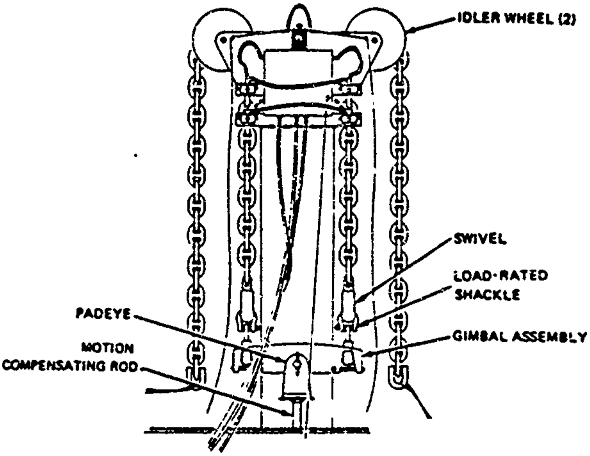


Figure 2-13: Jack Mounted on a Pile

Crew Size and Training Requirements

The NAVFAC publication P-460 and other documents have called for 42 people to be dedicated to the ELCAS erection process for each working shift (NAVFAC 1981). However, in most ELCAS training evolutions actual manning has ranged from 15 to 25 people per shift, many of whom were activated reservists who had not had the time to train and integrate with the active duty team before the operation. It is not realistic to presume that the ideal 42 man complement per shift will be available in an actual wartime scenario, because ACB assets are frequently spread thin while performing a variety of other higher priority functions.

The activities that must be completed to erect ELCAS will be discussed in further detail in the next chapter, but specific skills and training for certain key personnel are essential for the successful construction of ELCAS. Each of the personnel designated as crane operators must be thoroughly trained in the capability and operating procedures for their crane. Poor judgement on the part of a crane operator can easily cause injury. The training for a crane operator should entail both hands on and classroom training. The Navy Equipment Operator rating manuals and NAVFAC manual P-306/7 provide important crane safety information and instructions. However, before an Equipment Operator is even given a training license for the crane, he should be required to attend a 40 hour crane safety and rigging course.

The formal training program for ELCAS has become outdated. Present ELCAS training relies on an individual receiving signatures from qualified supervisors upon the completion of certain tasks as delineated in the ACB's Personal Qualification Standards (PQS). However, some of the systems listed for signature requirements are no longer used and the most current edition of the ACB PQS no longer contains many of the ELCAS watch stations. Additionally, their is a lack of instructional material that would dictate what must be accomplished to receive a signature. The Navy's PQS system works well when it is properly supported. However, the ELCAS PQS needs to be re-written to reflect current information on how the system is erected and what personnel are required to know.

Several years ago a formal ELCAS training school was planned but was never established. The design of the new building for the ELCAS team and the Steel Shop (Charlie Company) at ACB-2 in Little Creek, Virginia incorporated requirements for such a training facility. Training for ELCAS is presently devised and implemented by the personnel who happen to be in charge of the team at that time. Because of the long interval between actual training operations, the short period of time people are actually assigned to the ELCAS team, and the variety of other assignments to which an ACB is tasked, it is possible that the OIC, AOIC and LPO of a team could turn over before their replacements had actually experienced an operation. A formal training program utilizing the knowledge gained at both ACB's over the years and the expertise at NCEL would be very beneficial.

Deployability

ELCAS was developed with the design parameter that it be capable of deployment by Naval Amphibious shipping or commercial shipping. A detailed load plan was developed for putting the ELCAS system and all associated supplies, material and equipment onto the Seabee Barge Carrier in preparation for Operation Solid Shield 91 (which was cancelled due to commitments for Desert Shield/Storm).

The SBC (Figure 2-14) is configured to have three decks that can hold barges. These barges are part of the equipage for the SBC and are approximately 95 feet long, 31 feet wide and 16 feet high with a partially enclosed storage space. The opening in the top of the barge is approximately 65 feet long and 29 feet wide. This barge configuration renders some of the space unusable because the containers for ELCAS gear, and much of the ELCAS gear itself cannot be stored under the overhang. The logistics of how to load and off-load the Seabee must be carefully planned because of the layout and the manner in which the barges and other gear carried onboard can be stored. Each deck has a jacking and transfer system that rides on rails. This system is positioned underneath the item to be moved. The barge or other item to be moved is lifted a few inches off the deck and then carried down the rails to the stern of the ship where it can be loaded onto a 3000 ton capacity elevator. The elevator (see Figure 2-15) can be lowered or raised to each of the 3 deck levels and can also be submerged to allow the barge or other item to be towed away from the ship.

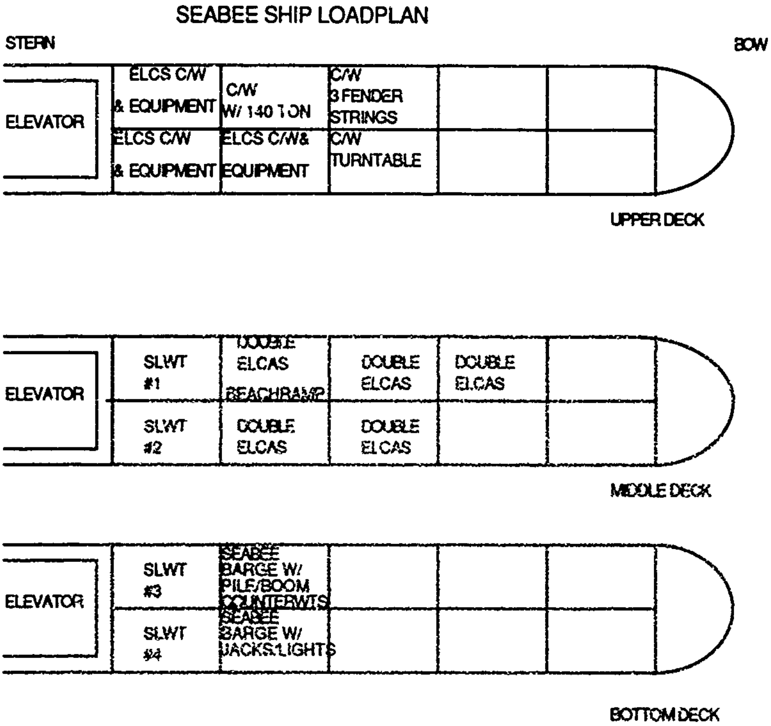


Figure 2-14: Diagram of the Loading Plan for a Seabee Barge Carrier

(Legend: SLWT= Side-Loadable Warping Tug

C/W= Abbreviation for pontoon causeway.)

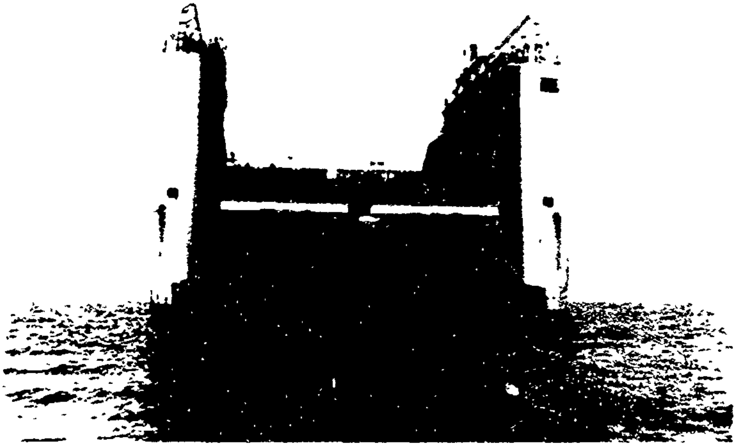


FIGURE 2-15: Stern view of the SBC showing the elevator.

The Seabee barges rest on two large steel I-beams when in position on the ship. However, the NL Pontoon causeway sections are only 21 feet wide versus the 31 foot width of a Seabee barge. This narrower width made necessary the installation of an additional I-beam to properly support the causeway. For the SBC which was used in the off-loading exercise in September, 1991, only certain areas of the ship had this modification, limiting the availability of space to place the causeway sections (see figure 2-8). However, this modification is planned for all areas of the SBC's which are in the James River reserve fleet.

Because of the high demand for this type of shipping in a contingency situation, it is likely that other equipment will also be loaded on the SBC. This other equipment will have a great effect on the load plan and off-loading procedures. It is very important that equipment be off-loaded in the order that it is needed. This is an important consideration that must be addressed in developing the load plan.

The load diagram (figure 2-8) shows 13 barge storage locations that are empty. During the JLOTS III exercise in September, 1991, the empty spaces were filled with other Army and Navy amphibious craft that were involved in the operation. It is likely that if ELCAS is ever deployed in an actual scenario, this space will be at a premium and the gear with the highest priority will be sent. However, if a longer ELCAS pier is needed, an additional 22 ELCAS sections could be carried, assuming the I-beam modification was made at all locations. Theoretically, this would allow the construction of a 2520 foot ELCAS pier with a 9 section double-wide pierhead. However, a longer pier would require additional storage space for pile and external spudwells, so the causeway carrying capacity would probably be reduced somewhat. Appendix C contains a listing of items that are required to deploy ELCAS.

Existing System Condition

The majority of the structural components used in the existing ELCAS system have been in service since the late 1970's and early 1980's (Groff 1991). These components are, for the most part, made of structural steel and have been exposed to direct contact with saltwater for at least 3 weeks every time a training evolution is performed (once or twice per year). At ACB-1 in Coronado, CA, many of the sections must be stored in the water for a longer period of time due to a lack of sufficient storage on land. ACB-1 also has a much smaller facility for sandblasting and painting the sections, which limits the amount of maintenance they can perform. At ACB-2, these sections are typically sandblasted and repainted on an annual basis. However, the combined effects of the saltwater, sandblasting and structural fatigue from use has left the sections in a deteriorated state. There are many areas of structural importance that cannot be reached for maintenance without disassembling the causeway itself.

Of particular significance are the connections between the pontoons and the angles that hold the pontoons in place. Causeway disassembly is a difficult procedure because the constituent components of the causeway are welded, in addition to being bolted into place. This means that disassembly usually results in the destruction of many of the causeway components.

Regular NL Pontoon Causeway sections that are used for deploying teams typically have a planned life of 5 to 7 years. The ELCAS sections see a comparable amount of wear and tear but have been in service for over twice that time period. NAVFAC and the Civil Engineering Support Office have been aware of the deterioration, but funding for rehabilitation on the old system has previously not been approved due to the anticipation of receipt of the new cantilevered or modular ELCAS system. However, the procurement process has been delayed since 1985 (Daley 1991-2) (this situation will be discussed further in the Chapter 4).

ACB-2 has identified that the most cost effective method to restore the system is for CESO to procure 12 new ELCAS sections to replace the ACB-2 deployable sections and to overhaul or replace the erection equipment. The existing sections could then be sandblasted, painted, and placed into storage for contingency use in the erection of a 3000 foot ELCAS. CESO now contracts for universal causeway sections that are designed to work as intermediate sections for barge ferries or as Roll On/Roll Off (RORO) sections. These sections are delivered with mounting locations for external spudwells, so they could be used as direct replacements for roadway sections.

Alternatively, replacement components (pontoons, internal spudwells etc.) could be procured and new sections could be assembled by ACB-2 personnel. However, due to workload requirements, this could delay system upgrade significantly.

CESO is presently planning to take action to rehabilitate the existing ELCAS systems at both ACB-1 and ACB-2 to maintain the operation capabilities of both systems until the new modular ELCAS system (ELCAS (M) which will be discussed in Chapter 4) is operational (Daley 1991-2). The eventual plan is for ELCAS (M) to be stored, operated and maintained by ACB-2 and for ACB-1 to receive both of the existing ELCAS systems.

Chapter 3: Development of a Critical Path Method (CPM) Planning Document for the Existing Elevated Causeway System

Discussion

The erection of ELCAS is a repetitive procedure that should be a relatively straight forward, mechanical process. However, because of the great expenditure of effort involved in an ELCAS exercise, the training evolutions are conducted at most twice per year and frequently only once per year. Because the military personnel (including the chiefs and officers) who perform the construction are typically assigned to only a two or three year billet at an Amphibious Construction Battalion and often they do not spend even that whole amount assigned to the ELCAS team, it is common for two-thirds of the active duty members assigned to the erection team to have no prior experience in ELCAS erection.

The NAVFAC publication P-460 (NAVFAC 1981` provides in-depth information regarding what the ELCAS parts are and how they function together, but some parts of it are outdated (it is presently under revision and a new issue will be published in the next few months) and a clear cut step-by-step erection plan is not clearly displayed. A CPM for ELCAS was developed based on the P-460 but it's usefulness for the personnel actually erecting ELCAS and their Operation Commanders is limited because it is not detailed. Additionally, the manning requirements called for in the P-460 are unrealistic, so the data in the existing CPM is for the most part obsolete.

Previous Project Scheduling Document for ELCAS

The development of a Critical Path Method planning document for ELCAS was conducted in 1983 (ADTECH 1983) in order to extrapolate manpower, resource, and time requirements for the construction of a 3000 foot ELCAS from historical performance related to the 810 foot ELCAS. The technical approach of this report was to :

1) Study the results of previously conducted ELCAS operations.

2) Examine the overall construction method and procedures with regard to best use of space, avoiding clutter, environmental effects, safety, etc.

3) The uniqueness of the configuration was studied so that apparent disadvantages could be used advantageously to facilitate construction where possible.

4) The construction method was optimized so that additional resource requirements were kept to a minimum.

5) Factors arising from the extreme length of the roadway and the large number of causeway sections were appraised to assure that there was adequate recognition of the necessary changes that they require.

This report took time, equipment and procedural baseline data from the P-460 ELCAS Manual (NAVFAC 1981) and made assumptions as to the following:

- 30 ton cranes can drive piling on an ELCAS section (from prior experience this has been shown to be true provided that the wave motion is small, i.e., less than 3 foot swells).
- No weather delays will be encountered.

- Surveying will be done incidental to elevation but will not affect the critical path (from prior experience this is not true, night pile driving and jacking operations can be greatly slowed by the inability of the surveyor to see the marks on the pile).

- That the ELCAS construction team members may be assigned to jobs outside of their rates (in the Navy a rate is a combination of of the person's rank and their field of specialization, e.g. an EO1 is a first class Equipment Operator).

- That the P-9 Pontoon is used, which adapts the flexor for use as a causeway side connector, thus allowing the lifting of side-connected sections simultaneously using a minimum number of jacks (this is not true, ELCAS sections have not been modified in this manner).

Drawing from the P-460, this report calls for a 42 man erection team per shift. This number had been achieved in a few prior operations where ELCAS was the main focus of the operational objectives, particularly when the system was new and ELCAS was a high visibility system. However, in all of the operations observed by this researcher, the erection team size has ranged from 15 to 25 people. These numbers are usually achieved by the augmentation of Selected Reservists who are activated only for the period of the exercise and in most cases have not developed sufficient skills in the construction activities or teamwork with the active duty members to be truly effective. Ideally, the 42 man complement could be permanently assigned to the ELCAS training team so that in a two shift operation at least one half of the specified manning would be available per shift. However, the ACB's are frequently tasked with a variety of manpower intensive activities without sufficient time to prepare for the requirement.

In reality, ELCAS is a component of the Assault Follow On Echelon (AFOE) and will probably not receive the same dedicated support as the units needed for the first line Because of this, it would be beneficial to create a planning document based upon a realistic manning and training availability, in order to provide the Officer-in-Charge of the theater where the ELCAS will be erected with a realistic schedule for having an operational ELCAS.

The previous CPM scheduling effort (ADTECH 1983) takes a general view of the erection process and provides estimates of performance based largely on what is written in the manuals rather than actual experience. Considerations that are not properly developed include: production degradation from integration of untrained crews; crowding of equipment and personnel; efficiency based on weather conditions that are within the working parameters but still degrade performance; and performance degradation from night operations and fatigue. These effects are inevitable due to the nature of the operation.

ELCAS has been erected and made fully operational in 62 hours of construction time from when it was first inserted. However, this erection was performed with an unusually experienced crew (and supervisors), working only during daylight and securing operations during periods of rough weather. Such a luxury would not be allowed during an actual wartime contingency where the equipment and supplies in the containers are needed ashore as quickly as possible.

Productivity Analysis

Probably the single most important factor in achieving and maintaining good productivity during an ELCAS operation is good planning and communication of objectives and responsibilities of the personnel involved. The activities that will be performed should be laid out in a step-by-step manner and thoroughly understood by all supervisors and crew leaders. In the week prior to the operation, the Officer-in Charge (OIC), Assistant Officer-in-Charge (AOIC), Leading Petty Officer (LPO), boat crew supervisors, and all other crew leaders should plan the ELCAS system ship layout and debarkation and how ELCAS will be erected once the equipment is brought ashore. Each of the work crews should be pre-established and have spent time training together prior to the operation.

One problem that has occurred in the past was a breakdown of communication between the boat crews and the leadership of the ELCAS team. As an example, the Seabee Ship was loaded in the wrong order at last September's JLOTS III exercise, which significantly slowed the operation and discouraged the personnel who worked on the project. It is imperative that all personnel, including the boat crews, know the gameplan prior to the start of the operation. It would be beneficial for someone who is knowledgeable regarding the overall planning process to accompany the boat crews during their evolutions to ensure that tasks are performed in the required order (this person should be a minimum of a responsible First Class Petty Officer (E-6) to insure that his input is considered).

All of the personnel who will work in the erection process should have a cursory understanding of what the work goals are for each day. The CPM presented will assume that all personnel are familiar with their duties and the ELCAS Team objectives for each working shift.

In the past, Selected Reservists have been activated for ELCAS training and brought to the ELCAS site on the first or second day of erection without a proper briefing of their responsibilities. The active duty leadership do not have prior knowledge of the reservists abilities and qualifications and do not know for certain who will arrive and when. This leads to confusion and actually degrades the performance of the ELCAS team during the early part of the exercise. However, it is likely that a similar situation would occur in an actual contingency operation The reservists would probably be activated from their home drilling locations and sent to the ELCAS erection location with little opportunity to integrate with the active duty erection team. Because of this, preparations should be made in advance to have a responsible individual act as an indoctrinator for the incoming reservists. The reserve training organization should provide him with clerical and administrative support and he should maintain a close working relationship with the AOIC so that the incoming reservists can be efficiently integrated with the active duty crews as quickly as possible.

If Presidential authority is not granted to recall reservists, it is possible that the ELCAS will have to be erected by only active duty personnel on the ELCAS team (since an augmentation of personnel from other companies of the ACB may not be possible due to other operational requirements). It would therefore be beneficial to have the ELCAS team ready and able to construct ELCAS without outside assistance in as rapid a manner as possible. The CPM presented here will assume this option and calculate the activities' durations accordingly. However, it would be possible to modify this CPM to account for incorporation of reservists or an active duty augmentation. The contribution of reservists for the first two days of the operation should be discounted. Additional crews could then be formed to perform some of the activities after two days.

Productivity Factors

Several reports have been written regarding production degradation in the field of construction due to a variety of factors (Crawford 1987 and Kieschnick 1987). Factors that degrade performance which are applicable to the ELCAS construction process include the degree of training and familiarity with the task. weather conditions, overtime work, fatigue, night operations, sub-floor soil conditions and overcrowding.

The factors discussed in the succeeding paragraphs are based upon the author's experience and judgement, as there is no research data available on this matter. These factors are summarized in Table 3-1. These factors should be considered to be additive in nature not multiplicative (i.e. if there are two factors that degrade performance of 25 and 50 percent respectively, the total added time would be 75 percent of the original activity time).

Productivity Degradation Factors

Productivity Inhibitor	Assigned Factor
Experience:	
1/3 of crew inexperienced	1.15
1/2 of crew inexperienced	1.3
nearly all of crew inexperienced	2.0
Overtime/Fatigue:	
8 to 10 hrs. per shift	1.1
10 to 12 hrs. per shift	1.2
12 to 14 hrs. per shift	1.5
working midnight to 0500	1.2
Wave action:	
pierhead 2 to 3 feet	1.4
pierhead 3 or more feet	2.0
roadway 2 to 3 feet	1.2
roadway 3 or more feet	1.7
Temperature:	
15-20 degrees F	1.6
20-29 degrees F	1.4
30-40 degrees F	1 2
85-90 degrees F	1 2
90-95 degrees F	1.4
95 to 100 degrees F	1.6
Night-time:	
Piledriving	2.0
Other night-time activities	1.2
Clay or organic sub-floor encountered in piledriving:	Add 13 hrs. per pile

Table 3-1: Productivity Degradation Factors

A factor to account for lack of training and familiarity with the system is largely subjective and could be assigned by the AOIC with knowledge of the individuals. In general, if the person has been involved with a previous ELCAS operation, or has been assigned to the ELCAS team for at least 6 months and has participated in several training evolutions, or is a licensed crane operator and has trained with the ELCAS team for a few operations then that person could be considered trained. However, if more than one-third of the personnel assigned to a crew are inexperienced, then a factor should be assigned to lengthen the time expected for them to complete an activity. A reasonable factor for a crew with one-third of its personnel inexperienced would be to add 15 percent to the time required to complete the activity. For a 50 percent inexperienced crew add 30 percent to the activity completion time. If the crew is inexperienced except for one or two personnel, add 100 percent to the activity completion time.

Workers who participate in the construction of ELCAS will be performing activities that are very physically demanding and also very dangerous. Fatigue must be a serious consideration to all personnel in leadership positions. Studies have shown (Crawford 1987 and Kieschnick 1987) that accidents and other safety incidents increase significantly when fatigue is a factor. For any work over 8 hours per shift, over 40 hours per week, or between the hours of midnight and 0500, a factor should be assigned to account for fatigue. This would not be a constant factor but would increase at some exponential rate as levels of fatigue increase. During some ELCAS operations, personnel have worked in excess of 20 hours straight with only a lunch break. Extreme care by supervisors and equipment operators must be taken at this point to ensure that there are no accidents. If several activities still need to be completed after a period of extended work of this nature, it is highly probable that the productivity will be so degraded as to negate any advantage gained by working the extra time.

Superior performance can be extracted from personnel by working moderate hours with sufficient rest time in between. A minimum of 6 hours sleeping time per day should be available to all personnel, preferably in an uninterrupted stretch. If personnel are required to work over 8 hours but less than 10 hours on one shift then an appropriate factor would be to extend the length of activities during this period by 10 percent. If they have worked between 10 and 12 hours or are working between midnight and 0500, a reasonable increase in activity time would be 20 percent. If they work between 12 and 14 hours on a shift, the activity times should be increased by 50 percent. Work on a shift longer than 14 hours will probably degrade future productivity and should be discouraged. However, there are times when stopping work will not be the best alternative. For example, it may hurt the morale of personnel (stop their "momentum") to be close to an obvious stopping point or intermediate milestone and not reach it. This should be weighed against what effects the fatigue is having in regards to safety in determining when to stop.

Weather parameters for which work must be halted can be a judgement call on the part of the OIC. However, weather conditions that are not severe enough to halt work will significantly degrade productivity. The construction process is most susceptible to productivity degradation while the ELCAS pier is still in a floating condition. Wave action causes the deck of the causeways to pitch and roll and this makes it more difficult for personnel to perform manual lifting and carrying tasks. This effect is amplified greatly when it is applied to operations with cranes, because a small pitch at deck level becomes multiplied by the length of the crane's boom and applies a pendulum motion to the load which is connected to the boom via the wire rope cable. This not only increases the time required for activities like pile driving and pile stabbing, but also makes the operations very dangerous.

As a rule of thumb activity lengths on the pierhead should be increased by 100 percent if wave action is above 3 feet and by 40 percent if wave action is between 2 and 3 feet. The effects of wave action for activities on the roadway are not as pronounced because the causeway sections are more sheltered and constrained in their movement. For roadway activities, the activity lengths should be increased by 70 percent if the wave action is above 3 feet and by 20 percent if the wave action is between 2 and 3 feet.

High winds (but not high enough to merit stopping work) will also slow some activities and will also have a greater effect when the causeways are floating than when they are elevated. However, higher winds are generally the cause of greater wave action so the factors listed in the previous paragraph should apply.

The physical comfort of the workers also has a pronounced effect on productivity. For temperatures between 40 degrees F and 85 degrees F, this effect should not be too severe. Productivity studies (Crawford 1987 and Kieschnick 1987) indicate that higher temperatures tend to affect productivity more than low temperatures. This is true in regards to the fatigue component of reduced productivity from temperature, but colder temperatures may also slow productivity because additional clothing must be worn which may be cumbersome. Both hot and cold temperatures will require additional break times for the team's personnel.

As an estimation, for activities performed when the temperature is between 85 and 90 degrees F or between 30 and 40 degrees F (including wind chill), add 20 percent to activity durations to account for required rest time. For temperatures between 90 and 95 or between 20 and 29 degrees F add 40 percent. For temperatures between 95 and 100 or 15 to 20 degrees F, add 60 percent to activity times. This researcher has not observed ELCAS team and boat crew personnel working outside of these temperature ranges and cannot justify factors to add to the activity times, although it would be logical to assume that the activity durations would increase as the temperature conditions got worse. High temperature factors should be greatly increased if the wearing of chemical protective clothing is required.

Night operations have the most effect on tasks that require clear vision. Poor visibility can be somewhat mitigated by the use of light plants and the ELCAS lighting system. However, these measures are never as effective as daylight. Perhaps the task most effected is the ability of the Engineering Aide (surveyor) to see the pile from the beach during a pile driving operation in order to measure blowcounts. Other operations that will be adversely affected include the ability of the crane operator to see exactly where he will place a load. In general, pile driving operations should have their activity lengths doubled and the duration of other operations should be increased by 20 percent. These factors also take into account the natural tendency of personnel who have not been working the night shift previously (as will be the case for the majority of the ELCAS team) to work less productively at night, partly due to fatigue and partly due to unfamiliarity with the work environment.

The sub-floor soil conditions have an influence only during the pile driving operations. If the soil is sandy, the proper blowcount can be achieved in a relatively short period of time. However, if a deep pocket of organic material is encountered, bearing will not be reached until the pile penetrates through the stratum. If the soil is made up of clay, the soil will initially be very resistant and will loosen and liquify as the vibrations of driving affect it. In this case, the present method in practice is to allow the pile to drive for 15 to 20 feet then allow the soil to set up for a period of at least 12 hours. The clay will resolidify and provide (hopefully) stable support for the pile. If clay soil is encountered, a delay time of 13 hours per pile should be added to the expected duration of the pile driving activity (this time amount can be taken simultaneously for pile that will be driven in the same crane set-up).

The scenario considered in this report is that a minimum size work crew will be used to erect the ELCAS system. This is based upon the theory that ELCAS is being erected as a follow-on asset in support of an actual

Amphibious Assault and that optimum assets could not be devoted to the erection team. Because of this, over-crowding will not be considered as a major factor. However, if more than the optimum crew size were available this could arise as a problem and appropriate production degradation factors should be developed.

CPM For ELCAS

The CPM diagram and supporting documentation are attached in Appendix E of this report. The activity durations are based upon the average of estimates provided by individuals who are knowledgeable in the ELCAS system and some time measurements from previous operations (Karrh 1992 and Miller 1992).

The productivity reduction factors listed in Table 3-1 have not been applied to the activity durations in this CPM, so it should be considered to be an optimum completion schedule. In addition to the productivity reduction factors listed, human error is always a factor. Simple mistakes or oversights can cause long delays and even require that the logic of the construction plan be changed. Equipment failure is common and unpredictable during an ELCAS deployment. The lift and transfer equipment on the Seabee Barge Carrier (elevators, lift and transfer mechanisms etc.) receives infrequent maintenance because of its status as a reserve ship and would be prone to breakdown. Additionally, the crews that would operate this equipment would be hired during the short activation period before the ship would sail and this could result in a greater likelihood of human error due to their lack of familiarity with the equipment.

The data for this CPM has been entered into the software package Plantrac. Plantrac has been used to check for logic error and calculate completion times. The use of a software system with this CPM would be very beneficial due to the numerous changes that must be made to accommodate the productivity degradation factors. A software system would also allow the planner to generate resource and sequencing plans quickly based upon ship configuration and available personnel. Lack of resources or changes in local conditions may also necessitate planning logic changes which can be quickly incorporated when using a software system. Plantrac is probably not the ideal software to use for planning an ELCAS operation due to its inability to use decimal fractions of hours for the time intervals (minutes must be used instead) and the awkwardness of the diagrams which it generates.

The CPM diagram in Appendix E shows 100 activities and a total duration of 110.5 hours. Half of the activities listed are on the Critical Path. The efficiency of the ELCAS erection process could be improved if these critical activities could be shortened. Two types of activities stand out as having the most potential for improvement; those involving the handling and driving of pile and the handling and operation of the jacking system. Seven activities on the Critical Path involve the stabbing or driving of pile and have a total duration of 22 hours. Six activities on the Critical Path involve the transfer, set-up or operation of the jacking system and have a total duration of 45 hours. Additionally, as discussed earlier, these activities are susceptible to substantial delay (poor sea-floor conditions and jacking system breakdown). Improvements to the methods of pile handling (e. g. improved splicing connectors) or jacking operation (purchase of an additional set of fours jacks and a power unit to lessen the requirement for transfer) should result in an overall time savings to the construction process.

It is hoped that this CPM will provide useful planning information for future OIC's and AOIC's of ELCAS operations. This author would be happy to provide copies of this CPM to any interested parties. This CPM can best be tested through use and observation during future operations.

Chapter 4: Cantilevered/Modular ELCAS System

Overview

The Modular ELCAS System (called ELCAS (M)) was developed as a replacement for the aging standard NL (Navy Lighterage) pontoon causeway system, to facilitate transport of the system by commercial container ships and to provide a system that is easier and safer to assemble (CESO 1990).

One of the most hazardous aspects of the existing ELCAS system is the fact that it is in a floating state during the first few days of erection. This makes it much more dangerous to operate cranes on this unstable platform and means that the construction deck is frequently wet and slippery and subsequently more equipment and manpower is required to erect the ELCAS. The ELCAS (M) system is designed to overcome this problem since it will be installed from the beach out to sea using a cantilever technique. As a result, it will be almost independent of surf conditions.

The ELCAS (M) System is composed of ISO (International Standards Organization) compatible (conform to standard container ship specifications for containers) pontoons, which improves its mobility by commercial shipping. Transport of the ELCAS system by active Naval Amphibious shipping is not realistic in a wartime environment. This was clearly evident during the preparations for Operation Desert Storm, when because of other, higher priority commitments, it would have been nearly impossible to secure a sufficient number of LST's to move a system like ELCAS to the Persian Gulf.

Container ships are designed to carry cargo that fits into either a 20 by 8 by 8 foot, or a 40 by 8 by 8 foot container size. The corners of the containers have fittings that facilitate lifting with a spreader bar arrangement by cranes or by RTCH. These containers are designed to fit efficiently into the holds of the container ships and can be stacked as many as ten high (80 feet). The standardization of the containers allows rapid loading and unloading of the ships and facilitates transfer ashore.

A network for container shipping has been developed to a great extent in most areas of the world. It includes rapid connections and inter-connectability with railroad and truck transportation networks (which also have vehicles specifically developed to handle containers) The availability of this well-developed transportation network makes an ELCAS system designed around the ISO containers much more mobile and capable of rapid deployment during contingency operations. Additionally, since ELCAS was initially designed to provide a means to move containerized cargo ashore, it is logical and functionally efficient that it should be capable of transport on the ships it is designed to unload.

A technical report and study was performed in April 1988 by MAR, Inc., of Severna Park, Maryland (MAR Inc. 1988). This study evaluated and discussed the transportation and installation scenario for the ELCAS (M). MAR divided the transportation and installation processes into the following key areas: Containerization of the Components, Off-loading of the System, Beach Operations, Marshall Yard Operations, Roadway Construction, Pierhead Construction, and Pierhead Equipment Installation. The ELCAS (M) structure will be comprised of three major areas: the Beachhead, the Roadway and the Pierhead. The beachhead will be composed of an 80 foot ramp and the first three wide section of 40 foot long pontoon modules. The Roadway will be composed of as many as 65 forty-foot long (3 section or 24 foot wide) road sections and a 40 foot long Roadway to Pierhead Interface section. The Pierhead will be 240 feet long (6 modules) by 72 feet wide (9 modules). It will provide operating space for two 160 ton cranes to transfer containers from lighterage to tractor-trailer trucks. Two air-bearing turntables will be used on the pierhead to turn the trucks around.

Since the final design of the ELCAS (M) system is part of the bid solicitation (the contract calls for a turnkey system (CESO 1990 and Daley 1991-2)), most of the details have not yet been determined. However, general requirements have been established and a general construction plan has been developed.

The general requirements for ELCAS (M) are (CESO 1990) that "the Contractor shall design, develop, support and fabricate a 3000-foot ELCAS (M) System and demonstrate (test) the ELCAS (M) System". All design and technical data would become the property of the Government. General requirements were that the ELCAS (M) system would provide for:

1) The transport in and on an ISO compatible containership.
2) Off-loading of ELCAS (M) System from the containership.

3) The assembly of pontoon barges in the water alongside the containership.

4) Transporting all hardware from ship to shore to the marshalling area or erection site.

5) Off-loading all hardware at the beach.

6) Erection by cantilevering pontoons from the beach.

7) Handling cargo at the pierhead and transport of cargo via tractor-trailers to the beach.

8) Retrieving, disassembly, preserving, and packing the erected system for transport and use in a different location or return to storage.

Personnel Requirements

The MAR report (MAR 1988) includes the development of bar/chart planning documents for the installation of ELCAS (M) and calls for a total required crew of 66 personnel per shift based upon observations that were made during operation JLOTS II However, for each task, such as RTCH operator, RTCH signalman, rigger, bulldozer operator etc they assign a separate person. In actuality, one member of the ELCAS (M) erection team would be trained to perform a variety of tasks and reduce the number of required personnel. Efficient division of the manpower should result in more realistic manning requirements.

Using the marshalling yard manning as an example, MAR calls for 2 RTCH operators, 2 RTCH signalmen, 2 forklift operators (to move connector hardware and other smaller items), 1 bulldozer operator, one 8 ton crane operator, one 8 ton crane signalman, one 30 ton crane operator, one 30 ton crane signalman, 8 riggers, 2 welders and 1 mule driver (a mule is a small tractor designed to pull the container sections when they are mounted on wheels). This manning (22 men per shift for the marshalling yard) would be extremely inefficient both as a utilization of manpower and creation of a crowding problem. With proper training, a Navy Equipment Operator should be able to perform all of the required operator tasks in addition to rigger or signalman duties. Additionally, the welders (known as Steelworkers in the Navy) would also be able to serve as riggers, signalman and possibly forklift and mule operators. The marshalling yard could be properly manned by 7 Equipment Operators, 2 Steelworkers and a supervisor (probably a senior E-5 or E-6) for a total of 10 personnel.

MAR's numbers for the roadway and pierhead erection teams are also inflated. Their requirement of 11 personnel could be safely reduced to 8 including an on-site supervisor. Additionally, they show a simultaneous requirement for roadway and pierhead erection crews when the pierhead crew will not be required until the roadway is completed MAR states a requirement for 17 personnel in the pierhead erection crew. This number could safely be reduced to 12, or more correctly stated there would be a required augment to the roadway erection crew of 4 personnel.

Additionally, MAR recommends 8 men per shift per pontoon causeway that would carry the ELCAS (M) modules from the ship to shore. Standard operating practice at an Amphibious Construction Battalion calls for 1 coxswain, 1 engineer and 1 bowhook for a powered causeway section and the addition of 2 or 3 riggers to provide additional manpower. Being conservative this gives a requirement of 6 men per causeway per shift.

Additionally, one senior enlisted person should be assigned to supervise the two causeway ferry crews

One requirement that MAR failed to identify is for that of mechanics to maintain the cranes and material handling equipment. From prior experience, a minimum of 2 mechanics would be required per shift. This gives a more realistic manning requirement of 38 personnel per shift, assuming the pierhead erection team requirement and including the pontoon causeway crew supervisor and an overall shift OIC (this would most likely be either the OIC or AOIC of the erection team depending upon which shift it was). Note that although this is a higher number than the 25 personnel per shift used to calculate the CPM for ELCAS in Chapter 3, this number includes 13 people for boat crews and has the additional requirement of a marshalling yard.

Contracting History

The existing ELCAS system was acquired through a series of component contracts. The ELCAS system was broken down into small packages and the CESO served as a general contractor and sub-contracted out the individual systems. The ELCAS NL pieces (internal spudwells etc.) were bought as normal pieces on a low-bid, price-per-item basis from steel manufacturers. The cranes were bought as a series of separate packages, the turntable was subcontracted out to a steel constructor, and the jacking systems were purchased separately. There were no major problems with this procurement process because it was handled at a micro-scale.

However, there was no long term agreement with the manufacturers to provide ongoing technical, training or spare parts support. Since the system was bought piece-by-piece, the responsibility for maintaining the system expertise and an inventory of spare parts was placed on the contracting agency, in this case CESO.

The basic intent of the new modular ELCAS system was to go to larger pontoon modules that would be easier to assemble together and would be readily transportable on commercial shipping (container ships (Daley 1991-2 and CESO 1990)). As previously stated, regular Naval Amphibious shipping could not afford to provide the space necessary to transport ELCAS by that means.

In the early 1980's, Robishaw Engineering presented a proposal for the cantilever ELCAS to some of the upper level Navy management in Washington and an edict came down that the new ELCAS would be cantilevered. The first solicitation for CANTELCAS (a cantilevered ELCAS system) was in 1985 (Daley 1991-2). The intent of the Navy was to receive a complete system including a training program, erection procedures, an improved connector design and repair parts availability. (Robishaw was one of the bidders but they were considered nonresponsive due to there unwillingness to modify their connector design for the project).

Ferry Marine, Inc., was awarded the contract in 1986 Ferry had a very good design, but they had a hard time getting a reliable subcontractor to build components in the U. S. and they had difficulties in organizing and pulling the project together (Daley 1991-2). They also did not have a good concept of what was entailed in the requirements for a turnkey system, including the development of training manuals and ongoing engineering support, etc. Their initial subcontractor produced a poor quality product (one of the initial pontoons was warped and unusable) in an untimely basis and subsequently went bankrupt. The bankruptcy court ruled that the contract with Ferry was one of their assets and Ferry had to expend a considerable amount of money to buy their own contract back. Ferry then unsuccessfully sought other subcontractors. Because of these problems, Ferry failed to make the required deliveries to the Navy and was initially terminated for cause in 1989 (which would have meant that Ferry would be responsible for the cost of the subsequent solicitation). However, Ferry filed litigation and NAVFAC agreed to a settlement which actually paid Ferry some of the contract value.

Bids were sent out again in December, 1991, and the contract was subsequently awarded to Jered Brown Bros., Inc., of Troy, Michigan. The selection process was based upon a numerical evaluation of the strength of the proposals in areas of capabilities of the company, technical development of the construction method and the strength of the design. The cumulative score regarding the strength of the proposals was then used as a weight multiplied against the bid price. Lakeshore, Inc , had the best overall score from the proposal evaluations but an extensive pre-award inspection and evaluation of their facilities indicated that they did not have the capabilities which they claimed to have in their proposal. As a result, Jered Brown Bros. Inc., who had the second best numerical score and a very good pre-award inspection (they had all the capabilities which they claimed), was awarded the contract.

Lakeshore subsequently filed a protest of the award. A second round of bids were taken and this time Jered Brown was the lowest because they cut their cost. After this second award, the Competition Advocacy Board under the Secretary of the Navy stepped in and said that it was inappropriate to rate the proposals on a numerical basis. Subsequently, the contract with Jered Brown was terminated for convenience and all the bidders have been compensated for their bid and proposal preparation costs.

At the present time, another proposal solicitation has been completed and the proposals are being evaluated by a technical review board. This time the review board is evaluating the bidders on an adjective rather than numerical basis. A business judgement board will review the proposal subsequent to the technical review board, and a contract award is anticipated by September (Daley 1991-2).

Improvements to the Contracting Process

An alternative to soliciting a "turnkey" complete system would be to divide the ELCAS (M) System into smaller packages and have the contracting officer (CESO) act as a general contractor and ensure that the components of the system are all procured in the proper amounts and with a high level of quality. However, this significantly reduces the possibility of receiving innovative ideas from an industry expert in the area of marine engineering and requires CESO to be the expert. Additionally, these smaller contracts will not have provisions for long term support from the contractor so the Navy would have to maintain a stock of replacement parts. An example of this is where the manufacturer for the air bearings in the turntable for the existing ELCAS no longer produces this product and replacements have to be custom fabricated at a much higher cost than would be if the parts were commercially available. The hydraulic jacking system is also no longer in production and existing components must be overhauled to maintain serviceability rather than be replaced.

Breaking the ELCAS (M) System into sub-packages and acting as a general contractor would require a much more intensive effort on the part of CESO in terms of manpower and resource commitment. The present push within the Department of Defense is to downsize the civilian force as much as possible to reduce the expenditure of the Operations and Maintenance (OM&N) Funds that pay for salaries of personnel. The Government has pushed for a centralization of supply, contracting and inventory control activities to reduce the number of personnel required to manage a certain number of items. However, when this centralization occurs, expertise at the contracting office is lost. The Sealift Support Branch at CESO is presently a small office, which would have a difficult time in managing the $5 million in design work required to bring the ELCAS (M) system onto line (Daley 1991-2). In order for CESO to properly manage the procurement and ongoing maintenance of the ELCAS (M) system by a component procurement process, it may be necessary to hire additional personnel.

Another possible alternative would be for the Navy to contract with a consortium of marine engineering organizations in order to secure their joint expertise and production capabilities. This would help to avoid the production difficulties encountered by Ferry Marine and provide a greater amount of engineering expertise.

Chapter 5: Commercial Alternatives to ELCAS (M)/Innovations

Development

The purpose of this chapter is to examine the feasibility of contracting for the new ELCAS System by selecting as many components as possible from marine engineering manufacturers' standard catalogs and having an engineer who is knowledgeable in the system piece together what would be required to make a workable system. The goal would be to use equipment that is already available in commercial industry and may be used for similar purposes, rather than specially fabricated items To collect the information given in this chapter a variety of Marine Engineering Firms on the Texas and Louisiana Gulf Coasts were contacted and their catalogs examined.

There are many advantages to this method. First of all and maybe most beneficial would be that the contracting time and procedures could be drastically shortened and simplified Secondly, engineering design work would be lessened. A properly selected system should require much less developmental work. Additionally, it could be possible to purchase or lease only a small portion of the ELCAS system in this manner and thoroughly test it before having to buy the whole system (McNair 1992).

Flexifloat and ISOLOG Systems

One company that carries a line of products in this area is Robishaw Engineering Inc. in Houston, TX (Robishaw 1982, Robishaw 1991 and McNair 1992). The author first became familiar with their "Flexifloat" products (tradename) in the fall of 1990, while stationed at ACB-2. Flexifloat modules are standardized pontoons of 10 foot width and 5 foot depth which are dimensioned for permissible overland transport. They are available in lengths of 10 feet (called a "unit-float"), 20 feet ("duo-float"), 30 feet ("tri-float") and 40 feet ("quadra-float"). Figure 5-1 is an artist's rendition of these modules (Robishaw 1982).

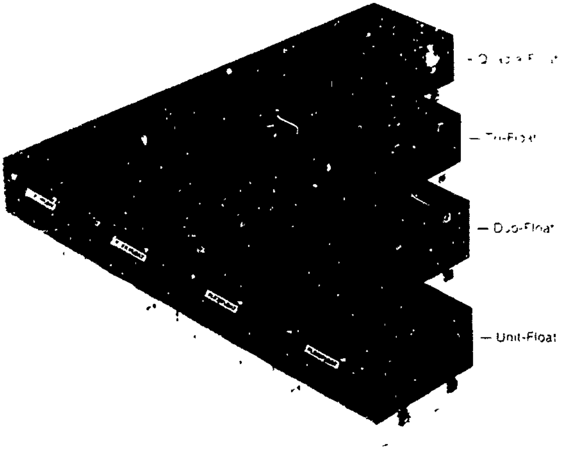


FIGURE 5-1 Picture of Flexifloat modules.

Flexifloat units use a rigid locking system that permits inter-locking on all sides of the module. This allows the pontoon system to be constructed to almost any configuration. A variety of specialized attachments and components are available to permit multi-purpose applications. These include bow and stern units which offer low resistance to turbulence for use in a Flexifloat ferry, ramps for loading applications, elevating and non-elevating spudwells and propulsion units. Flexifloat systems are commonly used for marine and riverine construction, in dredging and pipelaying applications, and as ferries and bridging units. Figure 5-2 is an artist's rendition of a Flexifloat ferry.

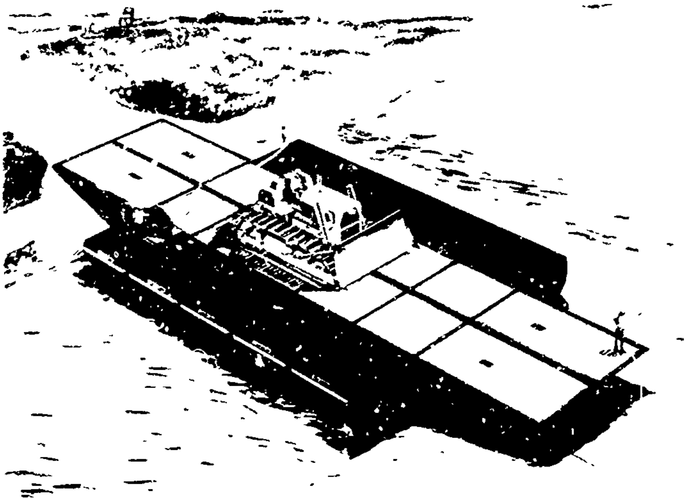


FIGURE 5-2 Picture of a Flexifloat ferry.

The ISOLOG system is a variation of Flexifloat system that uses pontoon modules that are dimensioned and manufactured to ISO container specifications, facilitating transport by container ship. One such system has been delivered to the U. S. Army Transportation Command At Fort Eustis, Virginia.

A test and evaluation of an experimental Air Cushioned Vehicle Landing Platform (ACVLP also called a Fly On-Fly Off platform) which was constructed from Flexifloat modules was conducted in October of 1990. ACB-2 personnel assembled and moved the platform to its test position in the Chesapeake Bay. This evaluation involved the lease rather than purchase of the modules, which was prudent since this was the first active evaluation of such a system and it is not known whether the Flexifloat modules will again be required for this purpose. The Flexifloat module shipment for this test came from various parts of the Southeast. This researcher initially travelled to one of the storage facilities near Richmond, Virginia to inspect the modules and develop a plan for their assembly. These units appeared to be very rugged and had been used in many other marine applications.

In order to construct the ACVLP, several of the Flexifloat units had to be interconnected. The side and end connectors used in the Flexifloat system are much more rigid than the flexor pins used in the Navy's Roll On-Roll Off (RORO) platform and there was some question as to how they would resist structural fatigue from the cyclical loading and unloading that would be encountered in rough seas. However, from personal observation as the safety officer for night operations on Chesapeake Bay, the ACVLP handled the up to 3 foot seas and 15 knot winds much better than the RORO platform to which it was attached.

During the Joint Logistics Over the Shore Test III conducted in September, 1991, ISOLOG causeway ferries did undergo rough weather (Rausch 1991-2). Some of the single sections received damage but this damage was comparable to that sustained by the Navy NL causeways. During this storm they encountered 8 foot seas which is significantly above the standard operating parameters.

Another concern that has not yet been fully evaluated is if the Robishaw connectors between each module will sustain contact damage due to their being directly along the perimeter of the modules (Daley 1991-2 and Rausch 1991-2). This question can perhaps be answered by a long term evaluation of the performance of the system currently underway by the Army.

The Flexifloat and ISOLOG pontoon modules have proved to be easy to put together (at least during calm to moderate weather) requiring only two or three workers to move them in the water by hand using one inch diameter line. By contrast the regular pontoon causeways require the use of a small tug for assembly. An additional advantage is that the Flexifloat modules are small and light enough to be easily taken from the water to land using a 65 ton hydraulic crane, even at a 25 foot plus radius. In comparison, a 140 ton crane cannot lift a standard NL pontoon causeway from the same lifting location.

The major disadvantages to the use of Flexifloat modules is their incompatibility with the existing Navy pontoon system and their non-conformance to standard ISO sizes. However, the recent development of the an ISOLOG system has overcome many of these drawbacks. This system is commercially available, conforms to the standard 40 foot by 8 foot ISO envelope, and has special pontoons available that will mate to standard Navy NL causeways. These special pontoons have male and female end-connectors that mate to the ends of standard Navy NL pontoon causeways. With these end-modules, they can form a standard 24 by 120 foot causeway and be well suited for transport by container ships, which would make them ideal for use in the reserve mission areas of the Assault Follow-On-Echelon (prepositioning ELCAS and RORO units on commercial shipping).

The ISOLOG units are sold on a commercial basis to organizations that need to be able to transport a pontoon platform system overseas. They have been used for a construction project on the Kwajalein Atoll in the Pacific and they are used by some of the major oil companies. However, this system is not sold commercially in large numbers like the regular Flexifloat system. A typical 40 by 8 by 4 5 foot section costs around $40,000 and can be ordered in any required quantity (McNair 1992).

The ISOLOG modules are similar to the regular Flexifloat modules in their rough shape, structural strength and locking connectors. Each of these connectors is rated at 150,000 pound capacity. A typical Quadra-float ISOLOG module (40 foot by 8 foot) is side connected using eight of these connectors. These modules have an additional advantage of having a draft of only 14 inches unloaded, which is six to eight inches less than the standard NL pontoon causeways. The uniform deck load which allows for 12 inches of freeboard is 145 pounds per square foot This gives a load capacity of 208 tons for the 24 by 120 foot causeway. This is almost double the rated capacity of an NL pontoon causeway (110 tons) This would allow one ISOLOG causeway section to carry three M-60 tanks whereas one of the NL type sections can only carry one.

The corners of the units are equipped with ISO type 1611 fittings that permit lifting and handling as standard freight containers. These modules also have the requisite strength to qualify for shipment. which means that they must be able to structurally withstand the weight of 14 forty-foot cargo containers stacked directly above them The Duo-floats (20 by 8 foot dimensions) can also be connected by means of integral connectors to form an "ISOPAK" that is dimensional equivalent to a forty foot container. The modules are all equipped with recessed pipe plugs to facilitate easy water drainage or filling with a flotation enhancing foam, if required, to mitigate the threat of battle damage to the units. Because of their ISO compatibility, these units can also easily be handled by RTCH, which are part of the allowance of the Maritime Prepositioned Force.

Robishaw has also developed propulsion modules that feature a steerable 360 degree water-jet and are 100 percent compatible with non-powered modules (Robishaw 1991). The rigidity of the connections between the propulsion modules and the non-powered modules should enhance the barge ferry's handling characteristics. With the existing pontoon causeway systems, Side Loadable Warping Tugs (SLWT) and Causeway Tenderboats are typically tied to the sections they are pushing by means of line. Handling problems can result when this line slips or breaks. However, attachment by way of line does allow the pushing craft to readily change positions as required to better handle the causeway string. Robishaw's propulsion module is only forty feet long compared to the 90 foot long SLWT and it is designed to be a component part of the causeway. Two modules would be used for a 4 string causeway with a total length of 480 feet. The ISOLOG propulsion modules have superior power to the SLWT's (600 hp per engine versus 425 hp) and are more efficient for transferring the power into maneuverability since they are an integral part of the causeway.

The propulsion modules could also be transported by container ship cargo but the coxswain's conn must be removed before other containers could be placed on top of it. However, it should be loaded on top of the stack because it would be needed in the water to handle containers as they are taken off the ship.

Robishaw has proposed use of the ISOLOG system for a cantilever ELCAS as shown in Figure 5-3 (Robishaw 1991). Studies have been performed at the Robishaw factory to test the strength of the Flexifloat connectors in regard to supporting a cantilevered load and to test the structural rigidity of the system with an equivalent load to that of a 140 ton crane on the sections when it was elevated. These tests showed only small amounts of deflection in the cantilevered arrangement which would not adversely affect the erection procedure. As previously discussed,

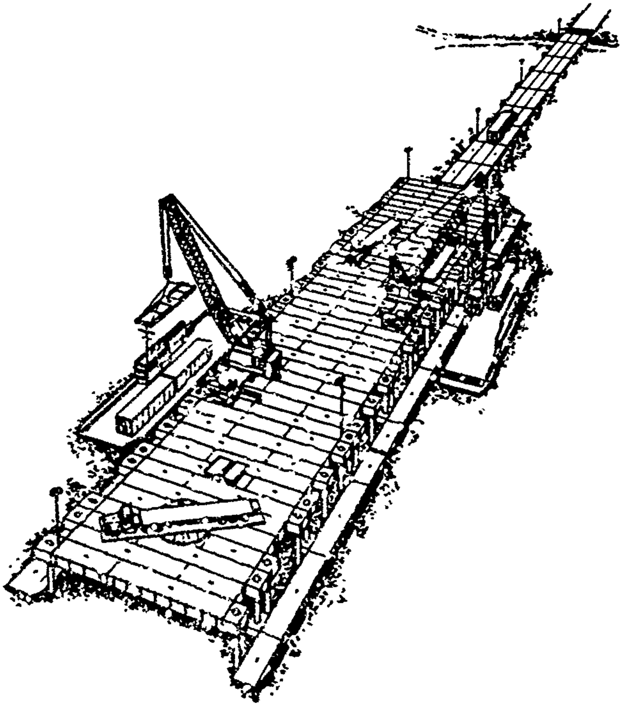


FIGURE 5-3: Picture of the ISOLOG ELCAS

Robishaw's connectors are rated at 150,000 pounds in tension, compression and shear. In a cantilevered arrangement they would have shear and tension forces, which given that the total weight of one module is only 22,400 pounds should not pose too much of a problem The spud attachments which would be used in this system are rated at the strength of two locks which is 150 tons They work under the concept of cutting the pile off at deck level than taking a one eighth turn to lock a cap in place over the top of the pile. The major concern would be the resistance of the connection and lack of deflection when subject to a moment of not more than 1.12 million lb-feet (McNair 1992).

Robishaw also manufactures elevated structure attachments or elevating spud wells. This equipment is used to have a platform raise itself (similar to one system that is in use at the present time by the U. S. Army in the DeLong Pier). This system has the capability to raise a platform with a crane and extra equipment already on it These spudwells do require the use of special pile that can be locked in place at any height. A variety of attachments can be purchased to facilitate the operation of the Robishaw systems. These can include winches for ferry operation across rivers, outboard motor units, fender, and bumper systems Air cushioned assemblies are available to permit operation in extremely shallow water Such an assembly may be towed by a tug or amphibious vehicle (possible the Army's LARC LX). Hinged connectors are also available to serve where changes in water elevation may be encountered (a possible application may be the ELCAS beach ramps). A variety of spud wells are manufactured and special items can be constructed if needed Some of these spud wells have devices to hold pile up so that a platform can be moved to another location and the pile re-stabbed (called a holding spud). Yoke spacers are available to provide space to work in between the modules of a platform, or to install a rake to minimize the forces of a current. The versatility that the Robishaw systems show in configuration and the wide variety and availability of accessories increases the utility of the Flexifloat and ISOLOG systems in a variety of applications.

Mechanical Connectors

Another area where improvement seems possible for the ELCAS system is in the method by which pile are spliced together. When a soft seafloor is encountered during pile driving it is usually necessary to splice an additional length of pile on to the pile being driven. One of the requirements for ELCAS is that it may have to be disassembled, re-deployed and re-erected in another location This means that the pile used to erect ELCAS must be recovered to the greatest extent possible. Therefore, if a pile splice connection is to be driven below the causeway deck level it must be carefully welded to ensure successful pile retrieval This pile welding process is time consuming and dangerous Steelworkers have received serious shocks while welding when they were hit with seaspray. The lengths of pile used in an ELCAS operation are typically 40 to 66 feet During an ELCAS operation in July 1990, some pile had to be spliced 2 or 3 times each Each of these splices required a 360 degree, full-penetration weld which took 60 to 90 minutes to complete A solution to this problem would be to use a mechanical splice which would be attached to the pile during the pre-deployment phase in the homeport

Information regarding these splices was received from the Vetco-Gray company (Vetco-Gray 1991). Their product which is applicable to the 20 inch diameter 1/2 inch wall thickness pile used in ELCAS is called the Rapid Lock Type RL-4S Conductor and Casing Connector The Vetco mechanical connector alleviates splicing problems by creating a mechanical connection between the two pile sections that is stronger than the steel itself and can be assembled in a matter of seconds

The current method used at ACB-2 for pile splicing is to weld an 18 inch pile section inside the 20 inch pile and weld shims on the exterior of the 18 inch pile so that it will act as a guide for connecting the two pile. This requires purchasing lengths of 18 inch pile (which is not as readily available as the 20 inch pile) and performing a good deal of preparation work prior to the operation The Vetco connectors also require installation prior to the operation but the only material cost is for the connectors themselves. They are self guiding and require only a one quarter turn to be secure The pin and box set for each connector costs approximately $800 per set. By comparison, each 8 foot length of 18 inch pile used in a conventional splice costs approximately $150 Vetco connectors are regularly used by the major oil companies for offshore platform support and hence can be ordered as an "off the shelf" item These connectors are designed to be reusable. Figure 5-4 is an artist's rendition of a Vetco connector

FIGURE 5-4 Picture of a Vetco connector

The incorporation of the Vetco-Gray or a similar type mechanical connector into the ELCAS system could reap benefits in other areas. One area that has been studied over the last few years by the Navy Civil Engineering Laboratory (NCEL) is an improved method of pile driving. This study has involved the use of a BOMAG combination vibratory/impact piledriver that can also serve as a pile extractor. Vibratory piledriving is much faster than the standard impact piledriving that is used with the current ELCAS system. However, the vibrations disturb the sand around the area of the pile and result in the pile being driven further down into the sand to achieve the same bearing capacity. The time savings during the driving operation is frequently negated by the additional time required to splice the pile. However, if mechanical connectors were used the resulting time savings in the splicing process may overcome this disadvantage. In any case having a pile extractor included as part of the equipment allowance for ELCAS would be beneficial because it would facilitate tear-down and re-deployment of the system if it was erected in a remote location.

Chapter 6. Conclusions and Recommendations:

Conclusions

The Elevated Causeway system (ELCAS) provides an important part of the Navy's capabilities in the area of resupply to forces ashore during the Assault Follow-On-Phase of an Amphibious Assault. ELCAS provides the only practical means to transfer containerized cargo over the surf-line. However, the existing ELCAS system is nearing the end of its useful life due to structural deterioration. A replacement system for ELCAS has been planned for many years but contractual difficulties have delayed its receipt.

The design of the replacement system, known as the modular ELCAS system or ELCAS (M), addresses this problem by being readily transportable by container ships. Container ships provide the most available form of commercial shipping to the Navy for overseas deployment of cargo The ELCAS (M) is designed to be constructed from pontoons that have the characteristics (dimensions and fittings) to be transported as containers and will be constructed from the shore outward in a cantilevered fashion. The ELCAS (M) system could be pre-deployed on a container ship in the vicinity of where it may be needed

However, problems have developed in the contracting process for ELCAS (M). A new ELCAS system is overdue and would be desperately needed if a war-time contingency arises

This report describes the components, equipment, construction methods and personnel required to assemble and erect the existing ELCAS, and develops a CPM logic diagram to off-load ELCAS from a SEABEE barge carrier, transport it ashore and erect it. The development of this CPM (Chapter 3) includes the assignment of productivity reduction factors to account for personnel fatigue, weather conditions, and level of training readiness and should assist ELCAS OIC's in the future.

ELCAS is a fairly low technology, rugged system that can be erected and operated in difficult environments. The need for such a system will most likely exist into the foreseeable future. In recent years amphibious forces have played an important role in military actions in Lebanon, Grenada and the Persian Gulf.

Recommendations

This report has identified several problems that affect the Elevated Causeway system. The following recommendations are derived from this report:

- Overhaul the existing ELCAS system. Aging cranes and other equipment require replacement and new ELCAS pierhead sections should be built.

- Revise and modernize the ELCAS training program. The Personal Qualification Standards (PQS) system for ELCAS needs to be re-written to reflect current information on how the system is erected and what personnel are required to know. The introduction of a formal school for ELCAS training would be beneficial. Training evolutions should be coordinated and integrated with the reserve forces as much as possible to enhance teamwork between the reserve and active forces.

- Purchase or lease a small portion of the ISOLOG or similar commercially available components to evaluate their suitablility for service as part of the ELCAS (M). Thoroughly test these components to see if they will work in the proposed application.

- Design and procure the ELCAS (M) system to utilize as many commercially available marine engineering components as possible.

- Maintain a cadre of ELCAS (M) system expertise at CESO and NCEL. and require that CESO maintain the inventory of required spare parts. This could require increasing the staff of CESO's Sealift Support Branch, but the likely savings from the procurement process could far outweigh this expense.

- NCEL and CESO should coordinate testing of the modular causeway system used by the Army at FT. Eustis to evaluate its applicability toward meeting the Navy's needs.

- Evaluate the feasibility of purchasing a crawler crane rather than rubber tired crane with the ELCAS (M) because of its enhanced mobility in the sand and quicker set-up time for lifts.

- The CPM and productivity factors provided in this report can serve as a starting point towards improving training for ELCAS leadership. The CPM should be evaluated, improved and incorporated into an appropriate software system. The productivity factors should be evaluated and could provide baseline data on actual installation time requirements.

- The CPM analysis in Chapter 3 identified pile-driving and jacking operations as the two most critical activities in ELCAS erection. If the existing ELCAS is intended to be kept in an active status, purchase an additional set of 4 jacks and 1 power unit for each ACB. Additionally, purchase a small number of the Vetco-Gray mechanical connectors discussed in Chapter 5 and test them during an actual ELCAS operation for suitability. These connectors would also improve the erection process for ELCAS (M).

Appendices

Appendix A

Author's qualifications and experience at ACB-2:
Oct-Nov 88: Assigned to the Operations Department, receiving an overview of battalion operations and functional relationships. Successfully completed the Ampibious Warfare indoctrination course at the Amphibious Warfare School.

Nov 88-Jan 90: Assigned as the Officer-in-Charge (OIC) of Causeway Lift/Launch and Amphibious Assault Bulk Fuel Team Blue TWO. Served as OIC of this team for a Mediterranean Sea deployment from May to November, 1989. On this deployment directed independent causeway operations at Sierra de Retin, Spain, Capo Teulado, Sardinia, Haifa, Israel, Saros Bay, Turkey and was part of a contingency force for the evacuation of the U. S. Embassy in Beirut, Lebanon. Qualified as a Barge Ferry Pilot and completed the Personal Qualification Standards for Officer of the Deck Inport, Small Boat Officer, Combat Information Center Watch Officer and Officer of the Deck Underway.

Jan 90-Oct 91: Assigned as the OIC of the ELCAS team and the Assistant Alfa Company Commander. Directed the erection and operation of ELCAS including the first ever installation of the Lightweight Multipurpose Spanning Assembly (LMMSA) as a bridge between ELCAS and a floating Roll On/Roll Off Causeway Platform from July to August 1990.

Oct 91-Jul 92: Assigned as the Charlie Company Commander responsible for the direction of the battalion Steel Shop, Sandblasting Crew and continued as OIC of the ELCAS Team

Appendix B

ELCAS Specifications:

1) Capable of being transported by Landing Ship Tank (LST) and commercial carriers, including barge ships.

2) Capable of being installed in 72 hours.

3) Capable of being elevated 15 feet above Mean Low Water, under conditions of 8-foot tides and 7- foot swells.

4) Provide berthing facilities for lighterage, including a 20 foot water depth at the pierhead.

5) Provide a fender system for pier/lighterage interface.

6) Provide mooring capability for lighterage.

7) Provide truck turnaround capability on the causeway pier.

8) Provide for lighter operation/cargo handling and transfer beyond the surf zone.

9) Be compatible with cargo from existing container ships and other container-capable cargo ships, such as roll-on/roll-off ships and barge carrier ships.

10) Handle 10 to 12 containers per hour from lighter to shore.

11) Handle from 20-foot (22-ton) to 40-foot (35-ton) containers at a 40 foot boom radius.

12) Perform continuous operations in sea state 3 (significant wave height at 5 feet with 30-knot winds and 4-knot currents).

13) Survive in sea state 6 (12 to 20-foot waves with 75-knot winds and 4-knot currents).

14) When given 24-hour warning for equipment removal, survive hurricane forces and become operational within 48 hours following the storm.

Appendix C

Deployment Requirements

As part of predeployment planning for a contingency operation in the Persian Gulf, a list of the following items which are required to deploy ELCAS out of the Continental U. S. was generated in January, 1991 (Groff 1991):

- 12 ELCAS Causeway Sections
- 20 Conex Boxes
- 1 Turntable with ramp
- 3 Tractor trailer trucks
- 1 Field Truck (Military)
- 40 External Spudwells
- 2 Beach ramps
- 3 ELCAS fender sections
- 2 Pallets of pile caps
- 4 Welders
- 300 feet of steel ASP matting
- 2 DE-30 piledrivers
- One 65 ton crane
- Two 30 ton cranes
- 1 Shim Box
- 2 Pin Boxes
- 1 Pallet of Acetylene
- 1 Pallet of Oxygen
- 1 30 kW generator
- 1 15 kW generator
- One 750 cfm air compressor
- 2 Gimbel boxes
- 1 generator platform
- One 10000lb forklift
- 6000 feet of 20" pile
- One 140 ton crane
- One 60 ton crane
- One 8 ton crane

Appendix D: Acronyms Glossary

ACB: Amphibious Construction Battalion. Military Unit of the Navy whose mission is to support amphibious assaults and landings in the areas of pontoon causeway operations, fuel delivery system installation and beach salvage and construction support.

ACVLP: Air Cushioned Vehicle Landing Platform. Floating platform designed to allow hovercraft to fly on and fly off to facilitate the movement of containers and equipment from anchored ships to the shore. It is designed to be attached to RORO platform.

AFOE: Assault Follow-On Echelon. The second wave of an Amphibious Assault designed to sustain extended operations.

AOIC: Assistant Officer-In-Charge. Second in command of a team or particular phase of an operation. Usually a Senior Enlisted person, Chief or Senior Chief Petty Officer (E7-E8).

BOMAG: Brand-name of an experimental piledriver used by NCEL.

CAF: Frame used to support boats and other equipment when secured on a deck of a Seabee Barge Carrier when the design of bottom of the equipment does not readily match the supporting rails on the Seabee.

CANTELCAS: Initially the name for the proposed modular ELCAS system which is designed to be built from the shore outward in a cantilevered fashion.

CESO: Civil Engineering Support Office in Port Hueneme, CA. Organization tasked with inventory maintenance and replenishment includes all the pontoon causeway system components and the ELCAS system.

CNBG: Commander, Naval Beach Group. Next superior in the Naval Chain of Command to the ACB.

COTS: Container Off-load and Transfer System. General Term for the Department of Defense systems designed to transfer containerized cargo over the shore.

CPM: Critical Path Method. Refers to a planning system for scheduling operations. Primarily used in planning construction projects. The system involves breaking the operation down into a series of activities and scheduling them taking into account dependencies between the activities and other constraints.

CSP: Powered causeway section.

C/W: Abbreviation for pontoon causeway.

DE-30: DE-30 Pile Hammer. Diesel driven pile hammer used to drive the supporting pile for ELCAS.

DOD: Department of Defense.

ELCAS: Elevated Causeway or Elevated Causeway System. Temporary pier facility used primarily to transfer containerized cargo over the shore. Refers to the existing system which has been in service since the 1970's.

ELCAS (M): Modular ELCAS. System planned to replace the existing NL pontoon ELCAS system. This system is intended to be built from the shore outward in a cantilevered arrangement. Utilizes modular components that are built to standard cargo container dimensions.

FLEXIFLOAT: Robishaw Engineering's standard pontoon system using in a variety of marine construction applications. The units are designed to be readily transportable by truck but do not have standard container dimensions.

ISO: International Standards Organization. Refers to the specifications for qualification as a standard container used for transport on containerships. ISO containers have special corner fittings to facilitate movement by port facilities (cranes, trucks and rail).

ISOLOG: Robishaw Engineering's modular pontoon system. Designed to be readily transportable by standard container carriers.

JLOTS: Joint Logistics Over-The-Shore. Refers to operations involving the movement of supplies and equipment from water based carriers to land, conducted by two or more of the armed services (generally Army, Navy and USMC).

LACV-30: Army hovercraft used in amphibious operations to transport cargo and equipment.

LARC 60 or LARC LX: Large Army amphibious vehicle used to carry other vehicles and cargo over both water and land.

LASH Ship: Lighter Aboard Ship. Commercial barge carrier which uses an amidships gantry crane to lift barges and transfer them in and out of the water and to place them into a large interior holding area.

LCU: Landing Craft Utility. Large (110 to 200 foot) landing craft used to transport cargo and equipment from ship to shore. Designed to be beached.

LMMSA: Lightweight Modular Multi-purpose Spanning Assembly. Modular aluminum bridge designed for rapid assembly and cantilevered deployment to replace damaged sections of ELCAS and to serve as a ramp between ELCAS and a floating RORO platform.

LPO: Leading Petty Officer. Next in command after the AOIC, usually a First Class Petty Officer (E-6).

LSD: Amphibious Transport Dock. Naval amphibious ship characterized by a large "well deck" which can be flooded to facilitate the loading of landing craft.

LST· Landing Ship Tank. Naval amphibious ship characterized by its ability to be beached and transfer equipment via a "bow ramp". Also used to transport pontoon causeway sections which are loaded onto its sides.

NAVFAC: Naval Facilities Engineering Command.

NAVSEA: Naval Sea Systems Command.

NCEL: Navy Civil Engineering Laboratory, Port Hueneme, CA.

NL Causeway: Navy Lighterage type causeway. Type of causeway currently used by the Navy. A standard section is made up of 45 pontoons in a 3 wide by 15 long arrangement.

OIC: Officer-In-Charge. Officer placed in command of a team of military personnel for a particular operation.

OSDOC: Over-The-Shore Discharge Of Cargo.

PQS: Personal Qualification Standards. A training system used by the Navy.

RORO: Roll On/Roll Off platform. Floating 3 causeways wide by 2 causeway long platform designed to be attached to a moored cargo ship to facilitate the driving off of equipment onto the platform for further transportation ashore via causeway ferries.

RTCH: Rough Terrain Container Handler Large forklift designed to move containers in a rough terrain environment (e.g. low traction conditions on a beach).

SBC: Seabee Barge Carrier or Seabee Ship. Commercial barge carrier which uses a stern elevator and a rail mounted lift and transfer system to load and position the barges.

TACS Crane Ship: Specialized ship designed to provide crane services to other ships and to lighterage to move containers and equipment when moored.

USMC: United States Marine Corps.

Appendix E: CPM Development

Two diagrams and a description of terms and abbreviations are provided to make the CPM development and activity list easier to understand. Figure E-1 shows the loading sequence for the SBC and numbers the ELCAS causeway sections. Figure E-2 shows the numbering sequence for the causeway sections when they are inserted in the ELCAS pier.

The CPM presented here makes several assumptions. Because of the way the upper and lower decks of the SBC are loaded, the middle deck must be off-loaded first to provide storage space for CAF's. ELCAS sections 1, 2, 7, 8, 9, 10, 11 and 12 are pre-loaded with 4 pile each (before loading on the SBC) to facilitate pile stabbing operations when the pier is inserted to the beach. Three pile would be stacked and chained down at one side of the causeway and one would be secured to the deck on the other side (this maximizes pile storage on the causeway deck and still leaves just enough room for the cranes to drive down the section). The cranes used to plan this CPM include one 8 ton cherry-picker, two 30 ton hydraulic cranes, one 60 ton hydraulic crane, one 65 ton hydraulic crane and a 140 ton lattice-boom crane.

Thirty minute breaks are included in the CPM at the noted locations to account for the non-productive time during the changing of shifts. Times in the activity list are given in hours.

Description of Terms and Abbreviations

"Assem."= Assemble or connect.

"BF"= Barge ferry (to push with one or more SLWT's).

"BR"= Beach ramps.

"C/W"= Causeway section.

"C/W (fender)"= C/W loaded with the three-section fenderstring.

"C/W(turntable)"= C/W loaded with the ELCAS turntable.

"C/W(140)"= C/W loaded with the 140 ton crane.

"EF"= Early Finish, i. e. the earliest an activity may finish with the given durations.

"ELCS 5"= ELCAS section number 5.

"ES"= Early start.

"F:"= The activity will start after the finish of the activity listed after the colon.

Lightoff= Required maintenance procedure to start an SLWT after a period of storage.

No.= Arbitrarily assigned activity number.

"S:"= The activity will start after the start of the activity listed after the colon.

"SBB"= Seabee barge.

"SBB (jacks)"= SBB carrying the ELCAS jacking system, lighting system and misc. gear.

"SBB (pile)"= SBB carrying pile, the 140 ton boom and counterweights.

"SBC"= Seabee Barge Carrier

"Spuds."= Abbreviation for external spudwell.

"w/"=With or containing.

"+0.3"= This means a delay of 0.3 hours will occur after either the start or finish of the activity which is the dependency donor.

"*"= Critical Path activity.

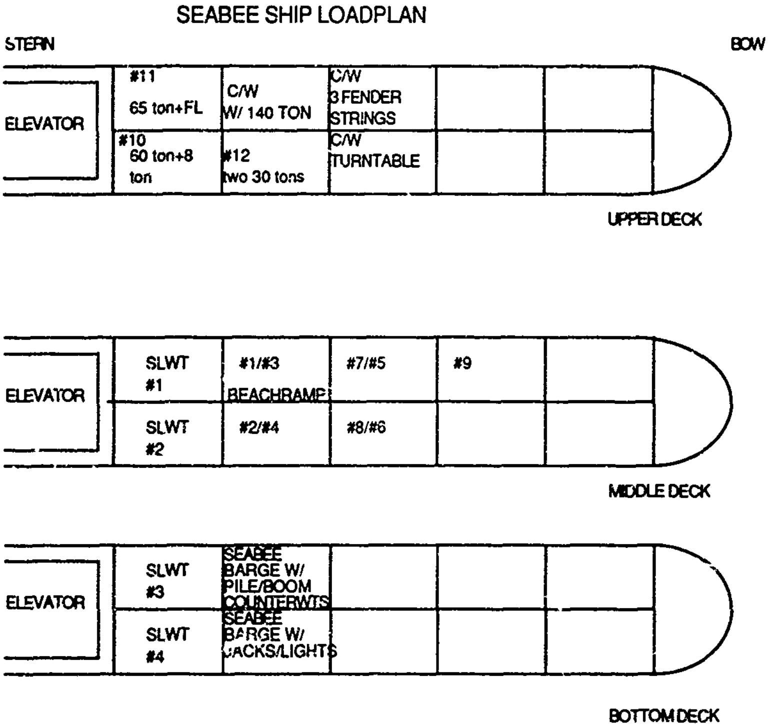


FIGURE E-1: Diagram of the SBC loadplan.

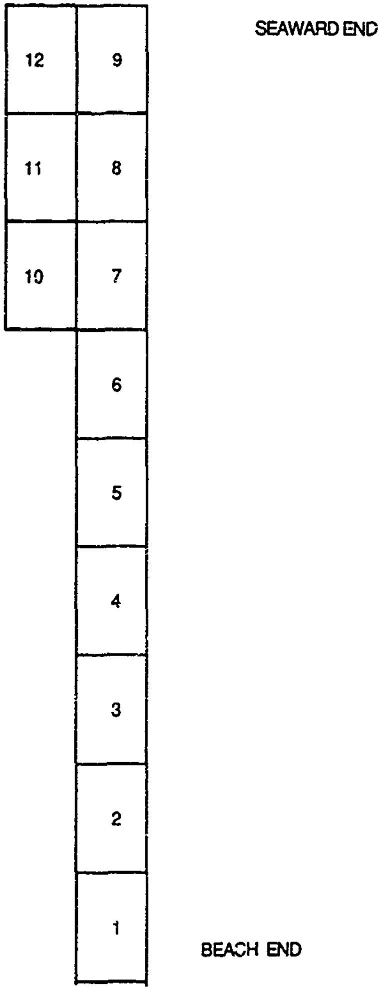


FIGURE E-2: Diagram of an ELCAS pier

ACTIVITY LIST (Table E-1)

Middle Deck

No.	Description	Dependency	Duration
*100	SLWT 1&2 ungriped	Start	0.5
105	ELCS 1/3 & 2/4 ungriped	F:100	0.5
*110	SLWT 1&2 to elevator	F:100	0.4
*115	SLWT 1&2 down elevator	F:110	0.7
120	ELCS 1&2 lifted	F:105	0.3
*125	SLWT 1&2 light-off	F:115	1.0
*130	ELCS 3&4 to elevator	F:120/125	0.5
*131	ELCS 3&4 down elevator	F:130	0.7
*133	Assem. ELCS 3 to 4	F:125/131	0.5
*135	ELCS 1&2 to elevator	F:133	0.5
*136	ELCS 1&2 down elevator	F:135	0.7
*138	Assem. ELCS 1 to 2	F:136	0.5
140	Assem. ELCS 1/2 to 3/4	F:138	0.5
145	ELCS 7/5&8/6 ungriped	F:105	0.5
147	Lift ELCS 7 and 8	F:145	0.3
*149	ELCS 5&6 to elevator	F:138/147	0.6
*150	ELCS 5&6 down elevator	F:149	0.7
*160	Assem. ELCS 5 to 6	F:140/150	0.5
170	Assem. ELCS 5&6 to 1-4	F:160	0.5
175	SLWT 1&2 BF ELCS 1-6 ashore and insert	F:170	1.0
Lower Deck			
180	Ungripe SLWT 3&4	F:145	0.5
182	Ungripe SBB's	F:180	0.5
*183	SLWT 3&4 to elevator	F:160/180	0.4
*184	SLWT 3&4 down elevator	F:183	0.7
185	ELCS 1-6 secured w/dozers	F:175	0.5
*186	SLWT 3&4 light-off	F:184	1.0
*188	ELCS 7&8 to elevator	F:186	0.6

*190	ELCS 7&8 down elevator	F:188	0.7
*191	Assem. ELCS 7 to 8	F:190	0.5
192	BF ELCS 7-8/assem. to 1-6	F:185/191	1.0
194	Ungripe ELCS 9	F:182	0.5
*196	ELCS 9 to elevator	F:191/194	0.7
*197	ELCS 9 down elevator	F:196	0.7
200	ELCS 9 BF&assem. to 1-8	F:192/197+0.8	1.0
<u>Upper Deck</u>			
210	Ungripe ELCS 10&11	F:194	0.5
*215	ELCS 10&11 to elevator	F:197+0.3/210	0.4
*220	ELCS 10&11 down elevator	F:215	0.7
*225	Assem. ELCS 10 to 11	F:220	0.8
230	Ungripe ELCS 12&C/W(140)	F:210	0.5
*232	ELCS 12&C/W(140) to elev.	F:225/230	0.5
*235	ELCS 12&C/W(140) dwn ele.	F:232	0.7
*240	Assem. ELCS 12 to 10-11	F.225/235	0.8
*245	BF ELCS 10-12 to 1-9 assem. end connected	F:200/240	1.3
246	C/W(140) to beach/off-load 140 ton to staging area	F:240	3.0
250	Disassem. ELCS 10-12 from 1-9, assem. side-connected	F:245+0.5	1.5
*254	60 ton set beach ramps	F:245+0.8	1.8
260	65 ton stab 4 pile on ELCS 8	F:245+0.5	1.5
265	8 ton set 4 spuds.ELCS 2	F:245+0.5	1.8
266	30 ton set 4 spuds ELCS 6	F:245+0.5	1.8
*267	Rearrange cranes	F:254/260/265/266	0.5
268	65 ton stab 4 pile ELCS 12 65 ton drive 2 pile ELCS 12 (including DE-30 preparation)	F.250/260+0.3	2.8
270	8 ton set spuds. ELCS 1&3	F:267	3.2
*271	30 ton stab 4 pile ELCS 6	F:267	1.5
272	30 ton set 8 spuds ELCS4&5	F:267	3.2

273	Install roadway mat/beach improvements (end activity)	F:267	30.0
274	30 ton stab 4 pile ELCS 3	F:271/S:270+1.8	1.5
*275	60 ton off-load 8 pile from SBB(pile)	F:271/285	2.0
276	30 ton stab 4 pile ELCS 2	F:274+0.2	1.5
277	30 ton stab 8 pile ELCS 4/5	F:272/275	3.0
278	65 ton stab 4 pile ELCS 11	F:268+0.5	1.5
279	30 ton stab 4 pile ELCS 1	F:270/276+0.2 & S:288+2.0	1.5
280	Ungripe C/W(fender) & C/W(turntable)	F:230	0.5
283	SBB's to/down elevator	F:240/S:246	1.3
285	SBB(pile) to ELCS 6	F:283	0.8
287	SBB(jacks) to beach	F:283	0.8
*288	60 ton off-load pile. boom, counterwts. from SBB(pile)	F:275	10.0
289	SBB(jacks) to ELCS 4	F:279/287	1.0
290	65 ton stab 4 pile ELCS 10	F:278+0.3	1.5
*291	65 ton stab 4 pile ELCS 9	F:290+0.3 & S:288+4.0	1.5
292	30 ton off-load jack & lighting gear from SBB	F:277+0.3/289	15.0
*293	65 ton stab 4 pile ELCS 7 (includes shift break)	F:291+1.0 & S:288+6.0	1.5
294	SBB(pile) to SBC (end activity)	F:288	2.0
*295	65 ton stab 4 pile ELCS 11 (note: ELCS 11 has 8 internal spuds)	F:293+0.3 & S:288+8.0	1.5
296	SBB (jacks) to SBC (end activ.)	F:292	2.0
*297	65 ton drive 10 pile at ELCS 11&12 (includes shift break)	F:295+0.5	7.0

298	Install lighting system (end activity)	S:292+5.0	30.0
299	60 ton drive 4 pile ELCS 7	F:288+1.0	3.5
300	60 ton drive 4 pile ELCS 9 (includes shift break)	F:299+0.5	3.5
*301	65 ton drive 4 pile ELCS 10	F:297+0.5	3.0
302	60 ton drive 4 pile ELCS 8	F:300+0.5	3.0
*303	Set up jacks for 10-12	F:292/301	5.0
304	60 ton drive ELCS 6/5/4 12 pile(includes shift break)	F:302+0.5	9.0
305	30 ton drive ELCS 3/2/1 (includes shift break)	F:279/301+1.0	9.0
*307	Jack 10-12 to grade, lower and pin (includes shift break)	F:303	8.0
*308	Transfer jacks to roadway	F:307	6.0
*309	Jack 1-9 to first lift & pin (includes shift break)	F:304/305/308	10.0
*310	Transfer jacks (includes shift break)	F:309	6.0
*311	Jack 1-9 to grade and pin (includes shift break)	F:310	10.0
312	Assem. boom-140 ton	F.246/288	4.0
*313	Side-connect 10-12 to 7-9	F:311	3.0
314	C/W(fender) & (turntable) to/down elevator	F:280	1.2
315	Attach safety rigging (end activity)	F:311	4.0
316	C/W(fender) to beach Remove fenderstring from C/W, Redeploy&Assem. fenderstring	F:314	5.0
317	Set 6 spuds. on ELCS 10-12	F:311	2.5
318	C/W (turntable) to beach	F:314	1.1
*320	Install fenderstring	F:313/316/317	3.0

*322	Drive & pin fender pile (includes shift break)	F:320	6.0
*324	140 ton drive to pierhead	F:312/322	2.0
*325	Redeploy, lift & position turntable.	F:318/324	3.0
*330	Turntable made operational (**end** activity)	F.325	2.5

ELCAS CPM: Plate 1

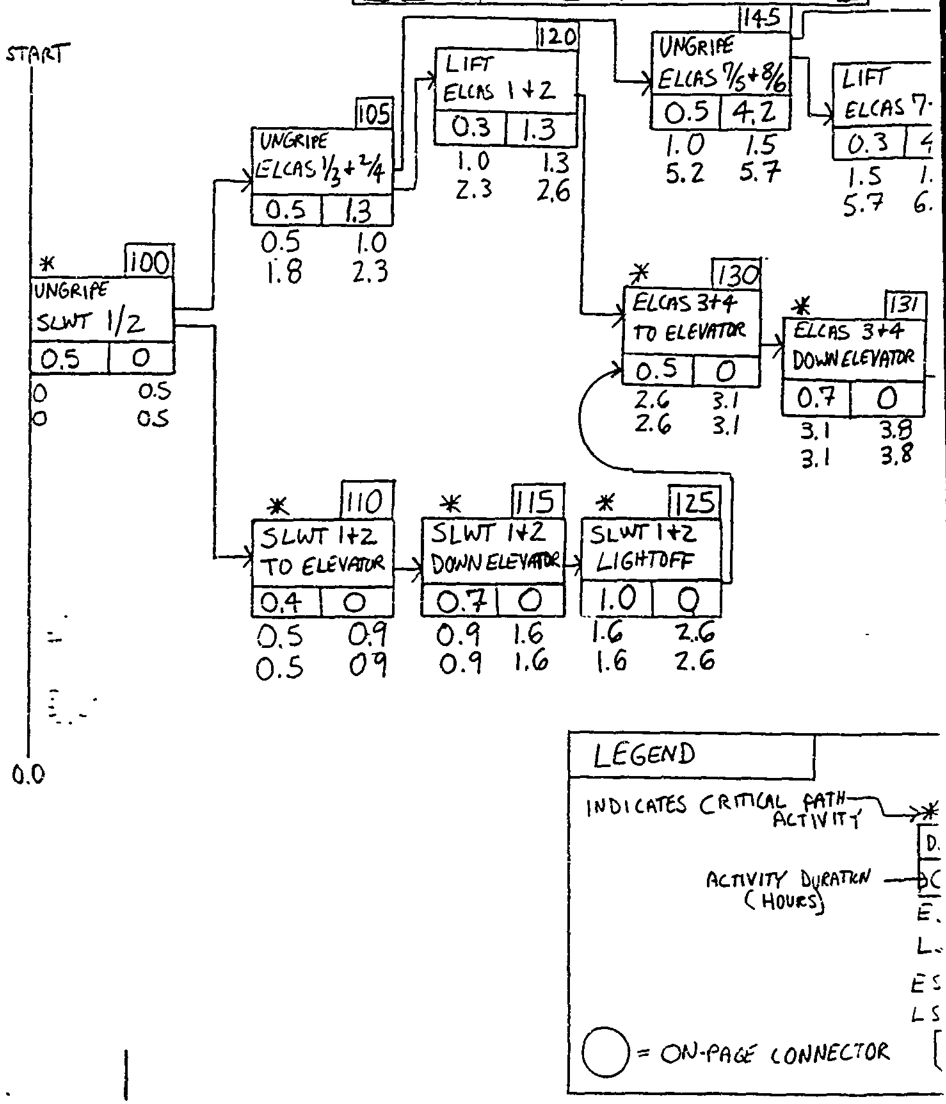
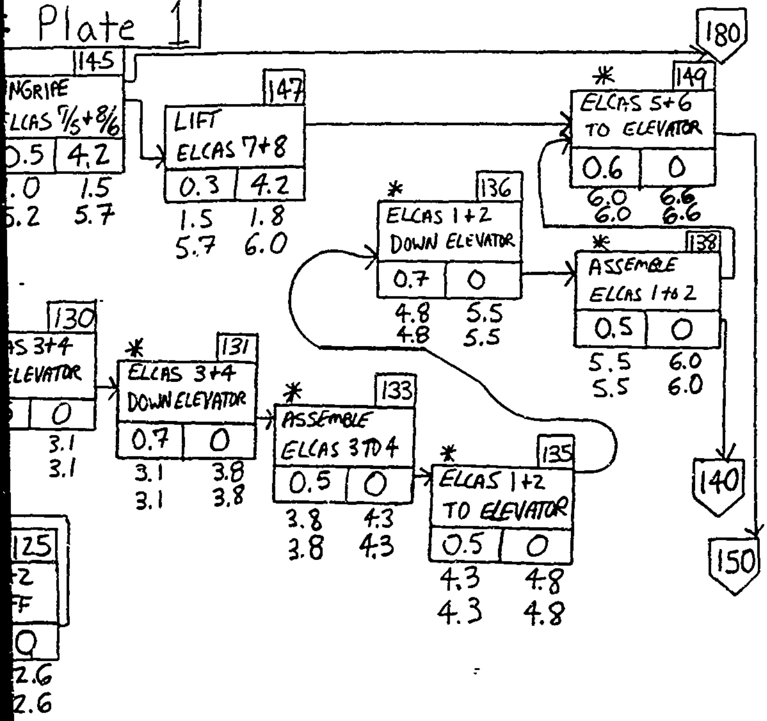
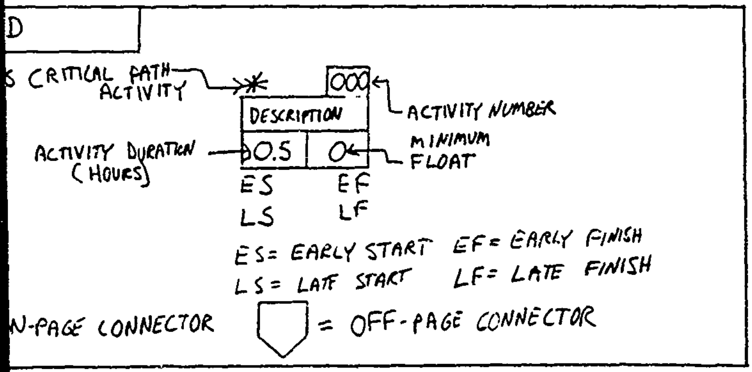


Plate 1

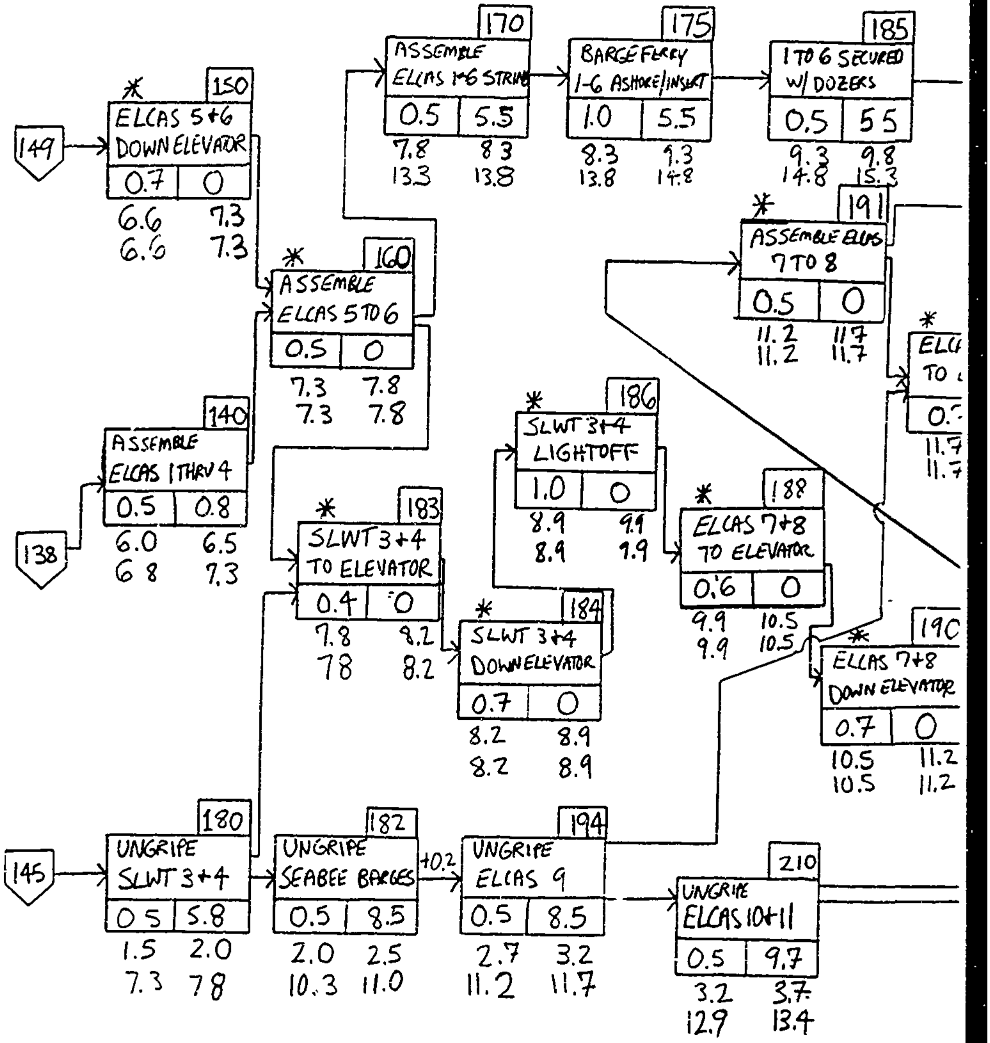


145
NGRIPE
LCAS 7/5+8/6
0.5
4.2
.0
1.5
5.2
5.7
147
LIFT
ELCAS 7+8
0.3
4.2
1.5
1.8
5.7
6.0
180
*
149
ELCAS 5+6
TO ELEVATOR
0.6
0
6.0
6.6
6.0
6.6
*
136
ELCAS 1+2
DOWN ELEVATOR
0.7
0
4.8
5.5
4.8
5.5
*
138
ASSEMBLE
ELCAS 1 to 2
0.5
0
5.5
6.0
5.5
6.0
130
AS 3+4
ELEVATOR
0
3.1
3.1
*
131
ELCAS 3+4
DOWN ELEVATOR
0.7
0
3.1
3.8
3.1
3.8
*
133
ASSEMBLE
ELCAS 3 TO 4
0.5
0
3.8
4.3
3.8
4.3
*
135
ELCAS 1+2
TO ELEVATOR
0.5
0
4.3
4.8
4.3
4.8
140
150
125
+2
FF
0
2.6
2.6

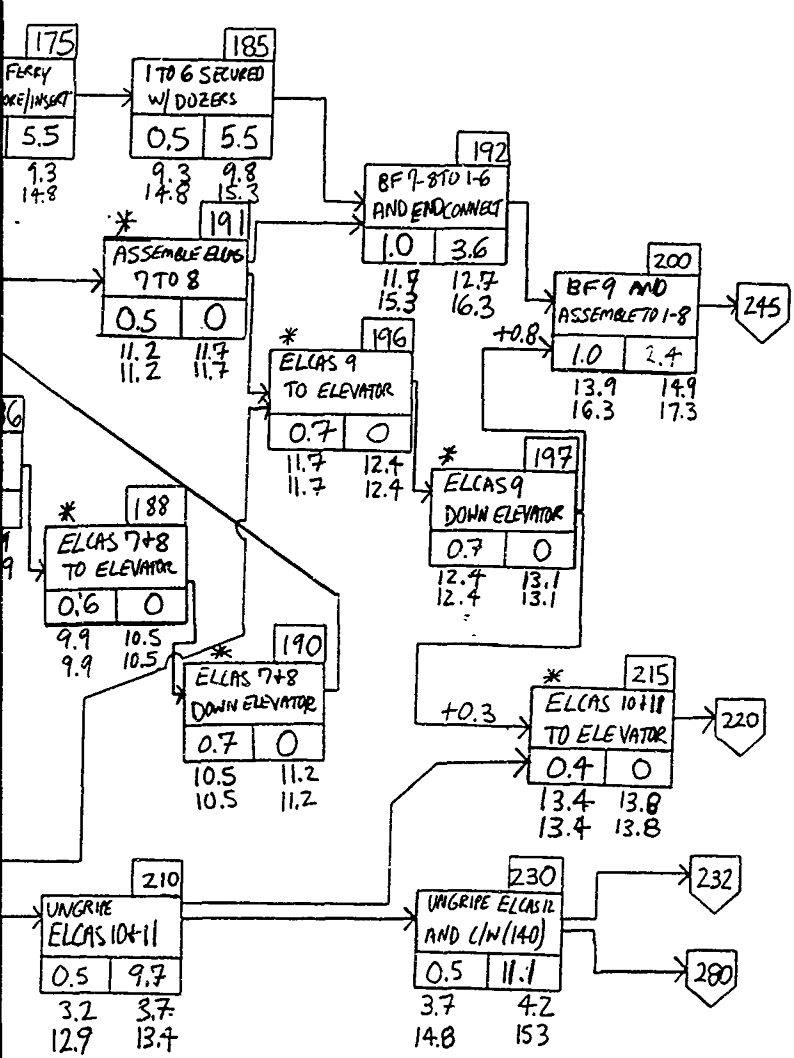


D
S CRITICAL PATH ACTIVITY
*
000
ACTIVITY NUMBER
DESCRIPTION
ACTIVITY DURATION (HOURS)
0.5
0
MINIMUM FLOAT
ES
EF
LS
LF
ES= EARLY START
EF= EARLY FINISH
LS= LATE START
LF= LATE FINISH
N-PAGE CONNECTOR
= OFF-PAGE CONNECTOR

ELCAS CPM: Plate 2



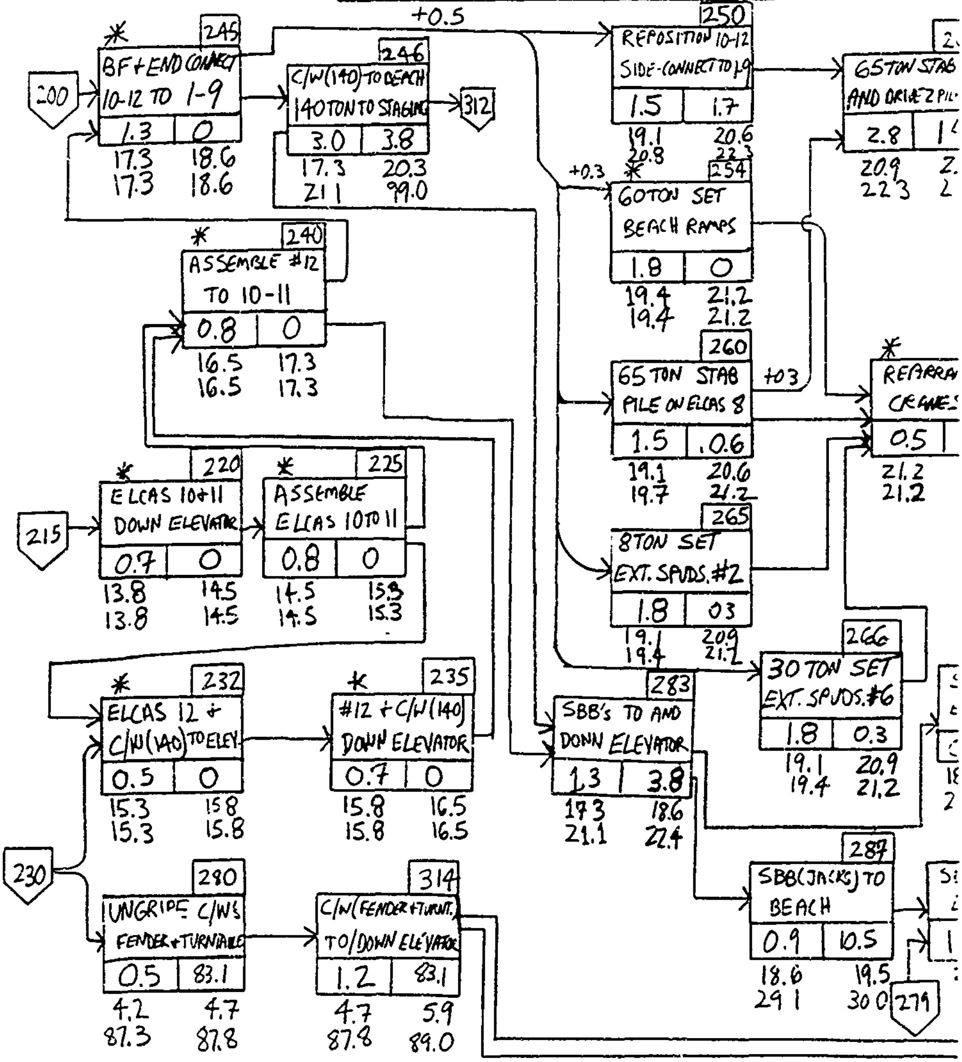
PM: Plate 2



175
FERRY
ORE/INSERT
5.5
9.3
14.8
185
1 TO 6 SECURED W/ DOZERS
0.5
5.5
9.3
14.8
9.8
15.3
192
BF 7-8 TO 1-6 AND END CONNECT
1.0
3.6
11.7
15.3
12.7
16.3
*
191
ASSEMBLE ELCAS 7 TO 8
0.5
0
11.2
11.2
11.7
11.7
200
BF 9 AND ASSEMBLE TO 1-8
1.0
2.4
13.9
16.3
14.9
17.3
+0.8
245
*
196
ELCAS 9 TO ELEVATOR
0.7
0
11.7
11.7
12.4
12.4
*
197
ELCAS 9 DOWN ELEVATOR
0.7
0
12.4
12.4
13.1
13.1
*
188
ELCAS 7+8 TO ELEVATOR
0.6
0
9.9
9.9
10.5
10.5
*
190
ELCAS 7+8 DOWN ELEVATOR
0.7
0
10.5
10.5
11.2
11.2
*
215
ELCAS 10+11 TO ELEVATOR
0.4
0
13.4
13.4
13.8
13.8
+0.3
220
210
UNGRIPE ELCAS 10+11
0.5
9.7
3.2
12.9
3.7
13.4
230
UNGRIPE ELCAS 12 AND C/W (140)
0.5
11.1
3.7
14.8
4.2
15.3
232
280

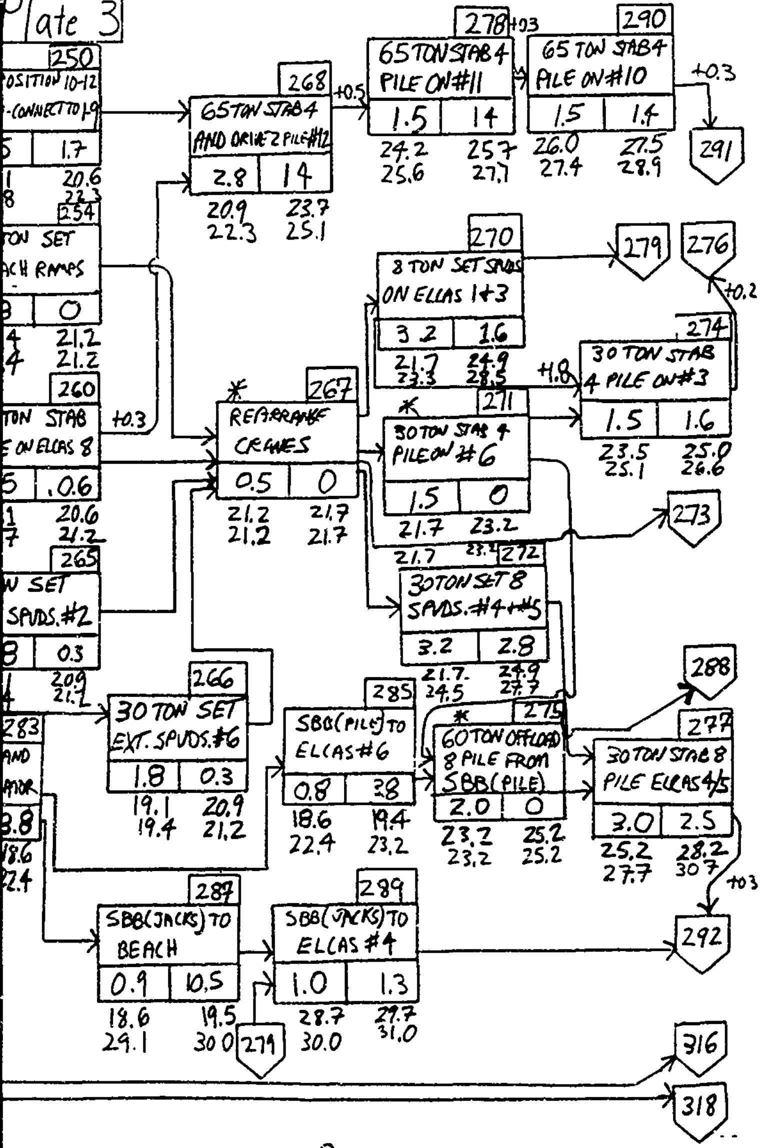
2

ELCAS CPM: Plate 3



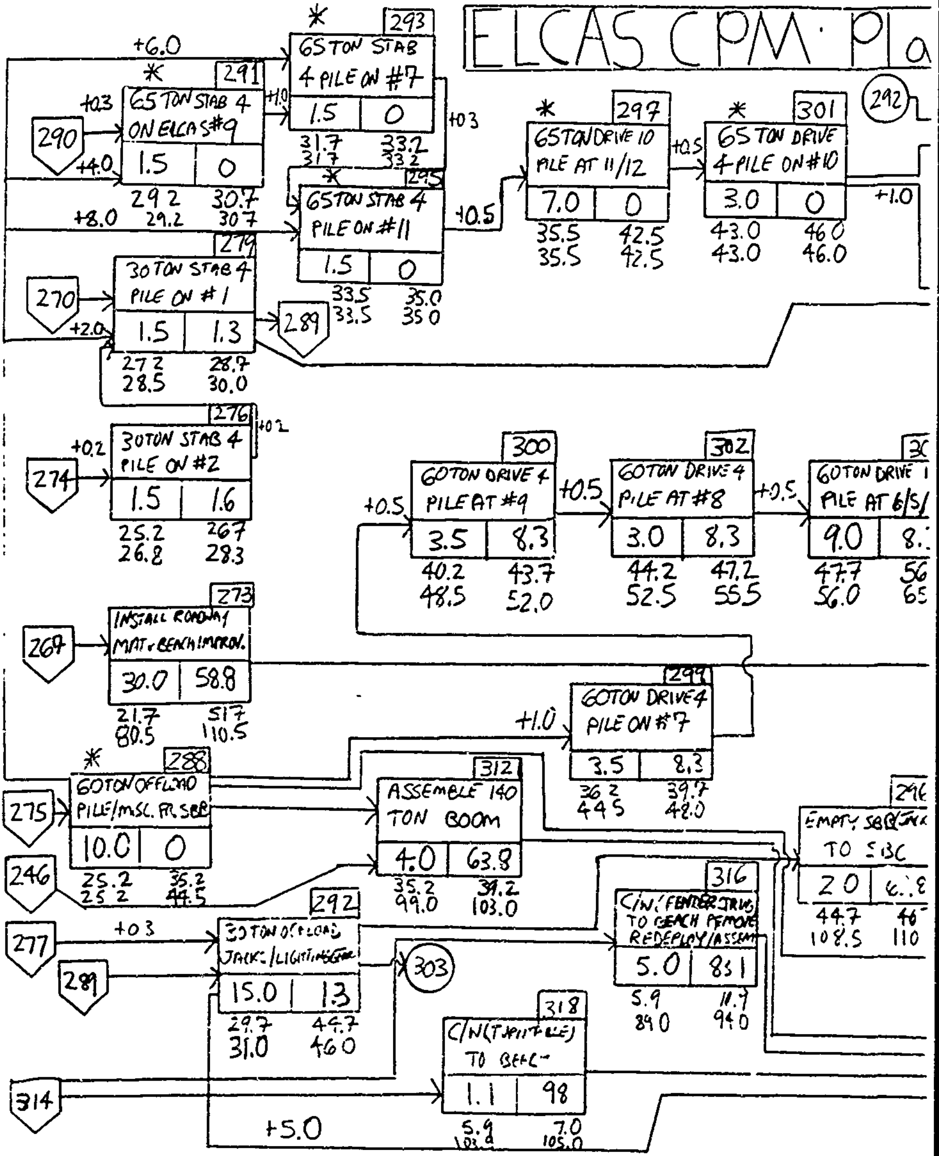
IVUL

Plate 3

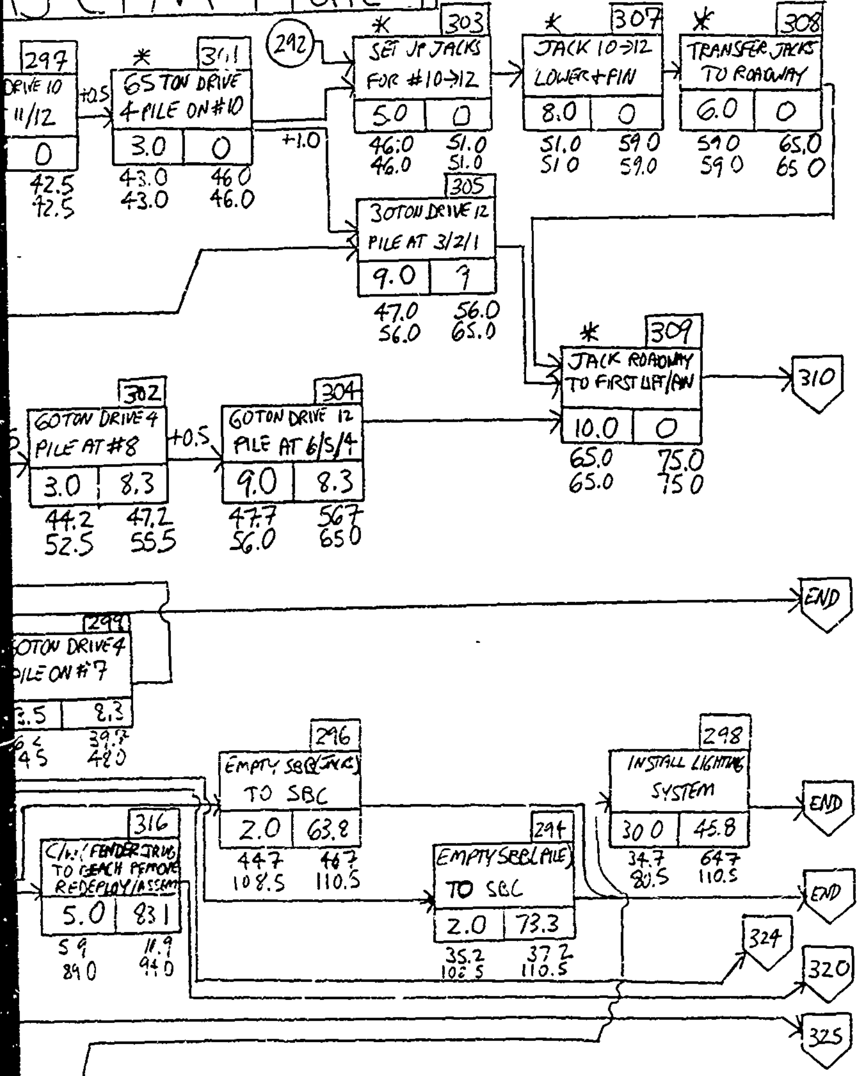


250
POSITION 10-12
-CONNECT TO 9
1.7
20.6
22.3
254
TON SET
BEACH RAMPS
0
21.2
21.2
260
TON STAB
E ON ELCAS 8
.06
20.6
21.2
+0.3
265
N SET
SPUDS #2
0.3
20.9
21.2
283
AND
ATOR
3.8
18.6
22.4
268
65 TON STAB 4
AND DRIVE 2 PILE #12
2.8
14
20.9
22.3
23.7
25.1
+0.5
278
+0.3
65 TON STAB 4
PILE ON #11
1.5
14
24.2
25.6
25.7
27.1
290
65 TON STAB 4
PILE ON #10
1.5
1.4
26.0
27.4
27.5
28.9
+0.3
291
270
8 TON SET SPUDS
ON ELCAS 1+3
3.2
1.6
21.7
23.3
24.9
28.5
279
276
+0.2
274
30 TON STAB
4 PILE ON #3
1.5
1.6
23.5
25.1
25.0
26.6
+1.8
267
REARRANGE
CRANES
0.5
0
21.2
21.2
21.7
21.7
271
30 TON STAB 4
PILE ON #6
1.5
0
21.7
23.2
273
21.7
23.2
272
30 TON SET 8
SPUDS #4+#5
3.2
2.8
21.7
24.5
24.9
27.7
288
266
30 TON SET
EXT. SPUDS #6
1.8
0.3
19.1
19.4
20.9
21.2
285
SBB (PILE) TO
ELCAS #6
0.8
3.8
18.6
22.4
19.4
23.2
275
60 TON OFFLOAD
8 PILE FROM
SBB (PILE)
2.0
0
23.2
23.2
25.2
25.2
277
30 TON STAB 8
PILE ELCAS 4/5
3.0
2.5
25.2
27.7
28.2
30.7
+0.3
287
SBB (JACKS) TO
BEACH
0.9
10.5
18.6
29.1
19.5
30.0
289
SBB (JACKS) TO
ELCAS #4
1.0
1.3
28.7
30.0
29.7
31.0
279
292
316
318

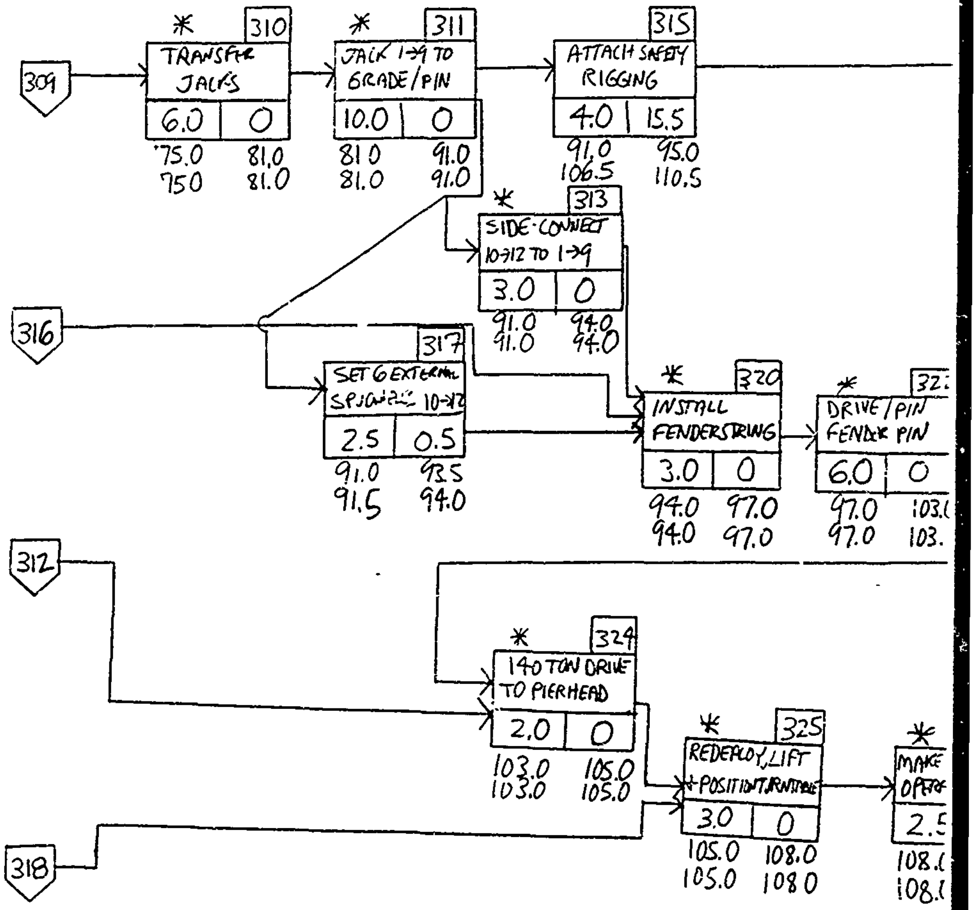
ELCAS CPM · Pla



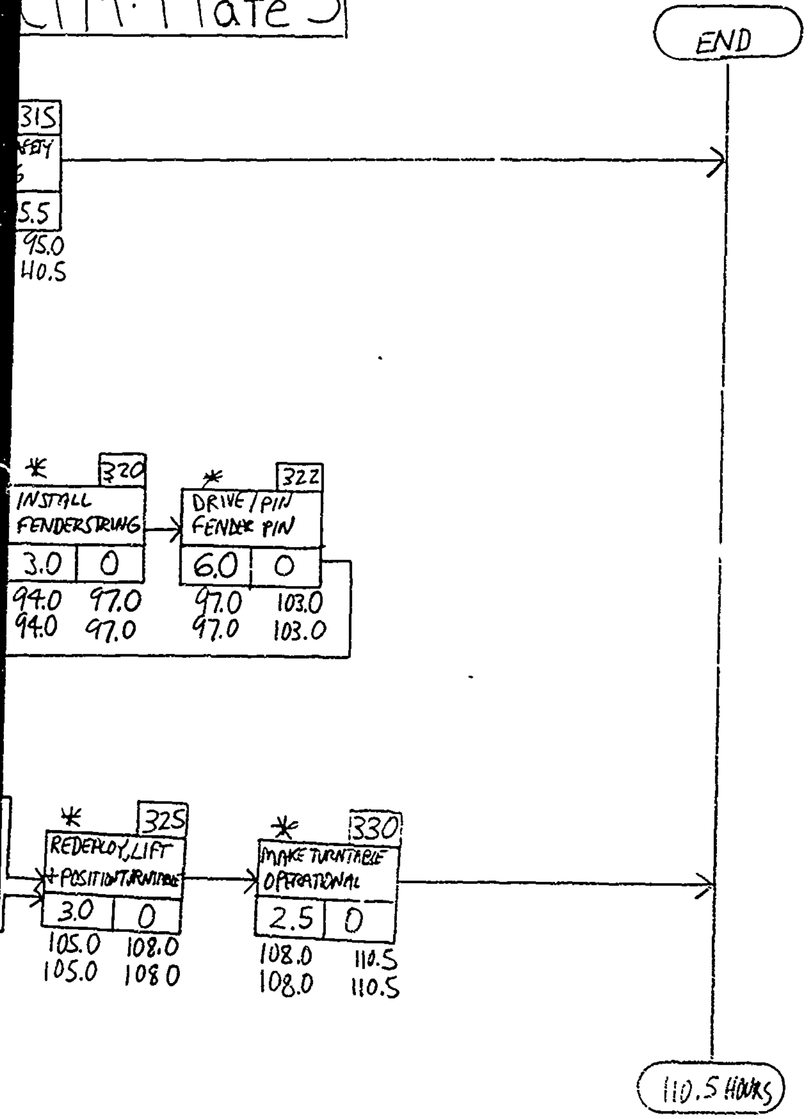
AS CPM · Plate 4



ELCAS CPM: Plate



CPM: Plate 5


END
315
FETY
5.5
95.0
110.5
*
320
INSTALL FENDERSTRING
3.0
0
94.0
97.0
94.0
97.0
*
322
DRIVE/PIN FENDER PIN
6.0
0
97.0
103.0
97.0
103.0
*
325
REDEPLOY, LIFT + POSITION TURNTABLE
3.0
0
105.0
108.0
105.0
108.0
*
330
MAKE TURNTABLE OPERATIONAL
2.5
0
108.0
110.5
108.0
110.5
110.5 HOURS

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