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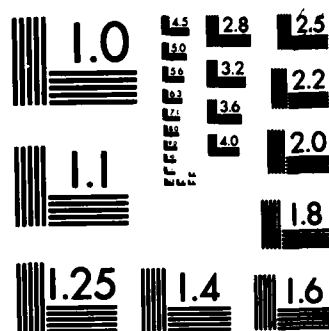
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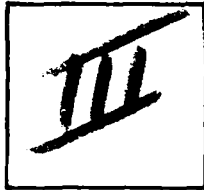


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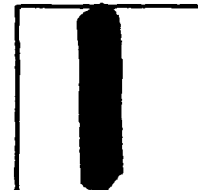
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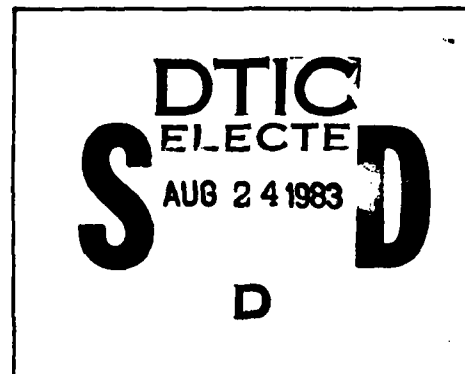
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THE JOINT LOGISTICS-OVER-THE-SHORE (LOTS) TEST REPORT

VOLUME II - ANALYSIS OF TEST RESULTS

5 JANUARY 1979

PREPARED UNDER
CONTRACT NUMBER MDA-903-75-C-0016
FOR THE OFFICE OF THE SECRETARY OF DEFENSE
OFFICE OF THE UNDER SECRETARY OF
DEFENSE RESEARCH AND ENGINEERING
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WASHINGTON, D.C. 20301

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This is the final report on the Joint Logistics-Over-the-Shore (LOTS) main test, consisting of an Executive Summary, Volume I - Conduct of the Test, and Volume II - Analysis of Test Results. A classified report based upon the test results was published separately (ORI, Inc. TR No. 1468) dealing with LOTS requirements to support a non-mobilization contingency situation. Additional reports were published on an automated data base and a LOTS simulation model. The main test was preceded by a one-year pretest phase dealing with deployment of LOTS equipment on a conventional breakbulk ship, a LASH, a SEABEE, and a		

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LARC-LX	LOTS	RO/RO
LASH	Marshaling Yard	SEABEE
LCU	Merchant Ships	Sealift Readiness Program
Lighterage	MHE	Ship Off-loading
Loading	Mobilization	Ship-to-Shore
Logistics	OSDOC	TCDF
	Over-the-Shore	Temporary Container Discharge Facility
	Roll-on/Roll-off	

Terminal Operations
Test and Evaluation
Throughput
Transportation

(20. continued)

heavy-lift breakbulk ship for which reports were also published.

The Joint Logistics-Over-the-Shore (LOTS) test was conducted in the Norfolk-Ft. Story, Va., area during the period 8 July to 21 August 1977. The test was conducted under the sponsorship of the Director, Defense Test and Evaluation, Office of the Under Secretary of Defense for Research and Engineering, with the Army as Executive Agent and the CG of the U.S. Army Transportation School at Ft. Eustis, Va., as the Joint Test Director. The Army, Navy, and Marine Corps each provided a Deputy Director and participating test units, data collectors, and evaluation personnel for selected system elements.

The overall objective of the test was to verify the Services' capabilities for conducting LOTS sustained throughput operations. Specific test objectives for the OUSDR&E test sponsor related to equipment performance, operational techniques, and planning factors.

The primary findings were that in a LOTS environment the Services do not yet have a capability of providing bulk POL support from large tankers off-shore to a corps size force or deploying a non-self-sustaining containership discharge system in a contingency situation. However, for container operations the Services can now acquire the equipments needed to support such contingencies. After equipment shortfalls are made up, LOTS type operations still involve a high degree of uncertainty in continuity of operations. Nevertheless, they remain an essential means of providing logistic support to a contingency force. The Services must provide required redundancy to safeguard against environmental and military threats.

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I. INTRODUCTION

GENERAL

This report is based upon the observations of test planners and participants and reflects detailed analysis of computerized and manual data reductions, simulation and modeling of test results, and the inputs and reports of Service evaluators. This report supersedes an earlier preliminary report¹ which was based upon the initial findings and observations of the six weeks of LOTS operational test activity. The preliminary report was a limited data analysis because of the necessity for quick report turnaround in order to capture the views and comments of key Service personnel. Subsequently, the initial findings and analyses were largely sustained and reinforced by a detailed in-depth review of the data on hand and new data received. The initial analyses have been expanded and a number of additional findings, conclusions, and recommendations have been developed in this report.

The overall objective of the test was to verify Service capabilities for conducting LOTS sustained throughput operations. Specific test subobjectives for the Office of the Secretary of Defense test sponsor (then Office of the Director, Defense Research and Engineering) were selected which related to equipment performance, operational techniques, and planning factors. Accordingly, the analyses in this report are directed primarily toward the areas of major interest to the Office of the Secretary of Defense and the Military Services. A subsequent report² contains additional analyses of a classified nature of primary interest to contingency planners.

The analysis, conclusions, and recommendations in this report are not intended to be all-inclusive regarding events and equipment in the LOTS

¹ ORI, Inc., Comment Draft Report on Main Test Results of the Joint Logistics-Over-the-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1275, 21 December 1977.

² ORI, Inc., Analysis of LOTS Requirements to Support a Non-Mobilization Contingency Situation (U), TR No. 1468, 5 January 1979.

main test. Because the LOTS main test (which involved handling a large number of containers) provided a rare test opportunity, considerable instrumentation was accomplished by Service laboratory personnel. In addition, experimental equipment was introduced for observation and preliminary evaluation and several items were undergoing operational or developmental evaluations. Where appropriate, reference is made to those separate evaluations.

It should also be noted that there is considerable data available to conduct additional statistical analyses beyond the scope of this report. There were some areas of interest for which insufficient data were collected or data were lost. (This is discussed below in more detail. Corrective actions for some of the areas discussed have already been initiated.)

Subsequent to the test and publication of the preliminary report, additional developmental activity has taken place. Where these cases are known, updated information has been supplied.

SUMMARY OF TEST DESIGN AND RATIONALE

The joint LOTS test was planned for and conducted in the July-August 1977 timeframe in a multi-scenario setting, reflecting likely non-mobilization contingency situations. To provide a realistic framework for test and evaluation, a three-phased approach was adopted with appropriate scenarios for each.

The first phase was intended to represent a "worst case" situation - a quick reaction, non-mobilization contingency involving a bare beach operation in an underdeveloped country. "Worst case" was not related to combat action but implied that severe constraints were placed on deployment and initial operations. This situation was intended to depict LOTS operations conducted over an unimproved beach facing an open sea. Prior to force arrival, the operational site would lack piers, jetties, or like structures that could be used to assist the force in the transfer of personnel, equipment and other cargo from ship-to-shore. Because it was a non-mobilization contingency, shipping for deployment to the site would be limited. LOTS force planners and operators could use only those vessels readily accessible to DoD without requisitioning or call-up of assets in the Sealift Readiness Program (SRP). In other words, shipping was essentially limited to vessels under control of the Military Sealift Command (MSC). Site improvements for this phase were to be limited to the capabilities of the LOTS personnel, tools, and equipment which could be deployed within the time and shipping/aircraft available.

The second phase of the operation was intended to provide an opportunity to use the test site, containership, and equipment assets in support of

the Navy's Container Off-loading and Transfer System (COTS). The COTS program, while still some years away from full operating capability, had certain components that could be available for use in the joint LOTS test. In cargo operations in support of the Marine Corps, the Navy is responsible for the discharge of the ship, lighter transport of cargo from ship to shore, causeway operations, and miscellaneous activities such as salvage operations.

The Marine Corps had defined its containerization requirements and programmed its container system developments to coincide with the Navy's COTS program, also had some modified and experimental equipment to test. The Marine Corps defines its cargo handling responsibilities as starting at the high water mark and continuing inland. Its primary interest in container operations centers on the fact that, with the sharp decrease in breakbulk shipping, considerable amounts of Marine Corps unit equipment and supplies will have to be containerized. In addition, the Marine Corps is opting for dimensional standardization as the cornerstone for restructuring its present logistic support system in a new program called the Field Logistics System.

Thus, the second phase did not represent a total system test so much as a test of selected components of a qualified Navy-Marine Corps capability. Consequently, some facets such as deployment received less participatory emphasis. As a result, the test design for the second phase called only for data collection on facility installation, throughput, and retrograde operations. The scenario for Phase II was built around a situation in which an assault force had been landed and the assault follow-on echelon was being off-loaded. This scenario would end with a transition into the third phase.

In Phase III the Army, Navy, and Marine Corps would all be involved to some degree in a joint LOTS operation. The Navy and Marine Corps were assumed to have been in place and operating an over-the-shore throughput system. The scenario was cast in a full mobilization setting. Ship requisitioning made possible the employment of a SEABEE ship, the only vessel in existence capable of deploying the Army's DeLong barges.

The crane-on-deck (COD) method of ship discharge normally would have been the only means available for Phases I and II because of the barge temporary container discharge facility (barge-TCDF) deployment limitations. However, only one hatch bridging kit was to be constructed for the COD test, although two cranes were needed. It was desirable to exercise both the COD and the TCDF to the maximum extent practicable in order to collect the largest data samples possible. Thus, with only one of each type of ship discharge system available, the test had an administrative artificiality built into it.

The Phase III design was intended to provide the Services a "best case" situation. For the Navy this did not mean any change to the way operations were conducted in Phase II except that the Army would be in charge, would operate the barge-TCDF, and would provide additional lighterage. For the Army, the DeLong pier with a 140-ton crane mounted on it represented the improved beach container handling capability. Thus, possible problems caused by tidal limitations were eliminated.

The test design was drafted, coordinated, and published.³ However, the requirement for use of Green Beach at Ft. Story was considered a problem for the Army. While Green Beach faced the ocean, it also had a rather shallow beach gradient and off-shore sandbars which in the pre-tests the previous year had severely limited the use of a 300-ton lifting capacity truck crane on the beach. Because of this recognized limitation and several other considerations, the Army requested relocation to a more favorable beach area. The alternative was the Red and Blue Beach area, which faced the mouth of Chesapeake Bay on the Lynnhaven inlet side of Ft. Story. After careful consideration the change was approved by the Deputy Director (Test and Evaluation), Office of the Director, Defense Research and Engineering.

Phase I (Repeat), referred to as Phase I(R), was not considered in the test design. Phase I(R), a 24-hour repeat of Phase I, provided opportunity for additional container handling and the application of experience gained from the earlier test phases to bare beach operations.

The August timeframe for the test was considered acceptable because historically it appeared that some adverse weather conditions would be experienced during the test period of sufficient severity to restrict crane and lighter operations. However, the adverse weather conditions that did occur normally were not so prolonged or so severe as to jeopardize the test as a whole. Of particular interest was the effect of sea state three on throughput operations.

³ ORI, Inc., Main Test Design of the Joint Logistics-Over-the-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1132, 20 June 1977.

Instead of having a statistically normal month, a summer-long drought was experienced, broken up finally in Phases II and III by thunderstorm activity with high winds, lightning, and brief downpours. There were short periods when sea state three conditions were approached, and at one time, small craft warnings were posted. Nevertheless, these storms were of short duration.

WEATHER DATA

The Naval Ship Engineering Center (NAVSEC), Norfolk Division, Combatant Craft Engineering Dept. was tasked through the Joint Test Directorate to monitor and report the environmental data during the period 29 July to 20 August 1977. Platform motion data (roll, pitch and heave) and true wind speed and direction were obtained through the use of gyros and accelerometers and other instrumentation installed in a dedicated LCU. The LCU maintained a position near the containership. Wave height and period data were measured by an instrumented wave riding buoy near the containership. Finally, weather and surf observations were made by data collectors.

Unfortunately, there were periods near the end of the test (17-18 August) when malfunctions were experienced in some of the NAVSEC instrumentation. These malfunctions happened to coincide with the most significant storm activity during the test period. The data otherwise available are recorded on tapes with NAVSEC in Norfolk. Not all data have been reduced because of the expense involved and the highly favorable conditions experienced. Finally, it should be noted that the instrumentation was operated only at periodic intervals and, as a result, it is not possible to capture the effects of some special events observed, such as a passing nuclear submarine whose wake disturbed Army barge temporary container discharge facility (barge-TCDF) operations.

TEST OBJECTIVES AND DATA COLLECTING REQUIREMENTS

The concept used in data collection and reduction planning was to support certain planned analyses derived from the ODDR&E stated test objectives. The overall objective of the test was to verify Service capabilities to conduct LOTS sustained throughput operations. Specific subobjectives were then selected which related to equipment performance, operational techniques, and LOTS system and subsystem throughput (planning factors).

Testing Service capability for sustained throughput gave commanders of test units a relatively free hand in the employment of their personnel and equipment. However, operating personnel were required to follow a test schedule using particular techniques or equipment long enough to fulfill the "sustained throughput" goals. Thus, data had to be collected for operations: during day and night; in different weather conditions; and for periods long enough to observe the effects of learning and fatigue, and to assess the impact of equipment servicing and maintenance, repositioning of equipment, and the like.

The second objective, to examine the total LOTS system, meant that the data collected would have to include such matters, for example, as: reporting and analysis of delays, the effects on overall throughput of repositioning of ship off-loading cranes, and removing hatch covers from the bays of the ship. It also meant that the impact of one part of the system on another, particularly in terms of bottlenecks in throughput, would have to be studied. To do so required that certain data be collected.

The subobjective concerned with planning factors was necessary in part because the Services have had little documented experience in handling containers in LOTS circumstances. The LOTS test adds substantially to the record, but allowances must be made for various differences between the test and what may be expected in a real emergency. These allowances would include operations in larger waves, over beaches with nearshore bottoms having a flatter slope (so that landing craft ground out farther from shore), a heavier mix of container weights, and ships with more or fewer containers per hatch.

In addition to these direct test-related data needs, others were anticipated because of the whole LOTS system analysis requirement. For example, to minimize the quantity of containers used in the test and the exercise cargo to stuff them, the ship was loaded to about two-thirds capacity. If during the test it was necessary to remove hatch covers "x" times, how often would it be necessary during the discharge of a full ship of like design —or for a different ship design? Data to answer these types of questions had to be collected during the test to the extent it was available there and then.

The assessment of the whole system generated other special data requirements to the degree they could be obtained. The test had certain unavoidable artificialities for which allowances have to be made. Three examples are given here.

- There were only two LACV-30s available for test. There is a need to estimate how many would be required in a LOTS operation with only LACV-30s available. This established a requirement for LACV-30 tie-up times, transit times, refueling and maintenance times, and deployment requirements.
- The containers returned to the ship in preparation for each successive test phase were full containers, whereas the great majority would normally be empty in an actual retrograde operation. For the retrograde of empty containers, some lighters would or could transport a larger number of containers per trip. Alternatively, use might be made of the return leg of a lighter that had already delivered a load of full containers.

- The use of a partially loaded containership resulted in a throughput penalty to operating personnel by requiring more frequent opening and closing of hatches than would have been the case if a full ship had been used.

DATA COLLECTION RESPONSIBILITIES AND PROCEDURES

The main data collection for the LOTS test was a responsibility of the JTD and accomplished by a group of enlisted personnel selected by the Services. Technical supervision was provided by contractor personnel. The contractor trained the data collectors, scheduled their work, and checked the results for accuracy during and at the end of each shift. The contractor also provided an active summary based on selected parts of the collected data, called "Quick-Look Reports." These normally were available approximately 10-12 hr following each reported shift. Their basic purpose was to help guide the planning and execution of the remainder of the test. They also provided a check on how well the data were being recorded.

Data collectors were furnished with pre-designed forms for the various repetitive operations of the throughput phases. A separate form was provided for each data collecting station. Sometimes more than one data collector was required on a station, as when it was not physically possible for one observer to see the whole operation. This occurred at the shipside cranes, where one person could not readily see into the ship hold and also watch the container being released in the lighter. In general, there was at least one data collecting station at each container-handling facility. An example was the beach crane facility where there were three data-collecting stations. One recorded lighterage operations, a second the crane activities, and a third the transfer of the containers to trucks by a frontloader.

Each data collector completed the form with information on the times that preselected events occurred and what took place. Data collectors recorded in spaces provided such information as container identification numbers, lighter type, and identification and direction of the container movement. They also made notes on delays and their causes, or any unusual happenings.

The written data was supplemented by other data collectors using voice-recording devices. They recorded observations on matters the other collectors were not in a position to see or trained to evaluate such as the conduct of the work, skill levels, and details of rigging.

SUPPLEMENTARY DATA

In addition to the main data collection effort outline above, there were certain special-purpose collections. They include:

- Sample throughput time-studies (made by ORI and used to augment this report),

- Still and motion-picture coverage,
- Wave and weather records,
- Stress studies on the crane-on-deck,
- Container weight tabulations,
- Data on erecting the elevated causeway,
- Data on LACV-30 operations, maintenance, and fuel consumption,
- Container throughput information from unit operational reports,
- Unit deployment data including weight and cube,
- Data on vessel outloading and objective area reassembly of equipment,
- Information provided by documentation control personnel.

BREAKDOWN OF DATA ON REPETITIVE CYCLES INTO COMPONENT PARTS

The test design called for timing specified segments of the repetitive cycles of equipment that transferred containers. This meant that during each operating cycle of a crane or other material handling equipment the time of occurrence of key events within the cycle were recorded. The elapsed time between these events can be found later by subtracting the time of one event from another.

The specifics of the breakdown of the cycles are discussed in some detail in the LOTS main test design.³ The purposes for these data were:

- Data on cycles that have been interrupted are not wholly lost. Data on partial cycles can be helpful in augmenting data from complete cycles.
- The start of breaks or delays can be more definitely measured. A problem analysts face is that it is not always clear when a delay began. With segments of cycles being timed, a boundary is at least placed as to when the delay commenced.

³ Operations Research, Inc., Main Test Design of the Joint Logistics-Over-The Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1132, 20 June 1977.

- Study of segments can permit predictions for circumstances different from those in the test. An example would be a travel time segment for a forklift. A simple prediction for a longer or shorter distance can be made by factoring up or down for the new distance.
- Comparisons of similar segments from different crane operating facilities may help explain differences in throughput.

PRECISION OF TIME DATA

The main data collection effort recorded time of all events to the nearest minute. Each observer was furnished with a digital wrist watch with a Light Emitting Diode type reading. A disadvantage of this was that to see the time, the data collector had to push a button on the side of the watch which distracted from the event taking place. Another limitation was that when the sun struck the watch face, the observer had to shade it to read the time. Although the watches chosen were accurate to within about two min per month, the watches were generally not synchronized within a minute. The data reflects differences between watches that could not be eliminated in the data-smoothing and reconciliation process.

As a result, problems are created when tracing container activity from one transfer point to the next, such as from ship to shore, and to a certain extent, in tracing containers through a single transfer point. For example, a number of calculations resulted in negative times when a comparison of ship off-loading operations was made between lighter arrivals at the ship and the times cranes unlatched the first containers. If these calculations were to be believed, a number of containers could not have been landed in the lighter specified because it had not moored yet. The accuracy of other elapsed times similarly must be viewed with caution when it is known that the calculations are based upon times provided by two different data collectors. Altogether there were about 140 data collectors on the test. Obviously, some watches were synchronized and the times are correct. Determining which ones were valid and which weren't and determining the accuracy by shift and by data collector were generally not possible in evaluation.

It was found that, as a general rule, data collected by an individual data collector could be relied upon as long as the event being analyzed did not involve a chain of calculations including data of other data collectors or if only a single sample was being analyzed. For example, ORI data collectors were tasked to time specific events to the nearest second. The data collectors assigned to the JTD recorded events in minutes. In comparing the data collected by the two groups, it was found that there were significant variances, especially for those events which required only brief periods of time. However, over the course of a 12-hr shift the means of the two samples were

relatively close when large samples were taken, or if the event required more than a few minutes, such as the average time an LCU was moored alongside the ship.

Thus, even using the best efforts of a reliable and alert data collector and analyzing only the data he recorded, it is possible to draw erroneous conclusions if too few samples are used. The number of samples needed for a valid conclusion is partly a function of whether or not a lengthy event is being timed. Two examples can be cited which illustrate this point.

The interval at the jacked-up DeLong pier between when a container is landed and when the latch is pulled unlocking the spreader bar from a container could readily be found by timing a dozen or so repetitions to the nearest second. This was found to be about 12 seconds. To achieve a comparable result (within, say, 10 percent accuracy) using data based upon minutes would require a most significant sample size since the intervals recorded would reflect either zeros or ones.

In the second case, the time an LCU was tied up alongside the ship (for the specific day when the comparison was made) was about 32 min. Over the course of a 12-hr shift the differences in averages were found to be minimal.

Accordingly, the preferred data when analyzing the brief detailed movements of booms, for example, was that data which was recorded to the nearest second if it were available. Where comparisons were to be made and it was known that only one data collector was involved, such crane cycle times for handling heavy versus light containers, the automated data base was used. Another example of use of the automated data base was the comparison of crane cycles during hours of daylight versus darkness. In both cases the sample size was very large and the interval measured was on the order of 5-6 min or greater. Thus, data base applications could be made.

In addition to the usual problems of times not being recorded properly, some errata were introduced when data were entered in the computer for storage. For the most part these errors have been corrected by the organization responsible for data input and management as these errata were surfaced. Unfortunately, problems of data omissions and incorrect times on raw data sheets, and there were many of these, have not been corrected nor has the problem of time differentials due to unsynchronized watches. Hence, guarded use must be made to screen both negative or unusually large numbers.

Some problems were inherent to the data collection approach. Certain data points required judgements by data collectors and a clear understanding of definitions. For example, on lighter activity forms the last two data elements were described as "ready to depart" and "depart".

The definitions according to the Data Collection Handbook⁴ were:

"LIGHTER READY TO DEPART: time lighter received or discharged last cargo, secured for departure and/or cast off mooring lines.

LIGHTER DEPARTURE TIME: time lighter crosses specified distance/fix from loading/off-loading position.

AT SHIPS: same as lighter clear of position time.

LIGHTER CLEAR OF POSITION TIME: time lighter has moved far enough away from loading/off-loading position to permit another craft to position."

In discussions with some data collectors the definitions quoted above were confusing. "Ready to depart" meant that the lighter was loaded and "depart" time was when the lighter cast off. Others understood "depart" time as defined above, but had varying ideas as to how far the "specified distance/fix" was from the ship. In reviewing the data, the elapsed times usually are consistent and small which would indicate the definitions were followed, or else the interval differences for their own adopted data points proved comparable. However, there are sufficient differences in the time intervals for some individuals consistent enough to indicate that different marking points were used.

AUTOMATED DATA BASE COMPARISON

An analysis was made of the Joint Test Directorate (JTD) automated data base to determine how the number of containers in the data base compared with the number actually transferred. This was known to vary by facility but the variance was of particular interest for the containership since the ship discharge systems were the throughput bottlenecks.

First a manual reconciliation was made. All lighters and their containers arriving at the beach had to be tracked back through the ship. A similar procedure in reverse was used for the retrograde phase. All differences were reconciled and double checked at other points enroute to verify an event had taken place in any situation where there was doubt.

Secondly, the sample data collected by ORI for in-depth analyses were used to compare with the JTD data. Gaps were discovered and additional checks were made to prove or disprove the validity of events not recorded. Finally, the lists were merged to provide the actual count. Most of the gaps noted were at shift change times when data collectors left before their reliefs arrived or else left under the belief that no further operations were going to be conducted. In at least one case at night, the data collectors and their contractor monitor/quality control supervisors all went to sleep during a slow period at the marshaling yard. Thus, there resulted about a 5-hr gap for data on marshaling yard operations. ORI data have not been used to fill in gaps since data points and timing procedures were different.

⁴ BDM Corp., (J-LOTS) Main Test Data Collection Handbook, July 1977.

Table 1.1 shows a comparison of the actual numbers of containers transferred, the count reflected in the data base, and the difference between the two counts. Although the overall difference is 8 percent, the impact is much more significant. First, duplicates result in zero cycle times that affect averages and there were several suspected as being duplicates in the TCDF file. Secondly, a complete cycle is calculated from the unlocking of a lifting device (spreader bar or container sling) for one container to the unlocking of a lifting device of the next. If a container is missed by the data collector or by the key punch operator, instead of an 8 min. and a 7 min. cycle being calculated there is a 15 min cycle. As noted in Table 1.1, there were 187 omissions. At the COD in Phase I omissions constitute about 12 percent of the productivity and the cycle times in the data base that would be affected by these gaps would be another 13 percent. Thus, 25 percent of the actual productivity of the COD in Phase I could be either omitted or in error. Hence, some caution is needed in using the automated data base if one assumes one is dealing only with an 8 percent error rate.

To circumvent this problem it was determined by inspection that most missing cycles could be screened out by eliminating all cycles greater than about $1\frac{1}{2}$ times the median. This approach had another desirable affect of also screening out lunch breaks (about 30 min), maintenance periods (usually from 15-90 min.), bad weather delays (usually of several hours duration), working ship activities (generally 15 min. to 2 hr), and other container transfer disruptions. What was left were crane cycles with normal 4-5 min. lighter delays. The other activities and disruptions were evaluated first in isolation and then with respect to their influence on crane operations that had to be done manually since the automated data base can not support such an effort.

FUTURE DATA BASE APPLICATIONS

To this point data base deficiencies have frequently been mentioned. Uses can be made of the data base provided that certain guidelines are followed. The user should look for periods of heavy activity in order to assure sufficiently large sample sizes. In this regard, Tables 1.2 and 1.3 are provided so that facility and selection can be made with some knowledge of where the density is greatest. Volume III of this report (Volume III - Joint LOTS Test Data Base Programming) provides information on the programs used to reduce the data base for analysis and includes additional comments on strengths and weaknesses of the data base.

TABLE 1.1
COMPARISON OF CONTAINER RECORDS OF THE LOTS AUTOMATED DATA
BASE WITH MANUAL RECONCILIATIONS AT SHIP

	Test Phases				
	I	II	III	I(R)	Totals
<u>OFF-LOADING COD</u>					
Data Base	139	198	203	80	620
Actual	153	225	222	101	701
Difference	-14	-27	-19	-21	-81
<u>RETROGRADE COD</u>					
Data Base	122	176	128	-	426
Actual	137	195	133	-	465
Difference	-15	-19	-5	-	-39
<u>OFF-LOADING BARGE-TCDF</u>					
Data Base	188	225	220	165	798
Actual	199	233	228	184	844
Difference	-11	-8	-8	-19	-46
<u>RETROGRADE BARGE-TCDF</u>					
Data Base	142	172	144	-	458
Actual	132	183	154	-	469
Difference Under		-11	-10	-	-21
Difference Over	+10	-	-	-	+10
<u>ALL OFF-LOADING</u>					
Data Base	327	423	423	245	1,418
Actual	352	458	450	285	1,545
Difference	-25	-35	-27	-40	-127
<u>ALL RETROGRADE</u>					
Data Base	264	348	272	-	884
Actual	269	378	287	-	934
Difference Under	-15	-30	-15	-	-60
Difference Over	+10				+10
<u>ALL TRANSFERS</u>					
Data Base	591	771	695	245	2,302
Actual	621	836	737	285	2,479
Difference Under	-40	-65	-42	-40	-187
Difference Over	+10	-	-	-	+10

TABLE 1.2
FORWARD THROUGHPUT*

Date: August 1977																
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Ship Systems																
COD	61	59	33			95	92	38			147	51	24		101	701
TCDF	87	64	42		6	83	107	43			174	52	2		184	844
Total	148	123	75		6	178	199	81			321	103	26		285	1,545
Beach Systems																
JUD											162	61	16			239
BBCS	66	49	22		5								2		192	336
ADP	79	65	52	2	5										93	296
LACH						69	67	22			2					160
Ele. c/w						101	132	67	4	4	125	52	4			489
Total	145	114	74	2	10	170	199	89	4	4	289	113	22		285	1520

* Not all containers were routed directly to beach transfer points.

TABLE 1.3
RETROGRADE

Date: August 1977																
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Ship Systems																
COD			27	74	36			24	88	83			65	68		465
TCDF	1	1	29	80	21			11	96	76		17	97	40		469
Total	1	1	56	154	57			35	184	159		17	162	108		934
Beach Systems																
JUD												10	50	32		92
BBCS			16	77	37								2			132
ADP			43	90	55							14	47			249
LACH								40	46	53						139
Ele. c/w								28	111	75			32	62		308
MISC*									24							24
Total			59	167	92			68	181	128		24	131	94		944

* Frontloader at floating causeway.

II. DEPLOYMENT AND ESTABLISHMENT OF SHORESIDE TRANSFER SYSTEMS

DEPLOYMENT SUMMARY

In analyzing deployment aspects of a LOTS operation, shipping resource constraints will determine the operational methods and limits of throughput capabilities of U.S. Forces. The throughput capability initially may require dependence upon self-sustaining containerships and crane-on-deck (COD) operations until a containership discharge facility can be deployed or a port facility becomes available. However, it should be noted that there are less than 20 self-sustaining containerships currently in service. The crane-on-deck method operationally is workable but, as will be noted later, full system development is still in process, acquisition is still pending decision, and funding is in doubt. (See COD analysis.)

The most significant deployment limitations involve the capabilities for deploying lighters and the B DeLong/barge-TCDF. A small capability exists for deployment of 10 of the 12 LCUs in an Army heavy boat company with the two-heavy-lift breakbulk ships and the (untested) heavy-lift RO/RO ship. LCM8s can at least be stowed one or two to a conventional breakbulk ship. However, the DeLong sections are another matter. The only potentially responsive deployment approach of DeLong sections (or a barge-TCDF) is on a SEABEE. Currently, there are no assured means of responsively obtaining this ship for a nonmobilization contingency, short of requisitioning.

Recent changes to the SRP have increased the number and improved the types of ships available to DoD under the SRP. Not all ships offered are needed or accepted. The SRP, which formerly was a voluntary program, has not been tested in its 10 years of existence. It must be recognized that SRP implementation would be disruptive to established trade operations, could be potentially costly to berth operators (whose systems approach to intermodal shipping involves other costs which are dependent upon maintaining high trade levels), and is

likely to be a politically sensitive move that could be legally challenged, to the detriment of meeting contingency responses.¹

The numbers and types of specialized ships available to the Services for non-mobilization contingency operations are very limited. DoD does not yet have a responsive and assured means of acquiring all merchant shipping needed for rapid deployment of equipment and supplies for a large force short of requisitioning. The MSC nucleus fleet is old and the already small MSC charter fleet may be cut back still further. The U.S. merchant fleet, in general, is becoming smaller, more specialized and rigid in trade route operations, while foreign flag fleets are expanding. Foreign charters cannot be considered an assured means for deployments in general and their availability for handling the specialized shipping requirements to transport LOTS equipment in particular is very questionable.

Activation of ships from the NDRF also requires a Presidential determination and proclamation. Even this source cannot provide sufficient specialized shipping for the deployment of such items as LCUs, LCM8s, DeLongs, and other heavy lift items. The NDRF at least until FY 82 (and potentially longer) will not be a timely resource for quick reaction. After 1982 the RRF within the NDRF may alleviate part of the problem -- but only if it contains some heavy-lift vessels or dock landing ships (LSDs) for lighterage support.

Finally, it is concluded that a clear-cut system for establishing priorities in the use of heavy-lift ship resources should be established by the JCS. This is necessary to ensure that heavy-lift ships are committed first to the heaviest and highest priority movement requirements that cannot be moved by other means.

BEACH PREPARATION SUMMARY

The concentrated efforts of the Army's 497th Engineer Company (Port Construction), Marine Support Element, and Amphibious Construction Bn. were required to prepare the beach areas for the test. For the 497th Engineer Company beach (and marshaling yard) preparations for a LOTS operation exceeded its capability. The normal mission of the company does not require a road grader and the capability to develop beach egress routes. To support the requirements for a LACV-30 trail and some of the heavier road construction, augmentation from a combat engineer company would have been necessary.

After the beach crane was positioned, frequent inspections were required to ascertain the stability of the jetty. Sandbags and bulk truck deliveries of sand were required to fill in areas eroded by the limited amount of surf action experienced. The absence of surf precluded a rigorous evaluation of the durability of the jetty.

¹ For a thorough discussion on the commercial implications of a call-up of merchant ships, see the special report, The Sealift Readiness Program prepared by the Maritime Transportation Research Board, National Academy of Sciences, Washington, D.C., dated June 1975.

During the course of the main test, approximately 51,000 sq ft of surface was covered with AMSS. Most of this area was coated twice and repairs on some areas essentially produced three coats. Approximately 100 rolls of Momat were placed on the main unimproved vehicle routes. More than 85 percent of this Momat was recovered after the test and is serviceable for future use.

As demonstrated during the period of this test, both types of surface stabilization were proved feasible and satisfactory for LOTS operations. There were no major failures of either type roadway surface. Overall, there was little deterioration of the roadway where AMSS was applied over Momat, such as at the corner areas on the turnaround road at Red Beach.

Standard techniques were used for the erection of tentage, placement of buoys, and emplacement of lighting. In general, the beach preparation was effective in supporting LOTS operations through all phases of the test. Inexpensive, better soil stabilizing materials to support heavy sustained beach traffic have not yet been developed. However, with proper care and support the AMSS and Momat materials and techniques used can support LOTS operations in beach conditions as difficult as those at Ft. Story.

GENERAL

The equipment used in an Army terminal service company (container handling) necessitates special deployment considerations since it requires specialized shipping. To put this requirement into perspective, a 2½-ton M-35 truck weighs only about one-third of what a fully loaded 20-ft container weighs. The equipment on the beach to lift and load containers weigh approximately 12 to 54 times as much as the truck. One Army 300-ton lifting capacity crane weighs more than three combat loaded M-60 tanks. In its most stripped down form, the crane chassis weight is about equal to the tank. The crane's next largest piece (the crane upper) in this configuration also weighs nearly as much as a tank. However, the problem in deploying a LOTS system is not just weight, which in some cases can be reduced, but size also. Ligherage is a prerequisite to LOTS operations and it is both heavy and very large. LCM8s, for example, can be lifted by a 60-long ton jumbo boom which is normally available on a conventional breakbulk ship. However, because the LCM8 is 73.5 ft long by 21 ft wide and 14.75 ft high, it won't fit in the hold of a conventional breakbulk ship. It has to be stowed on deck and, except for CHALLENGER-class ships, normally only one can be stowed per ship. The CHALLENGER-class ship jumbo boom can work two holds and has space on deck for two, but many more than two LCM8s are required. Besides LCM8s, of which there are 17 per medium boat company, the container company has frontloaders and cranes that are required for operations. These items also can be disassembled to reduce their weights for loading but their major components remain outsized. In addition, disassembly of equipment has important readiness implications, as noted in the deployment analysis that follows.

Once deployed to the objective area and lightered ashore, the equipment must be reassembled and the site itself made operational. As required in the LOTS test design, scenario-related time limits were placed on assemblies and disassemblies and the date when the beach had to be ready for container

operations. The schedule of events for the test was organized so that all Army test activities paralleled scenario required responses. However, since no long ocean voyages were necessary, scenario timing was compressed.

Scenario days were referred to as "D-days" and test days as "T-days." T-days were days in which specific test events or milestones were scheduled. T-day was the day in which a warning order was given to the 7th Transportation Group and coincided with "D minus three." D-day was the day in which the order was given to execute the operations plan and initiate preparations for immediate deployment. Using this type of approach events realistically could be scheduled, data collected, separate scenarios supported, and evaluations made apart from test artificialities or delays. Major milestones and events took place as described in Table 2.1.

TABLE 2.1
LOTS MAIN TEST SIGNIFICANT DEPLOYMENT AND
BEACH ESTABLISHMENT MILESTONES

Event	Scenario Schedule	Test Schedule	Date Accomplished
<u>Army:</u>			
Warning Order Issued	D-3	T-Day	21 July
Execute Operations Plan	D-Day	T+1	22 July
Advance Party Deploys by Air	D+4-D+5	T+3-4	23 July
Initial Beach Preparations Started	D+4-D+5	T+3-4	24 July
Load Heavy-lift Breakbulk Ship (Simulate other sea tail deployment)	D+7-D+9	T+6-7	27 July
Troop Echelon Deployment	D+15-20	T+5	27 July
Heavy-lift Ship Off-loads	D+23-25	T+8-10	29 July
Beach and Site Preparations Completed	D+27	T+12	3 August
Containership Arrives; Off-loading Begins	D+28	T+13	6 August
Army DeLong Pier Installed (Improved Beach Capability)	D+59	T+19	11 August
Improved Beach Operations	D+63		
<u>Navy-Marine Corps:</u>			
Commence Elevated Causeway Installation	N/A	N/A	11 July
Commence Site Preparation	N/A	T-7	14 July
Elevated Causeway Ready for Operations	N/A	N/A	26 July
Site Preparation Completed	N/A	N/A	31 July
Conduct Containership Off-load	D+58	T+18	11 August

The only event not meeting its schedule was the containership's arrival which slipped from 1 August to 4 August. When this was known, test activities and the test "clock" were halted three days to accommodate the

delay. Army unit personnel were either given administrative time off or made busy on non-essential matters. The Navy and Marine Corps units, which had never used the elevated causeway before, trained.

PRETESTS

Leading up to the LOTS main test were several preliminary field tests (pretests). During 1976 a series of ship deployment and beach establishment field tests were conducted in a special LOTS pretest program.² Because the equipment required for container operations was new to the Army inventory and because there were new type merchant ships in the US flag fleet such as barge ships that would be required, certain equipment and ship loading/off-loading combinations had been prescribed. The tests were conducted for a conventional breakbulk ship³, a LASH vessel⁴, and a heavy-lift breakbulk ship.⁵

During the pretest program, two other ship tests were specified but subsequently cancelled due either to technical problems or scheduling difficulties. These tests involved a containership primarily to be evaluated as a candidate deployment vessel⁶ and a SEABEE⁷ to load a barge-TCDF. Subsequent to the LOTS main test a SEABEE became available and the test was conducted.⁸

The LOTS preliminary field tests were conducted to minimize delays and problems in the main test for the deployment of heavy items on various types of commercial vessels. Not only did this preparation provide opportunities to examine closely the use of newer ship types in a military environment, but

² Operations Research, Inc., Design of Preliminary Field Tests for the Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report 993, 6 January 1976.

³ Operations Research, Inc., Report on the Results of the Conventional Breakbulk Ship Pretest of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1037, 29 October 1976.

⁴ Operations Research, Inc., LASH Ship Pretest Results of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1121, 7 March 1977.

⁵ Operations Research, Inc., Heavy-Lift Breakbulk Ship Pretest Results of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1168, 25 July 1977.

⁶ Operations Research, Inc., Report on the Cancellation of the NSS Containership Pretest of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1075, 1 October 1976.

⁷ Operations Research, Inc., Report on the Cancelled SEABEE Pretest of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1148, 15 June 1977.

⁸ ORI, Inc., SEABEE Pretest Results of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1267, 7 December 1977.

also the timing, equipment and operational modifications that would be necessary for their use as deployment vessels. Out of this program the parameters for deployment and operations were more closely defined and anticipated capabilities and deficiencies were confirmed. Table 2.2 summarizes the types of lifts that could be made and the types of commercial ships available to do them.

TABLE 2.2
PRETEST VALIDATION OF SHIP-EQUIPMENT LIFT CAPABILITIES

Lifts Attempted	Merchant Ship Types Tested			
	SEABEE	LASH	Heavy-lift Breakbulk	Conventional Breakbulk
P&H 6250 Crane (Admin. Disassembly)		X		X
P&H 9125 Crane (Tactical Disassembly)		X	X	
LCM8	X	X	X	X
3 x 15 Causeway Section	X	X		X
Sideloader		X	X	
Frontloader			X	
P&H 6250 Crane (Tactical Disassembly)			X	
LACV-30	X			X
LARC-LX			X	
LCU, 1466-class	X		X	
LCU, 1646-class	X			
DeLong Barge, w/6250 Crane	X			
Tractor, Ottawa XM878			X	
Semi-trailer, General Purpose, 34-ton			X	

Each of the ships tested was found to be limited in one capacity or another, or to exhibit some feature so as to be less suitable than another as a deployment vessel for LOTS equipment. Table 2.3 briefly summarizes the results of the pretest.

CALLAGHAN CAPABILITIES

One ship type which could have been included in the pretest program was the GTS ADM WM CALLAGHAN, a RO/RO vessel with a heavy-lift boom capability. The CALLAGHAN was specially built for the DoD and has remained under long term charter to MSC, normally in service between the US East Coast and Europe. One of the most important features of the ship is that it was designed to embark two LCUs using its two 120-ton booms in a boom marriage. In this respect it is only one of three ships that can lift an LCU. However, MSC cannot verify that that capability has ever been tested since the ship was commissioned. Rarely, in fact, are the heavy-lift booms used because in peacetime it is more economical to use the RO/RO rather than the breakbulk features of the ship.

TABLE 2.3
ANALYSIS SUMMARY OF LOTS EQUIPMENT-SHIP
PRETEST RESULTS

Ship	Test Objectives	Conclusion
Conventional Break-bulk Ship	Disassemble container cranes into components for loading aboard ship; also deploy and off-load needed lighterage; conduct ship-to-shore operations; reassemble equipment on the beach. Load and off-load causeway sections.	This approach was feasible. The LCMB could support the mission. Time limits could be met but required well-trained crews, exposed sensitive equipment to harsh treatment, and involved a considerable amount of work and risk. The detailed crane assembly and disassembly operations, although feasible, should be avoided. Causeway sections, although oversized and at maximum weight for this ship, could be deployed.
Heavy-lift Break-bulk (TRANSCOLUMBIA/TRANSCOLORADO)	Embark all types of heavy and outsized Army LOTS system equipment, including lighterage, and off-load them from an anchorage. (Ship availability allowed for limited container ship-to-shore practice, including use of the barge-TCDF.)	The heavy-lift capabilities made possible deployment in a near ready-to-use configuration, which was approximately 3 times faster than for the conventional breakbulk ship (above) and LASH ship (see below) and reduced hazards to equipment. The 1610/1646-class LCU lacked a sling for loading (both in the pretest and main test). A single section DeLong B pier with mounted 140-ton crane could not off-load landing craft around low tide.
LASH	Load selected LOTS equipment in-port and discharge them while at anchor. Test a causeway lifting frame. Opportunity was used to discharge barges at an off-shore floating cargo transfer platform. Test a remote automated data facility for cargo management.	The LASH equipped with the LCMB lift beam can be used for deployment of many LOTS equipment items; 300-ton container cranes require administrative disassembly. A major error was found in overhead clearances for the gantry crane used (4 ft greater than believed). A pierside modification to the gantry crane's gathering cones was necessary in order to attach the LCMB lift beam. An interim causeway lifting frame was slow but could be used for 3x15 causeway sections, but not for a simulated 3x14 causeway warping tug which should be tested. The floating transfer platform operations were slow and potentially risky, especially as conditions approached sea state 3. More LCMB lift beams are needed (only 3 on hand).
SEABEE	Load major LOTS end items in-port and discharge them at anchor off-shore. Use container adapter frames to support cargo and to provide an interface between the cargo and the barge transporters.	With adapter frames the SEABEE can embark and off-load a barge-TCDF, LCUs, causeway sections, LACV-30s, LCMBs, and other heavy or outsized equipment. The barge transporters need to be synchronized to load the barge-TCDF or DeLong sections. The container adapter frames were too buoyant but can be flooded by removing side plates. Improved lashing of adapters on the elevator would expedite ship loading and discharge. Used in a RO/RO fashion the ship would be slow and difficult to off-load in a LOTS environment except for LARCs. It is the only ship capable of deploying DeLong B section and priority use should be given for this lift.

In addition, there is some question regarding the use of the CALLAGHAN for loading the Army's Ottawa yard tractor model 50 (then referred to as the XM878) and XM872 34-ton dual purpose trailer. The ship was designed primarily to accommodate military vehicles but not the newer intermodal RO/RO transportation methods where 40-ft trailers with containers are embarked. MSC was asked to review potential problem areas in loading out the container company's equipment, specifically tractor-trailer combinations loaded with boom sections of the 300-ton crane. MSC was given vehicles and cargo dimensions as contained in Table 2.4.

TABLE 2.4
VEHICLE-LOAD SPECIFICATIONS USED
FOR ANALYSIS OF OVERHEAD CLEARANCES

TRACTOR:	Commercial Yard type, XM878
	Length = 14' - 0"
	Width = 8' - 0"
	Height = 9' - 6"
TRAILER:	Semi-trailer low bed XM872 tri-axle
	Length = 41' - 10 3/4"
	Width = 8' - 0"
	Height of 5th Wheel = 5' - 2"
	Thickness of Bed = 0' - 9 3/4"
	Height of Bed from Deck = 5' - 4 3/4"
Crane Boom Section:	
	Length = 42' - 3 1/2"
	Width = 8' - 8 1/2"
	Height = 8' - 6"
Container:	Length = 40' - 0"
	Width = 8' - 0"
	Height = 8' - 0"

Mobile loading boom sections on trailers is an important step in deployment of the crane since denting of the boom's tubing critically degrades the strength. MSC reported that:

"Loading the crane boom section using specified tractor-trailer (the XM878 tractor and the XM872 dual purpose trailer) would require approximately 14'-8" overhead clearance. Overhead clearance in No. 6 upper tween is 14'-3"; therefore, loading the crane boom section via the stern ramp with the specified trailer would not be possible. Loading the crane boom section via the side ports would also be impossible with specified trailer since the heights of the side port openings are 13'-0".

"The specified tri-axle trailer appears to be unsuited

for loading 40' x 8' x 8' containers and 42' boom section, due to the height of the trailer bed and the long span between the rear wheels and the fifth wheel. The minimum overhead of the upper tween decks is approximately 14'-3". Therefore, in order to load 40' containers and 42' crane boom sections a lower trailer with shorter span between the rear wheels and the fifth wheel would be necessary. Loading the 40' containers and 42' crane boom sections via the side ports appears to be feasible provided that the total height of the trailer and load is less than the 13'-0" side port height..."⁸

The MSC report did not address the possibility of loading the trailers carrying boom sections via the ships forward cargo hatches. However, this option is not possible either since the hatches are too small to accommodate the length of the trailers. Therefore, it would appear that trailer-load height limitations must be considered when employing the CALLAGHAN for contingency operations. Further, it would be advisable for the Army to consider verifying by loading the yard tractor and the tri-axle XM872 trailer combination on the CALLAGHAN. The Army should test the use of the side ports and stern ramp and check ramp clearances throughout the ship, especially up to the heavy-lift boom loading points.

SHIPPING REQUIREMENTS

General

Essentially two separate deployment requirements would have been necessary to support the organizations participating in the LOTS test, one to support Army activities and one to support Navy-Marine Corps activities. However, all three Services to varying degrees would have had to draw on the US flag fleet for shipping support; the Navy and Marine Corps to a lesser degree than the Army. Because of the largely experimental status of the Navy-Marine Corps system at the time of the test, deployment was not a major data collection requirement. However, the elevated causeway is a new component in the amphibious warfare inventory and it relies heavily on an assault follow-on echelon (AFOE) to deploy a large share of the supplies and equipment needed. The same is true for the Marine Corps lightweight amphibious container handler (LACH) in support of its deployment requirements.

The most significant deployment requirement is for the Army, which must rely solely on merchant ships for deployment. The LOTS test required that deployment data be submitted for all personnel and equipment. No attempt was made by Army personnel to load out the force onto ships, a function normally the responsibility of the Military Traffic Management Command (MTMC). The Army was limited to a number of C-5A aircraft for advance force and troop deployment. The approach was to deploy an advance force to begin establishment of the LOTS site. The main body of the LOTS force was to follow later in increments by air and the LOTS equipment by sea to the LOTS site. There the units would marry up with their equipment.

⁸Military Sealift Command Memorandum M-4E41c/1sh., Subj: GTS ADM WM CALLAGHAN: Loading of 40-ft Long Containers and 42-ft Long Boom Sections, dtd 9 Dec 1977.

Scenario Assumptions

It was assumed that two cases should be considered. First, that a bare beach operation involving both breakbulk and containerized handling was required and that in deploying to the site no SEABEE ship would be available. This was the "worst case" situation represented in Phase I. Theoretically, the barge-TCDF had not been deployed but instead two cranes-on-deck were operating. In the second case, it was assumed that mobilization had taken place and SEABEE ships were available. Therefore, barge-TCDFs and DeLong Piers were available. This was the situation represented by Phase III, the improved beach or "best case."

During the test there was an excess of lighters for the breakbulk and container operation. This was desirable for training and to ensure ship cranes would be productive, but unrealistic for the level of effort required. Accordingly, for the deployment analysis it is assumed that the "excesses" were not there. It was also assumed that the breakbulk requirement was a full shipload of vehicles and palletized cargo to be lightered ashore. Based upon these requirements a notional lighterage capability was selected (see also the section on lighterage). This lighterage consisted of 10 LCUs (a heavy boat company), 4 LARC-LXs (a heavy amphibian detachment), 2 LACV-30s (a provisional detachment), 6 LCM8s (a detachment from a medium boat company), and 8 LARC-XVs (a detachment from a medium amphibian company). Table 2.5 compares this mix with the lighterage used in the test.

TABLE 2.5
LIGHTERAGE DEPLOYMENT COMPARISON

ARMY LIGHTER TYPES	MAXIMUM NO. USED (PHASE I - CNTR + BBLK OPS)	NO. USED FOR DEPLOYMENT ANALYSIS	DIFFERENCE FROM LOTS MAIN TEST
LCU	10	10	0
LCMB	17	8	-9
LARC-LX	3	4	+1
LARC-XV	15*	8	-7
LACV-30	2	2	0
TOTALS	47	32	-15
* 25 LARC-XVs were listed for deployment but only 15 were used in this phase for cargo operations.			

With the exception of the LACV-30 detachment the above comparison allows for 25 percent maintenance spares, a 5-hatch breakbulk operation, and special purpose requirements (crew changes, salvage, miscellaneous transportation). Greater reliance is placed on LCUs than other craft because of their greater productivity, potential self-sustaining capabilities, and presumed better operational suitability for foul weather conditions. LARC-XVs would be used for the special purpose and palletized cargo requirements.

Other mixes of lighterage could be assigned and some additions to the LARC-XV detachment could be made without seriously altering the shipping needed for deployment. Much of the decision as to composition of the lighterage mix depends basically on the mission and environmental conditions in the LOTS objective area. For this analysis two other notable exceptions in the LOTS test force are made. These changes are the substitution of four frontloaders for six sideloaders (sideloaders were deleted from the T.S. Co. TO&E) and the addition of an engineering detachment (also discussed later) for beach preparation. Otherwise the deployment requirements listed in Table 2.6 are essentially the same as those in the LOTS main test. The net result of these changes was that the shipping requirement decreased by about 15,200 sq ft and the lift was simplified by the elimination of nine LCMs from the deployment requirements submitted by Army units for the LOTS test.

SHIP RESOURCES

As noted below, shipping assets may be drawn from a variety of sources subject to the type of force being deployed and the nature and authority of the call-up.⁹ There are limitations on each of these:

- U.S.N. amphibious ships
- MSC nucleus and charter fleet
- Activation of vessels from the National Defense Reserve Fleet (NDRF)
- US flag fleet assets available under the Sealift Readiness Program (SRP)
- US flag fleet assets available when requisitioning is effected.

The Navy with its amphibious ships has the capability to deploy all LOTS equipment except DeLong barges. However, these ships are considered essential to the conduct of the amphibious assault and subsequent operations until the landing force is established ashore. Nevertheless, some Navy and USMC LOTS-type equipment (such as LCUs, causeway sections, MHE, and engineering equipment) assuredly would be transported in amphibious ships because such equipment provides assault support and a capability for the build-up of supply dumps for subsequent operations ashore. Because of a short-fall in amphibious shipping, to some degree Navy and Marine Corps follow-on support personnel, supplies, and equipment would be deployed in merchant vessels. On the other-hand, because amphibious ships are dedicated to naval combat force requirements and are very limited in number, they cannot be made available for other uses. Thus, the Army is totally committed to the use of merchant shipping for surface deployment overseas.

⁹Effective U.S. Control (EUSC) general dry cargo ships (11) are of foreign registry and reasonably could be expected to be available to the U.S. after all other sources, including the National Defense Reserve Fleet, are found insufficient. As a result of this low priority they are not considered here.

TABLE 2.6
PHASE I (BARE BEACH) DEPLOYMENT REQUIREMENTS

Unit	AIRLIFT				SEALIFT			Special Lift Requirements
	Personnel	Cube	Square	Weight	Cube	Square	Weight (lbs)	
Headquarters and Headquarters Co., 24th Transportation Bn	93	463	1,086	54,288	1,080	301	26,424	
119th Transportation Co. (Terminal Service) (Container)	251	1,207	234	37,684	12,394	44,746	3,945,805	1-6250 model crane 2-9125 model cranes 10-Front loaders
329th Transportation Co. (Heavy Boat)	148	-	234	15,560	-	49,278	4,876,350	10-LCU
1098th Transportation Co. (Medium Boat)	100	-	234	15,560	-	13,078	1,145,432	8-LCM8
497th Engineer Co. (Port Construction)	208	-	9,730	951,863	1,960	3,540	267,442	1-Diving barge
567th Transportation Co. (Terminal Service)	135	-	-	-	-	2,132	237,758	
309th Transportation Co. (Heavy Amphibian)	88	-	59	2,550	522	7,815	899,766	4-LARC-LX
331st Transportation Co. (Medium Amphibian)	164	114	290	17,676	3,291	7,479	604,841	8-LARC-XV
491st Transportation Det. (Cargo Documentation)	3	-	-	-	5	-	25	
544th Transportation Det. (Trailer Transfer Point)	16	899	282	91,249	603	282	40,470	
LACV-30 Det	20	-	-	-	12,000	5,883	181,504	2-LACV-30
Transportation Co. (Medium Truck)	30	-	-	-	267	4,680	376,258	
LOTS Force Supplies (Class I, III, IV, V)	-	-	-	-	51,325	-	1,052,300	
TOTALS	1,261	2,683	12,149	1,186,430	83,447	139,214	13,656,375	

The active nucleus fleet under MSC is composed largely of tankers and special purpose ships. Except for two RO/RO ships, the fleet is largely of World War II vintage. There are only six ships altogether that would be useful for LOTS deployment. None of them could deploy an LCU.

The charter fleet under MSC contains the best and most valuable ships for deployment. The two heavy-lift breakbulk ships can each carry four LCUs plus LCM8s and LARC-LXs in the holds. As noted previously, the heavy-lift ships can also lift the 300-ton crane in its tactical disassembly, saving 2/3 of the deployment and reassembly time required when deployed by conventional breakbulk or LASH ships. The CALLAGHAN with its two heavy-lift booms is the only other ship controlled by MSC that can theoretically deploy LCUs. The depth in the fleet is provided by the conventional breakbulk ships, of which there are 21. Two-thirds of the breakbulk ships are of the CHALLENGER-class, the most modern breakbulk ship in the US flag fleet, each with 70-long ton booms capable of servicing two holds. The remaining breakbulk ships are not as modern but are still valuable assets for deployment.

The National Defense Reserve Fleet (NDRF), which consists of about 129 World War II Victory ships and nine Seatrains inactivated ships under the administrative control of the Maritime Administration, is considered the backup to the active fleet. In fact, before the Naval Sealift Readiness Program can be implemented, it must be established that the ships of the NDRF cannot economically be available in sufficient time to meet initial or delayed replacement requirements. MSC has estimated that 30,000 to 35,000 man-hours would be required to activate an NDRF ship. This corresponds to about 6 days of topside work before the ship is ready. However, preceding shipyard work, time is required for decision making, shipyard selection, and other preparatory activities. The best time before a ship can be made ready has been estimated as 47 days and it could be as much as 120 days. Following that time the ship must be crewed. MSC estimates are that optimistically 17 ships could be crewed in a 30-day period and possibly 36 ships in 38 days. However, the maritime manpower pool has been slowly decreasing since World War II and a series of MARAD studies¹⁰ have predicted that manpower shortages for regular maritime service was expected by mid-1977.

To upgrade ship response time the DoD has established a requirement for ship availability within 7 to 10 days following notification. As a result the Ready Reserve Force (RRF) was established for a less-than-full mobilization for the initial phase of mobilization. The initial RRF is tentatively planned to be completed by FY 82 and will be composed of a mix of ships still being determined. However, under consideration are the numbers and types listed in Table 2.7.

¹⁰U.S. Maritime Administration, Deck and Engine Officers in the U.S. Merchant Marine, Supply and Demand, 1974-1984.

TABLE 2.7
CANDIDATE HULL TYPES BEING CONSIDERED FOR THE RRF

<u>Quantity</u>	<u>Hull Type</u>
1	VICTORY
5	C-3
9	SEATRAN
11	C-4
2	Combination Container/ Breakbulk

Merchant Ship Acquisition

Chartering. Merchant ship availability is a highly variable matter. As evidenced by the difficulties in scheduling ship procurements for the LOTS pretests and the LOTS main test, ship operators are highly reluctant to abandon or disrupt their normal commercial business for occasional military use of their vessels. In addition, the shrinking of the U.S. flag fleet, the systematized approach toward modern shipping, and the extended planning time requirements for chartering vessels by contracts through MSC greatly restrict responsiveness from the merchant sector.

There are several options that may be open to MSC in meeting shipping requirements if the nucleus and charter fleets and the NDRF cannot, provided certain conditions are met. These options are briefly summarized as follows:

- Charter a U.S. flag vessel from the open market,
- Charter a foreign flag ship from the open market,
- Call up the needed vessels through the SRP, and
- Requisition the needed ships.

Chartering a U.S. flag vessel is obviously a matter of time and circumstance. Given favorable market conditions for ship owners, chartering could be a difficult matter, especially for certain specialized vessels such as LASH and SEABEE ships. There are no surpluses of these type vessels. Similarly, chartering self-sustaining containerships could be difficult because the number has been reduced to less than 20.

It is possible for MSC to charter a foreign vessel, but because this leaves the U.S. open to political uncertainties, there are serious drawbacks to such employment for quick response in contingency situations. The number of foreign flag vessels is increasing, but like U.S. flag vessel operators, they also are reluctant to remove their better vessels from established trade routes.

Sealift Readiness Program. A third option is the SRP. Until September 1978, the SRP was only a voluntary contractual arrangement between MSC and berth line operators carrying DoD cargo. In June 1978, Congress passed a law that requires participation in a Sealift Readiness Program of any vessel receiving an operating differential subsidy or any future vessel for which construction differential subsidy is made. Since the law was passed as part of an appropriations act, it was applicable only for FY79.

The result of Public Law 95-298, June 26, 1978, was to increase the number of ships subject to the SRP. Previously DoD was not necessarily in need of more ships, but rather more specialized and better ships were required and potentially some adjustments to call-up times were under consideration. Thus, it should not be assumed that all ships offered are normally accepted nor that DoD will always be fully supported in its deployment requirements. Similar legislation is needed either on a year-to-year basis or a law needs to be enacted to continuously ensure that wider DoD assets are available under an SRP program.

It is significant to note that in the 10 years that the SRP has been in effect there has been no occasion to exercise this option nor a test of the call-up procedures. Figure 2.1 outlines the action parties and responsibilities for implementing the SRP. The needed shipping assets are, for the most part, in the SRP. CPX type test of a call-up with vessel operator participation would appear to have value in shaking out problem areas, exercising of communications channels, and procedures, and develop response times for planning purposes. The cost and disruptions to normal business make a "live" test infeasible. Even if an actual non-mobilization emergency happened, the long term economic implications might generate resistance and political action sufficient to delay call-ups and render the SRP as an ineffective and unresponsive source. The capability to respond quickly to a minor contingency could hinge upon market conditions at the time, the willingness of the carrier to make a financial sacrifice (ship charter costs do not cover idle fixed facility costs), and the loss of markets to foreign shippers.¹¹

Under the best of conditions the process of implementing the SRP is rather slow. Figure 2.1 lists the steps and responses necessary in the event of such a call-up. The time required for such a process is not known and estimates would have to be considered highly subjective.

¹¹Maritime Transportation Research Board, The Sealift Readiness Program, The Commercial Implications of a Military Contingency Call-up of US Flag Merchant Ships, National Academy of Sciences, National Research Council, June 1975.

<u>Action Parties</u>	<u>Action Required</u>
NATIONAL COMMAND AUTHORITIES, JCS	Requirement Established for Shipping Capability to Meet Contingency
MSC	Controlled Assets or Berth Available for Charter at Fair & Reasonable Charges?
MSC	U.S. Flag Shipping Available for Charter at Fair & Reasonable Charges?
ASN (MRA&L), MSC (MARAD, ASD (MRA&L))	Charter Foreign Flag Shipping?
MSC	Foreign Flag Charters Available at Fair & Reasonable Charges?
SECDEF	NDRF Economically Available in Sufficient Time to Meet Initial Requirement?
MARAD, MSC, ASD (MRA&L)	NDRF Economically Available As Delayed Replacement Capability?
NSC, SECDEF, JCS (MARAD, MSC)	Is Remaining Requirement Greater Than Capacity of Current SRP Commitment?
SECDEF, SEC COMMERCE (MSC, ASN (MRA&L), OPNAV, MARAD, NSC)	Call Up SRP?
MSC, MARAD	Determine Ships to be Called up by: Ship Type and Commitment Timing Ship Location Equalization of Burden Among Carriers
SECDEF, SEC COMMERCE (ASN (MRA&L), ASD (MRA&L), MARAD)	Approval of Individual Ships Proposed For Call-Up
COMSC	Issuance of Call-Up
MSC	Charter Vessels Subject to on-hire Survey. In Satisfactory Condition?
MSC	Employ Vessels

FIGURE 2.1. SEALIFT READINESS PROGRAM IMPLEMENTATION PROCESS
(BASED ON SRP AS DEFINED IN RFP 1200, FY 1978)
REQUIRED ACTIONS

Consequently, the response time of the SRP is largely an unknown and untested determinant for non-mobilization contingency support. Once authority has been given and cooperation received, then ships would be brought into DoD service in agreed upon intervals. These intervals have been specified as being periods within 10 days, 20 days, 30 days, and 60 days. The turnover of a vessel does not have to be at a port where DoD has a scheduled load; thus, possible underway time must be considered before the estimated berth assignment closes.

Requisitioning. The authority for requisitioning is based upon the Merchant Marine Act, 1936. Specifically, section 902a of that act states:

"Whenever the President shall proclaim that the security of the national defense makes it advisable or during any national emergency declared by proclamation of the President, it shall be lawful for the Commission to acquisition or purchase any vessel or other watercraft owned by citizens of the United States..."

The act of ship requisitioning has not been exercised since World War II with one minor exception in the case of two privately owned U.S. ships requisitioned during the 1958 Lebanon crisis.¹² For the Korean conflict ships were brought out of the NDRF to provide support in addition to the nucleus fleet. For Vietnam, ships were chartered and some were taken out of the NDRF. Thus, requisitioning and the machinery to conduct and operate vessels on a large scale under this type of program have not been employed since the early 1940's.

Since that time sealift movement has been revolutionized by intermodal systems. Hence, future acquisitions will have to be expanded beyond the framework of "vessel or other watercraft" to include maritime system support such as containers, special handling equipment, and chassis. These types of items are vital components of modern intermodal systems without which the ships cannot operate. This problem has been recognized for some time by MSC and Military Traffic Management Command (MTMC) but the statutory authority solving the problem has not yet been produced.

While requisitioning appears to be the most responsive course to follow, there are some drawbacks. Such type of ship acquisition historically has only taken place during mobilization and, consequently, would be viewed in such light. The act of mobilization or even the appearance of mobilization may not be the intent or desire in supporting a sealift requirement. Secondly, the act of seizing ships is politically sensitive and the resultant effect would prematurely divulge the intent and approach being attempted (such as prepositioning near the objective area). Thirdly, without at least a partial mobilization, requisitioning may be judicially challenged in which case deployments could be delayed to the extent that responsiveness is lost.

¹²Ibid.

To provide shipping in the event of a major full mobilization contingency, requisitioning would undoubtedly be used. Figure 2.2 describes the process involved. MSC and CNO would determine the ships to be requisitioned based on ship types, capabilities and locations. Their request for ships would be made to the Joint Transportation Board (JTB), the Secretary of Defense, and Secretary of Commerce. Ships that are approved for requisitioning would then be obtained by the National Shipping Authority (NSA). Ships under Effective U.S. control would also be requisitioned. If the requirements were not met following requisitioning, foreign owned vessels located in U.S. waters would be taken under control. In the event of a NATO war, MSC would be provided ships by NATO countries which have agreements with NATO's Planning Board for Ocean Shipping (PBOS).¹³

Until September 14, 1978, a proclamation of national emergency was still in effect from December 16, 1950. Subsequent to that time and until recently the authority to requisition was still in effect. Despite this authority it is noted that during the Vietnam build-up requisitioning was not exercised even though DoD was hard pressed initially to find sufficient shipping. The event easing this predicament was a dock strike which tied up commercial cargo but not Defense shipments.

Total Resources. The dry cargo ships available for deployment under the circumstances described above are given in Table 2.8. It should be noted that the SRP assets represent the case as it generally appears on a year-to-year basis. The final offerings are adjusted slightly but the distributions generally do not change significantly. One exception, however could be the SEABEE which could drop out as an SRP asset, depending upon whether the annual appropriation act or a permanent law requires their participation.

TABLE 2.8
U.S. MERCHANT SHIP RESOURCES

	MSC Nucleus Fleet	MSC Charter Fleet	SRP Assets	Mobilization Gains	TOTALS
Conventional Breakbulk Ships	3	18	67	66	154
Heavy-lift Cargo Ships	1	2	-	-	3
Conventional RO/RO Ships	2	-	-	15	17
CALLAGHAN-class RO/RO	-	1	-	-	1
LASH	-	-	8	12	16
SEABEE	-	-	3		3
Container	-	-	49	56	109
TOTALS	6	21	131	149	303

¹³Based upon MSC Position Paper, M-62A2, Subject: Requisitioning, dated 20 Jan 1978.

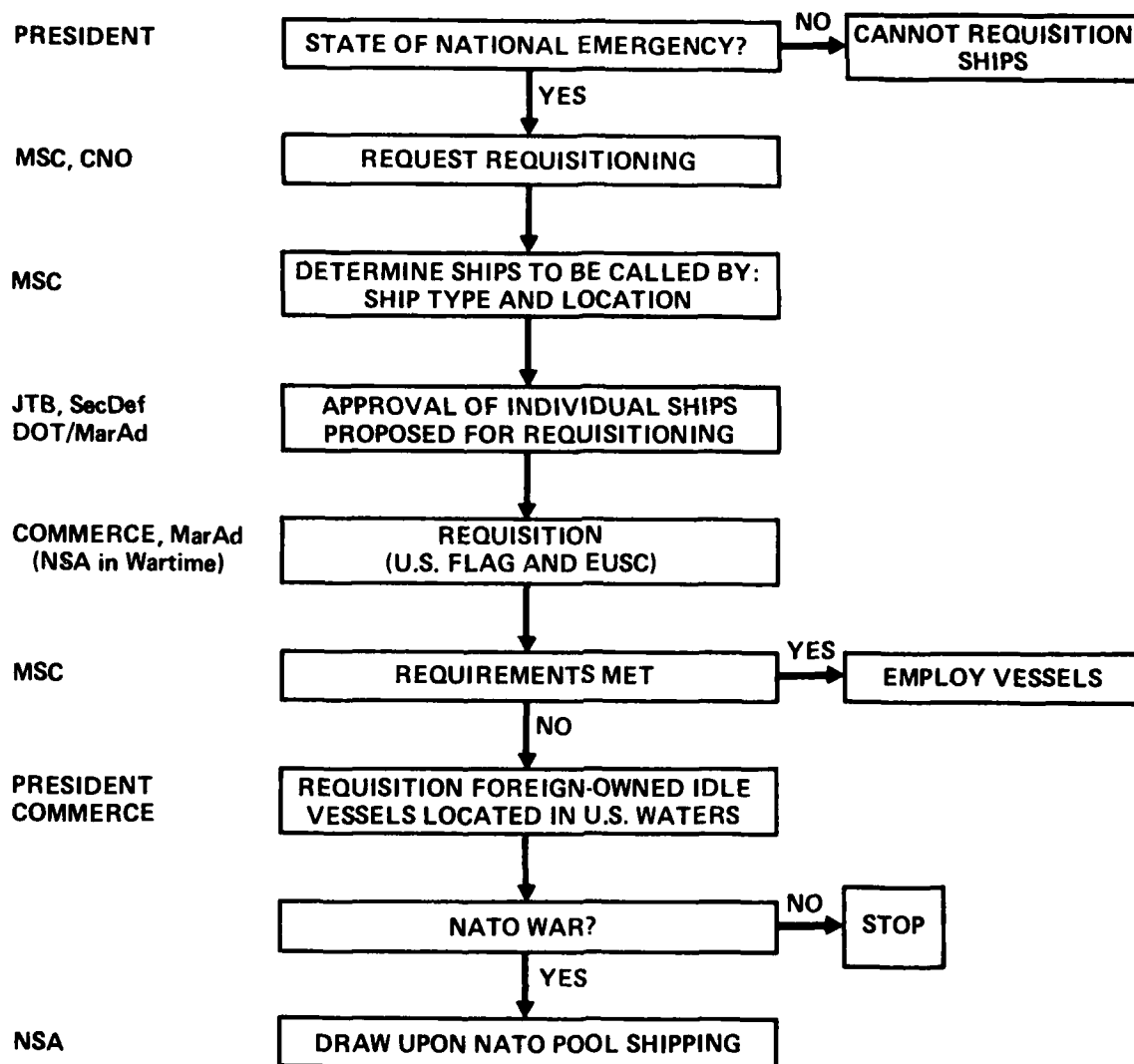


FIGURE 2.2. PROCESS FOR REQUISITIONING SHIPS

SHIPPING ASSIGNMENTS

As currently practiced by the Joint Chiefs of Staff (JCS), no pre-determined allocations of shipping are made, such as assignments of specific units to specific ships or ship types. For normal deployment of cargo, notional shipping assignments are possible. Unfortunately, inherent with this type of procedure is the fact that there is no guarantee that extraordinary equipment, which should be operational in the objective area before the arrival of the first convoy, will arrive before the first convoy. For example, lighters needed to transport tanks from ship to shore could be bumped from the first deployment echelon because tanks have a higher priority for combat on the front lines than lighters do in rear areas to transport cargo.

Secondly, is the problem that specialized shipping could be wrongly assigned and used. For example, SEABEE vessels could be assigned solely to support the movement of helicopters, a mission for which the ship has been tested and found suitable. The SEABEE is also the only ship potentially capable of loading and off-loading DeLong barges/barge-TCDFs. In point of fact, the two loads are compatible. The DeLong sections can only be loaded on the upper deck and aircraft loading is preferred below decks.

Thus, predetermined allocations in certain instances are necessary if equipment and operations are to mesh in the objective area. Accordingly, some priority must be made by JCS and MSC to support barge-TCDF and LCU deployment, among other LOTS equipment items.

UNIT DEPLOYMENT

Based on the units and equipment previously described and the foregoing discussion on shipping resources, the Army LOTS force was analyzed for surface deployment. Two cases were considered. The first did not involve a SEABEE vessel and, therefore, no DeLong pier nor barge-TCDF would be immediately available;¹⁴ either self-sustaining containerhips or cranes-on-deck would be used for ship discharge. The second case includes the use of a SEABEE. Figure 2.3 illustrates the courses and options available and action required in both cases.

In the first case considered where a SEABEE was not available, Table 2.9 illustrates the shipping required to move the LOTS force needed for a one containership and one breakbulk ship LOTS operation. The total ship requirement is eight and is driven largely by the need to deploy outsized and heavy equipment, chiefly lighters. The two heavy-lift breakbulk ships were given similar loads and both could be loaded to greater capacity with more small vehicles such as quarter-ton trucks or palletized equipment. The heavy-lift

¹⁴B. DeLong barges can be towed to the objective site but this is not appropriate in a quick-reaction situation. Upon arrival the crane requires mounting on a set of ramps that are centered on the DeLong. Mounting involves lifting the crane and centering it on the barge. The crane weighs approximately 180 tons. The availability of equipment with the necessary reach and lift capacity to support the mounting in an area of operations cannot be assumed.

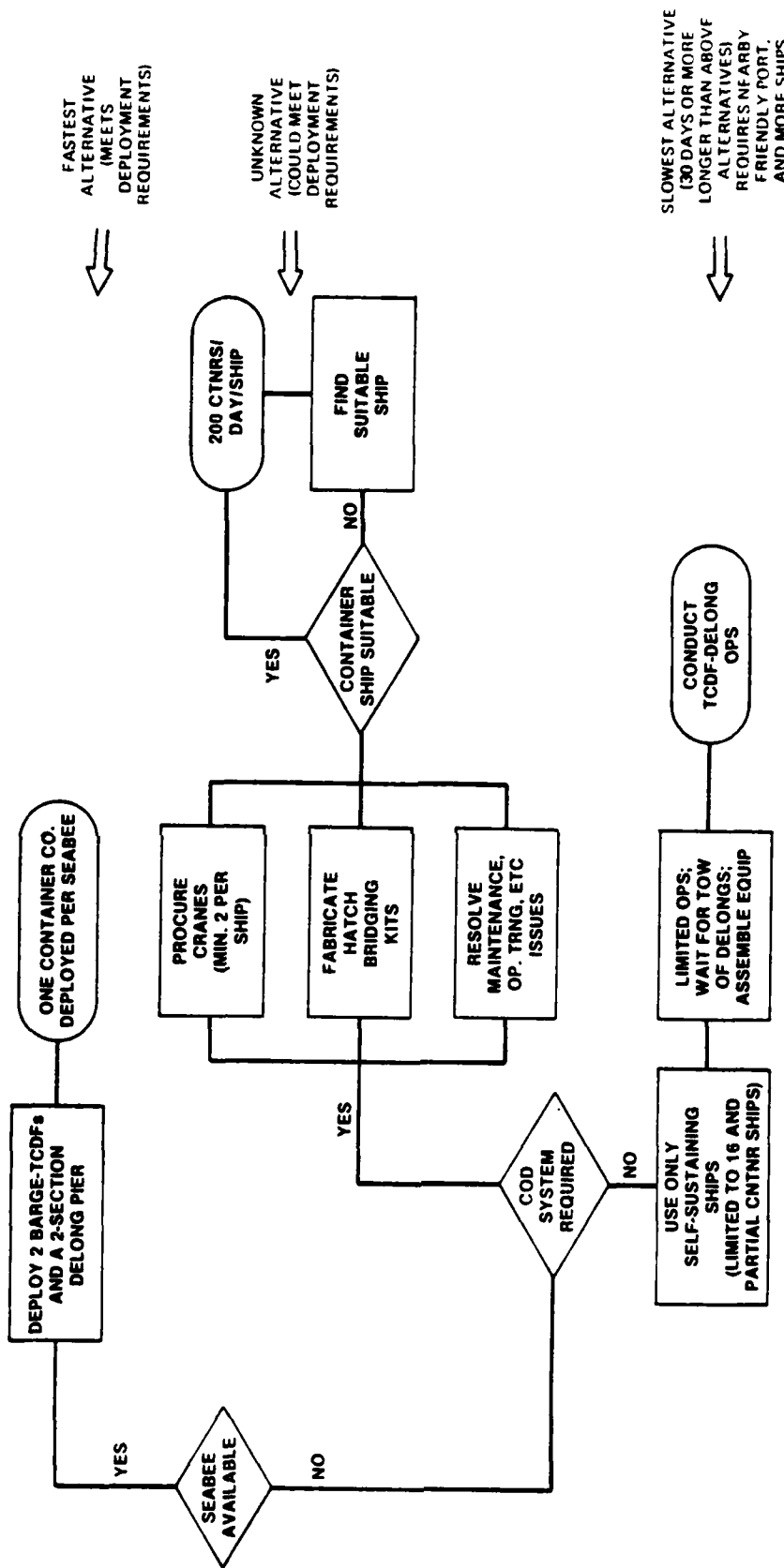


FIGURE 2.3 OPTIONS POSSIBLE AND ACTION REQUIRED SUBJECT TO SEABEE SHIP AVAILABILITY

TABLE 2.9
ASSIGNMENT TO SHIPPING FOR LOTS UNITS

DEPLOYMENT REQUIREMENT	PERCENT UTILIZATION OF SHIPS SHOWN BELOW*								
	HEAVY-LIFT BREAKBULK SHIPS		HEAVY-LIFT RO/RO SHIP	CONVENTIONAL BREAKBULK SHIPS (CHALLENGER-CLASS)					
	NO. 1	NO. 2		NO. 1	NO. 2	NO. 3	NO. 4	NO. 5	
MH Co., 24th Trans Bn	1	1							
119th Trans. Co. (Term Service) Container	37	37							
567th Trans. Co. (Term Service)			2	6					
329th Trans. Co. (heavy Boat)	MD(4)**	MD(4)**	MD(2)						
1098th Trans. Co. (Med. Boat) Det.	9	9		5	5	5	5		
497th Engineer Co. (Port Construction)	9	9		5					
Engineer Det. (To be Determined)	7	7							
Det. 309th Trans. Co. (Heavy Amphibian)	9	9							
Det. 331st Trans. Co. (Med. Amphibian)	9	9							
Det. 491st Trans. Co. (Cargo Documentation)				Negli- gible					
Det. 544th Trans. Co. (Trailer Transfer Point)				2					
Trans. Co. (Medium Truck)			22						
Det. LACV-30									19
LOTS Force Supplies (Class I, III, IV, V)	6	6		12					
TOTAL SHIP USAGE*	87	87	24	30	5	5	5	5	19

* After .75 Broken Stowage Factor Applied. No bulk POL equipment are included since that data were not available.

** Main deck.

RO/RO ship, the CALLAGHAN, is barely 25 percent loaded and should be used as a lower priority ship for deployment. In a LOTS environment with its limited number of booms, off-loading of the CALLAGHAN could be slow.

If the SRP were implemented, one LASH ship could replace four of the CHALLENGER-class ships in transporting the LCM8s. In fact, more LCM8s could be embarked and additional cargo could be carried below decks. With a DeLong pier the Army has not yet demonstrated any capability of off-loading LASH or SEABEE barges nor developed a concept for such an operation. Thus, without a pier facility, in the near time frame barge cargo would be unsuitable.

In all likelihood the ships noted previously as being necessary for LOTS unit deployment also would be filled with equipment from other units required to establish the surface line of communications, depending upon the scenario and mission.

In the event a SEABEE ship were available, the Army container company could deploy a two barge-TCDF ship discharge system and a two section (300-ft long) pier. These items would require all of the SEABEE's upper deck. Other shipping support would still be required for LCUs, LACV-30s, and LOTS equipment. Items such as LARC-LXs which can be floated off the SEABEE elevator and which would not require container adapter frames can be handled fairly rapidly, as noted in the LOTS SEABEE pretest. However, elevator operations are slow. At anchor, off-loading vehicles into lighters, which has not been attempted, would appear to be an even slower process. Thus, loading more LOTS equipment items onto the SEABEE lower decks and main deck is not preferred over other vessels if off-shore discharge of the equipment is to be required. LOTS equipment must be loaded aboard ship for early discharge in order that the beach can be established and throughput operations initiated at the earliest possible time.

BEACH ESTABLISHMENT

General

Establishment of beach systems is highly dependent upon Service mission, scenario, and environment. However, both Army and Naval forces must have the organic capability to prepare a site for landing lighterage and operating vehicles and equipment. The preparations accomplished for the LOTS test were adequate in most respects and were accomplished generally within the established time parameters. In the planning stages it was recognized that as many as 4,500 transits of heavily loaded trucks could be made on the beach during the test, in addition to frontloaders, cranes, dozers, small vehicles, as well as specialized vehicles such as the LACH and LACV-30s. Those expectations may have been high by about 1,800 transits. Overall judgments on beach conditions during and subsequent to the test were that the prepared surfaces could have continued to hold up with periodic maintenance. The materials used proved satisfactory for the most part at the Ft. Story beach.

Advanced Multipurpose Surface System (AMSS)

The AMSS system can be easily transported to an objective area. The dispenser is relatively small and lightweight. None of the components (equipment or chemical) weigh more than 400 lb.

The skill level of the operators does not require more than two weeks of training. However, this system, with the installation of Momat, is highly dependent upon adequate site preparation. Considerable grading must precede the soil stabilization effort. In the case of AMSS, ditches must be made on both sides of the prospective roadbed. During the test, the standard road grader used for ditching frequently got bogged down in the sand. An articulated, six-wheel drive grader was tried and it was highly successful. Bulldozers were also used for grading, however, they are slower and not as versatile as the grader.

There was no significant erosion noted on any of the AMSS areas during the entire test period. This proved the worth of the ditching techniques used. However, pot holes of various sizes formed in the AMSS after being exposed to a few days of traffic. These holes were mainly caused by rocks wearing through from underneath the surface. The appearance of these pot holes indicates that rolling the graded roadbed may be necessary to pack loose sand and gravel before the AMSS is applied.

The elements of the AMSS compound can be a hazard for personnel not familiar with their properties. The catalyst contains benzoyl peroxide and is highly flammable. The material can become unstable when stored over 4 months. The promoter is 100 percent active dimethylaniline and is toxic. Protective clothing must be worn by personnel during any handling procedures.

AMSS cannot be employed in wet or cold areas because the chemical agents will not dry under these conditions. R&D efforts are addressing this shortfall. During the test some problems were experienced on hot and humid days generally from about mid-morning on through until early evening.

Momat

Sheets of Momat can rapidly be placed on a prepared roadbed. However, attaching adjoining sheets is a time consuming process. Anchoring the outside edges of Momat became a requirement after wind had displaced sand and had lifted some sheets, resulting in damage during the early stages of the test. Mushroom shaped pins were fabricated and driven into the outer edges. (see Figure 2.4.) This appeared to be a satisfactory solution. No surface area was lost as would be the case if sandbags were used for this purpose.

Most of the Momat was used on straight segments of the roadway. Its durability under the turning motions of heavy traffic at corners is questionable because of the inability of the sheets to remain connected. Most of the Momat maintenance problems were the result of connecting bolts working free.

Erosion along single lane areas became readily evident as the test progressed. The most pronounced was the crowning effect that developed from the heavy traffic. Had the test continued much longer, reblading would have been necessary and sections of the Momat roadway would have had to be re-installed but this would not have been a major effort. Unlike the AMSS ditches which held the sand in place, the Momat had no feature as satisfactory to prevent erosion.

Because less surface preparations are required, Momat can be emplaced faster than AMSS. No special skills are required nor protective clothing, other than gloves. Significantly, Momat is reusable and, therefore, less expensive when amortized over several operations.



FIGURE 2.4 MOMAT. Momat required anchoring because sand was displaced and wind lifted the corners.

Jetty Construction

General. The Army's installation of a jetty for 300-ton crane operations was one of the more significant activities observed during the beach preparation phase. As stated the problem with crane operations at the waterline, the more shallow the beach gradient the greater the amount of reach required for a crane. As crane reach increases, its lifting capacity decreases. During high tide periods lighters could approach the crane, but at low tide the reach was exceeded and operations were halted until lighters could get in closer. This condition had meant a cessation of operations during the pretests except for a brief period around high tide.

This problem had been recognized before the 1972 OSDOC II experiment when a jetty concept was tested. The jetty employed was relatively elaborate with piling driven for a steel sided coffer dam filled with sand. During a storm the sand was washed out and subsequently replaced. Operations were conducted and were, of course, strongly influenced by the tides. While recognizing this limitation, the Army retained this approach for want of a better alternative as part of its shoreside transfer system for the unimproved beach phase of LOTS operations.

Questions concerning the construction of a readily deployable jetty that can be quickly installed and withstand surf action to permit crane operations under a variety of situations are addressed here.

Requirements for Jetty Length in Areas Different From Ft. Story

The crane on the sand jetty worked effectively in the test but it is questionable if it could do as well in an area where beach slopes are flatter. The Army's TRANS-HYDRO study (U.S. Army Training and Doctrine Command, U.S. Army Trans-Hydro Craft Study (1975-1985) (Trans-Hydro), Appendix L. 1 December 1973) shows the result of surveys of strategic areas of the world and indicates that beach slopes are generally flatter than Ft. Story. Figure 2.5 includes one result of the survey and also shows the crane reach and beach slope at Ft. Story. The figure suggests that considerably longer jetties would be needed in most areas.

A note of caution must be sounded in using the strategic surveys. If Ft. Story experience with more specific surveys can be taken as a guide, the surveys do not necessarily apply accurately to the near-shore bottom within 100 or 200 ft of the low-tide mark. This is the area of concern for the crane-on-beach jetty. The surveys of the Ft. Story beach, for example, show soundings about 60 ft apart moving to seaward from the low tide mark. The soundings are shown to the nearest foot. An error of half a foot is, therefore, considered allowable in the surveys. Half a foot in 60 ft is nearly 1 percent in slope. In turn, such an error if applied to jetty design could lead to having the jetty 60 ft too short or 60 ft longer than needed. Further, all this assumes no shift in the bottom sand, accurate surveys, no sandbars to seaward of the area of interest, and bottom slopes that are uniform. Actual bottoms, of course, vary considerably from these idealized conditions. (The top part of Figure 2.5, in fact, is based essentially on operations data

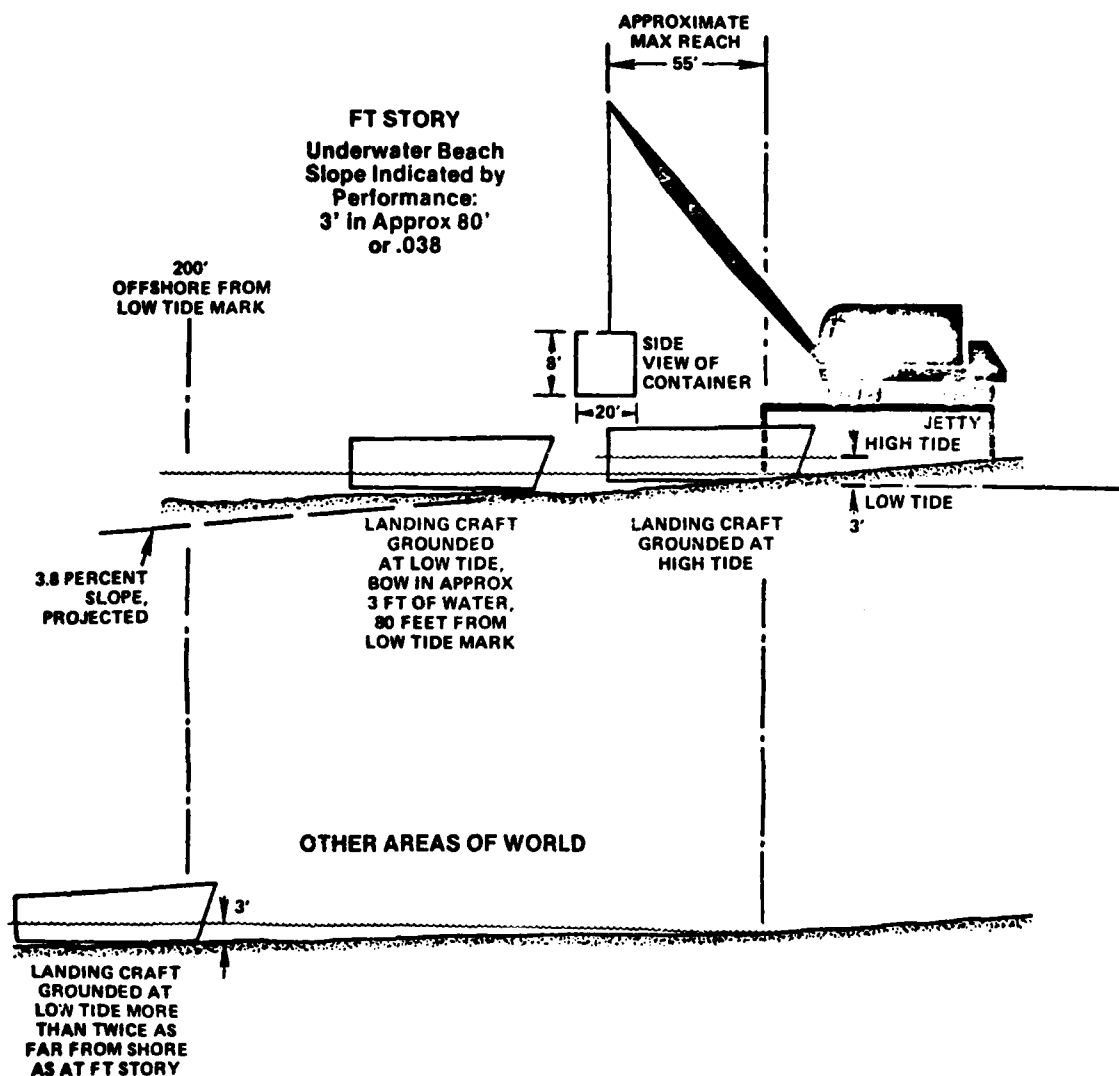


FIGURE 2.5. VERTICALLY EXAGGERATED SKETCH SHOWING JETTY, CRANE,
AND NEARSHORE BOTTOM SLOPE AT FT. STORY

(Also suggests effect of flatter beaches that predominate in
strategically important areas of the world.)

and assumed landing craft drafts at Ft. Story rather than surveys.) In particular, for many beaches just as at Ft. Story the bottom may be steeper between the high and low water mark than further to seaward.

The overall general beach slopes at Ft. Story are on the order of 2 to 2½ percent as measured by surveys, while surveys for other areas show slopes that are substantially less. The conclusion is that for other areas of the world the jetty would have to extend much farther into the surf in order to operate a substantial fraction of the tidal cycle. However, the question remains unanswered, at least in quantitative terms, of how well a jetty that extends farther outward would stand up to the heavier surf that also must be expected. OSDOC II results would indicate it might not stand up for long.

Jetty Installation. Considerable engineer support, although rapidly accomplished, was required for the emplacement of the jetty and crane. The jetty itself was fabricated from old sections of pontoons and filled with sandbags and approximately 1,000 cubic yards of sand. Mats or panels made out of rails and rail ties were used for the crane to travel on and off the jetty. All of the crane's beach movements required the use of these mats because of the crane's inability to move unsupported in the sand.

Prior to actual installation of the jetty Army dozers amassed several large piles of sand and personnel filled sandbags. Several of the metal panels were welded together to form an open ended, rectangular shell. These type preparations were initiated about 1½ weeks prior to actual installation and were accomplished on an infrequent basis so complete data on this effort are not available. Work was accomplished by personnel from both the port construction company and the container company.

On 3 August a partially completed jetty shell was pulled into position, the final panels were welded together, and the jetty filled. Operations were timed so that a low tide could be used. Work began shortly before 0500 and was completed about 1500 the same day. Detailed operations are discussed in Volume I.) On the following day the crane was positioned on the jetty and test lifts were made. During Phase I some seepage was noted and more sandbags and sand were placed in the forward corners of the jetty. Equipment used in the installation consisted of welding and cutting gear, dozers, forklifts, a frontloader (with forklift tines), small cranes, and an LCU (used to pump water over the sand for packing).

For all intents and purposes the Army LOTS force established that a deployable jetty could be made and rapidly installed. While some of the preparation activity was done well ahead of time, such preparations would have been possible in the time available to an advance force. The equipment used could also have been deployed with the advance force.

Port Construction Company. The primary burden for the Army's beach preparation fell on the 497th Engineer (Port Construction) Company. It's mission does not include nor is it equipped to support the efforts needed to prepare a beach site for container operations. The following additional capabilities were needed:

- Preparation of beach roads and working areas to be covered with Momat for heavy use. During the test this deficiency was overcome by borrowing a small grader from the Navy and Marine Corps effort at Blue Beach.
- Soil stabilization capability for surfacing turns and irregularity configured areas for which Momat is not well-suited. This was resolved by using Marine Corps personnel and AMSS equipment.
- Construction of beach entrance and exit roads, and preparation of marshaling yard area and other related engineering tasks that are needed for logistical facilities on shore.

While the unit may have been well-organized for port construction and rehabilitation of damaged port facilities, container operations place a great emphasis on heavier duty construction on shore more appropriate to other combat engineer unit missions. This does not mean an escalation to level of paved roads, concrete wharves, etc., but it does indicate that more capability for early LOTS operations is needed. To a large extent AMSS satisfied the beach road network requirement because it did not loosen as a result of erosion from hard rains and wind, is very portable, is relatively fast to install, and does not require a large number of people for installation.

In the initial stages of site preparation, augmentation of the port construction company would be advisable to accommodate crane installations, beach roads, site clearance, drainage, and other construction requirements on a time phased basis. All site preparation requirements for general cargo, ammunition, packaged POL, bulk POL, security, lighterage approaches, maintenance, and access roads need to be evaluated. In addition, the daily maintenance of roads, storage areas, and the like will be a continuing requirement and responsibility of the port construction company. These requirements need to be meshed with others of the port construction company, such as for lighterage channels and pier support. For deployment purposes a notional engineering detachment was added to the LOTS force, which included dozers, road graders, dump trucks, tractors, scoop loaders, forklifts, cranes, and miscellaneous lesser equipment.

III. CONTAINERSHIP OPERATIONS

SECTION SUMMARIES

Experience and Management

In general, Phases I and II were learning experiences for Army and Navy crews. While crane cycle improvements were noted at both the COD and barge-TCDF, the main reasons for these improvements were simply better organization and management. This resulted in improved coordination of working ship activities, the minimizing of lighter delays, and the generation of more crane transfers. The Army at the COD had a 13 percent improvement in crane cycle time but increased container off-load productivity 66 percent in the final phases of the test over early test results. For the Navy, at the COD there was a 17 percent crane cycle improvement and a 55 percent increase in overall container off-load productivity. At the barge-TCDF the Army had a 34 percent improvement in crane cycle time and a 111 percent improvement in off-load productivity. The Navy did not operate the barge-TCDF a second time, so there was no comparison to be made. In these cases, it appears that organization and management had a considerably greater impact on system productivity than just equipment operations alone.

Retrograde operations moved slower than off-load operations. Although in an actual operation the retrograde of empty containers would eventually become as important as off-loading, for this test it was handled as an administrative readjustment to prepare for the next phase. Instead of empty containers (or containers filled with cargo such as empty brass), fully loaded ones were used. However, this should be discounted as a reason for delay. Statistically it was found that, in terms of crane operations, container weight generally had no significant effect. In reality, by the time a Service got to a retrograde period, its hatch crews were considerably more experienced. Nevertheless, fewer containers were always retrograded than off-loaded, presumably because of the need to more precisely locate a container in a cell than in a lighter and possibly because maintaining a rapid rate during retrograde might seem to Service personnel less important than off-loading.

Training Requirements Summary

From the results of the test it is apparent that periodic large scale round-the-clock container exercises are badly needed by the Services. Establishing an efficient ship-to-shore container system, developing and maintaining management and operating crew skills for around-the-clock operations while experiencing normal personnel turnover underscore the need for LOTS field exercises, at least once annually. Different types of operational problems such as timing at each container transfer point, balancing resources with deployment limitations, employment of personnel, the stressing of units and equipment, and confidence in mission capabilities do not become evident without a full scale exercise using large numbers of loaded containers.

Crane-On-Deck Summary

The crane-on-deck method for container transfers proved to be a sound approach. The COD was not hampered by the mild sea state conditions experienced, although once some gusty winds banged a container into the side of an LCU and lightning and hard rain periodically halted crane operations everywhere for safety reasons. When the barge-TCDF was forced to halt because of local wave action, the COD was able to continue. COD sea state operating limitations could not be determined during the LOTS test for lack of rough seas. Crane cycle times varied from 6-10 min, depending upon whether day or night and off-load or retrograde operations were being conducted. (Crane planning factors are discussed in Section IX.)

The 200-ton lifting capacity crawler crane had no problems operating on the Navy hatch bridging equipment. The crane was able to work both sides of the ship from its centerline position although it was not able to take full advantage of this capability due to the presence of the barge-TCDF. Otherwise, lighter delays might have been eliminated by the mooring of an empty lighter on the opposite side loading was taking place. With this type of queue system operations and management could have been greatly facilitated.

The COD is inherently restricted by the inability of the crane operator to view the lighter moored alongside. This requires excellent teamwork among the crew, especially between signalmen and crane operators. In this respect the COD was penalized by inexperienced signalmen and crane operators and its cycle times suffered accordingly.

Further complicating COD operations was the requirement to pass tag line handlers (referred to as "jumpers") from one lighter to the next. This was supposed to be done by the use of a safety boat before the container landed. A fast and simple means of transferring tag line handlers is needed.

The crane-on-deck method is still undergoing system description, procedural documentation, and has not been accepted for implementation. As a system it will be used only for one- or two-ship type missions in lieu of deploying either barge or ship-TCDFs or possibly to augment TCDF resources for meeting surge throughput requirements. If the decision is made to implement this system, relatively inexpensive, hatch bridging kits need to be procured and positioned at locations yet to be determined. This latter course would be followed regardless of crane procurement/leasing decisions and, as needed, could have application in conjunction with a TCDF crane-on-ship hull program.

Barge-TCDF Summary

The barge-TCDF in most cases had higher daily productivity and transferred 20 percent more containers than the COD. It also had the highest 24 hr rate (184 versus 147 for the COD) and was the crane system most familiar to Army participants. Like the COD, its efficiency also was penalized by having to work with a different type crane system (in this case, the COD). The barge-TCDF would not have been forced to make lengthy moves around the ship and most of the time at least one barge-TCDF could have enjoyed the calmer water on the lee side of the ship. Crane cycle times varied from less than 6 min to about 10 min, subject to whether off-load or retrograde and day or night operations were being conducted. (Planning factors are discussed in Section IX.)

Because it has a relatively small (150 ft by 60 ft) platform the barge-TCDF crane was more subject to pendulation caused by wave action than the COD. It had to halt operations because of ships passing nearby, conditions in the sea state (upper) two and (lower) three range, and occasionally for choppy water (sea state not identified). Since this is one of the major areas of weakness with the barge-TCDF (another being its deployment), the Army needs to closely monitor research and analyses of the effects of sea states on crane platforms programmed by the Navy in CY 1979. The Army also should consider the use of wave dampening equipment, also a Navy development, to improve TCDF performance.

The barge-TCDF crane operator had the advantage of being able to see the lighter he was loading or discharging (which the COD operator could not), as well as the containers on deck and some in the hold (that the COD operator could also see). Relocations of the barge-TCDF were more frequent (once per bay) than the COD (once per every other bay); but they required less time (about 35 min per relocation from bay to bay versus about 100 min for the COD). Tagline handlers could work on and off the barge-TCDF when loading lighters, eliminating the need for a boat to support the transfer. Mooring was easier for lighters at the barge-TCDF than the COD even though the lighters were further from the wave sheltering effects of the ship.

As part of a LOTS system the barge-TCDF has a critical deployment weakness due to its size and weight and it is also sea state sensitive. However, if available it is highly productive in fair weather. At the present time it is the only ship discharge system on hand in an operational unit.

DoD Support Needed

For the near term DOD support is needed to accelerate the Navy development of a less sea-state-sensitive, self-deployable containership discharge system which will meet the requirements of both the Navy and Army.

BACKGROUND

Preparation

Participation by all of the units involved was on a first-time basis. For the most part, there were no manuals, films or experienced personnel to plan and direct operations. There were some prior training exercises but no opportunity to practice with all interacting components of a complete LOTS system. For the Army container company their equipment was less than a year

old and for the Navy none of the major items of the ship container handling equipment were theirs at all, except for some slings, spreader bars, and deck gear.

Going into the test there were a number of questions about procedures and potential problem areas that were not and could not be answered until at least one full day of the test had been accomplished. Matters such as adequate lighting at night, tie-downs for the cranes, maintenance during sustained operations, crane refueling procedures, maintaining ship stability, coordinating with ship's company, and controlling and mooring lighters all had to be planned and worked out in a relatively brief interval of time, usually during the test.

Organizational Confidence

A substantive influence on the test was the psychological challenge of what initially seemed to be an impossibly high throughput objective of 300 containers per day. There were many doubters at all levels. It is to the credit of all participants that this objective was exceeded once (321) and could have been attained a second time on the last day of the test if the ship crews had not run out of containers (285) to discharge. In all probability this daily rate can be exceeded again in future exercises if the lessons learned on the Joint LOTS test are applied, the weather is favorable, and motivation continues to run high. The "300 containers per day" goal was demonstrated to be an attainable objective under ideal conditions.

GENERAL

For the evaluation of LOTS capabilities it is necessary to make two major adjustments to interpret test findings. First the containership was loaded to about 60 percent instead of full capacity. Second, a combination of two transfer methods was used (COD and barge-TCDF) instead of just one type, such as two CODs or two TCDFs (depending upon the scenario). These measures were necessary in the preparation and organization for the test and were artificialities that influenced test results.

Partial Ship Load Implications

In the first case, a partially loaded ship had two effects. First, certain "working ship" activities such as opening and closing hatches and crane relocations had to be accomplished about 40 percent more frequently than otherwise would have been required. The length of time for such working ship activities varied, depending upon the level of experience and degree of organization.

The second effect is even more difficult to identify. The containers in the upper levels of the ship could be handled faster than the ones in the lower areas because the crane operators could see, better control, and execute the minor boom and spreader bar adjustments necessary for attaching the lifting device. At lower levels they had to rely on a signalman for directions to make the connection between spreader bar and container; the communications between signalmen and crane operators were another highly variable matter. With an experienced team such a difference might not be as significant. Because of the paucity of samples and the fact that the JTD data was taken only in minutes instead of minutes and seconds, it was not possible to conduct an in-depth analysis of this second effect with a reasonable degree of accuracy.

Single Method Discharge

While the opportunities for making side-by-side comparisons of COD and barge-TCDF operational methods are available, the two methods are not actually compatible. The barge-TCDF limited to a significant extent the side at which lighters could be moored at the COD. The COD has the inherent advantage (if it has a 200-ton lifting capacity) of working either side of the ship. If, for example, a lighter were moored and waiting on one side of the ship while another lighter was being loaded on the opposite side of the ship, it can be speculated that there would have been no lighter delays at all. COD productivity could easily have been higher.

On the other hand, with two barge-TCDFs there would have been no requirement to relocate the barge-TCDF from one side of the ship to the other. Also, at least one barge-TCDF would have been in the lee of the ship almost continuously where transfer operations would be easier and faster in choppy seas.

However, there was only one barge-TCDF and only one COD available for the test, so to that degree operations were constrained. There was no doubt about the adverse effects of higher sea states when the barge-TCDF was forced to halt on occasion and the COD was able to continue container operations.

Cranes

In considering only total numbers of transfers by day for each crane, some caution is needed. The Manitowoc 4100 W crawler crane (200-ton lifting capacity) was a leased, 4-year old crane that had been used in heavy construction in New York City. It was not a familiar inventory item to the Army and Navy crane operators, but, according to the owners, it is an easy crane to operate. Secondly, it was heavily instrumented and had an "umbilical cord" to an instrument van nearby. Although everything possible was done to minimize the influence of such instrumentation, it was a burden. The crane was not free to rotate 360 degrees. Whenever the crane had to relocate, the slings for lifting the hatch bridging kit had to be changed and the spreader bar attached; the instrument van had to be shifted; and the spreader bar detached and slings reattached before the relocation could continue. This was an artificial and disruptive feature in the test. Valuable data were gathered from the instrumentation, however, that made it worth the effort.

Approximately one year after the test the leased crane, according to its owner, was still operating and being used in the port of Richmond to discharge containers from ships. No major maintenance was performed on the crane subsequent to the test. In fact, a company representative reported that during the test the crane had not been worked very hard and no wear or strain was evident. It was the representative's opinion that the crane could have been used as in the test for several years without heavy maintenance being required.

By contrast, the barge-TCDF was about a year old. It had been used on the heavy-lift breakbulk ship pretest but had no prolonged heavy construc-

tion use. Army and, to a lesser degree, Navy personnel had trained with it on the James River. Also, some Army crane operators had operated similar cranes earlier while on Okinawa (but not barge mounted). Hence, there at least had been some crane operator experience using this crane system.

Some of the down periods due to maintenance were the result of operator error and inexperience. In one case an operator two-blocked the boom and hook on the COD causing a two-hour delay. In another case about an hour was lost because a loose radiator cap allowed the water to boil off. In another case an hour was lost simply because no oil had been added on the previous shift. A cable was mashed on a drum and had to be replaced. These types of delays were costly and indicative of the training level of the military crews.

Daily Activity

At the containership, as at other sites, a period was set aside at the beginning of each shift for crane maintenance. In Phase I this procedure was not strictly followed at first but subsequently improved. Maintenance consisted of operator checks, refueling, lubrication, and minor adjustments. This type of activity was accomplished on a regularly scheduled basis and generally required about 60-90 min. In addition to this necessary period of operational inactivity, a lunch break was usually taken both during the day and at night about midway through the shift, usually lasting about 30 min.

Thus, each crew would be aboard ship for a period of about 12 hr, but crane activity was more on the order of 10 hr or less -- depending upon weather, breakdowns, lighters, and other factors. For analysis purposes, therefore, a day consisted of 20 hr of crane transfer operations and 4 hr of (crane and crew) maintenance and shift changes. Daily calculations, however, are based upon the full 2-shift 24-hr period (0600 to 0600) to indicate daily productivity and to develop planning factors. Hourly rates are strictly 60 min. segments to indicate the pace of off-loading or retrograde.

CRANE-ON-DECK

In the 15 days of container throughput during the LOTS test the COD made some 1,166 container transfers. Of these, 60 percent (or 701) were discharged from the ship and the remaining 40 percent (or 465) were retrograded aboard ship.

To summarize its operations, the COD started very raggedly and, in fact, the average container rate (total minutes of crane operations divided by total containers transferred) was about 18½ min. per container, including unscheduled maintenance requirements and other delay periods. Peak operational periods occurred in Phase III when the overall rate was 14½ min. per container and in Phase I(R) where the overall rate for off-loading was only 10-1/3 min. per container.

Part of the problem in Phase I was related to unfamiliarity with equipment and procedures. This was evidenced by the fact that in one case 5 hr were spent during the step by step procedure of relocating the COD. To illustrate all of the steps involved, this effort consisted of changing lifting devices, closing one hatch, changing lifting devices, shifting the two hatch

bridging spans, changing lifting devices, relocating the instrument van, changing lifting devices, moving the crane from one hatch to the next, shifting the old two hatch bridging spans, changing lifting devices, opening a new hatch, and changing lifting devices to resume 20-ft containers operations. This was a lot of working ship activity, but it was activity that later was accomplished in less than an hour to move the crane and shift all hatch spans, 13 min. to move the instrument van, less than 30 min. to close one hatch and open another, as well as all the requisite lifting device changes. Altogether, the same move that earlier took 5 hr eventually took about 1-3/4 hr.

The Navy in Phase II had its first-time shipboard experience with the COD and also had organizational and familiarization problems. But on the first day, they transferred 56 percent more containers than the Army did in Phase I. Then on the first day in Phase III, the Navy COD crew exceeded its own highest daily record by 55 percent. In its second hands-on effort at the COD in Phase I(R), the Army improved its previous highest daily rate by 66 percent but still was about 30 percent short of the Navy's high mark. Thus, the data were considerably affected by the learning experience and, accordingly, discrimination is necessary in analyzing applicable COD data and estimating capabilities. (Table 3.1 summarizes productivity by phase for the COD.) The shifts listed in the table include times for all activities, not just for container transfers.

TABLE 3.1
COD PRODUCTIVITY FOR
VARIOUS PHASES OF THE TEST

Operational Phase	Number of Containers Off-Loaded	Number of Containers Retrograded	Phase Totals	Number of Shifts (12 hr each)	Containers Transferred, Most Productive Shift
I	153	137	290	9.00	38 Off-ld
II	225	195	420	9.25	63*
III	222	133	355	7.00	96 Off-ld
I(R)	101	0	101	1.75	63 Off-ld
TOTALS	701	465	1,166	27.00	-

* Peaked at 63 two times, once during off-load and once during retrograde.

Because the start and stop times for delays are not recorded in the JTD data base, there is no means of accurately determining the length of all delays. For that matter, there were also a number of delays labeled "unknown," which considerably obscures operational difficulties, management shortfalls, learning experiences, and miscellaneous problems. Thus, computer-assisted breakdown of delay times from the data base could not be accurately compiled. However, based upon data from data collection forms, samples and notes made during the test, analysis on some of the major operational requirements was possible.

COD Working Ship Analysis

Refueling. Crane refueling was an area that required better planning, especially for the Army. Nearly 5½ hr of delay time can be identified in Phase I as being associated with refueling. This involved changing rigging to lift fuel pods, bringing a lighter alongside, loading and off-loading fuel pods, and the use of a hand-operated fuel pump. The crane has about a 315 gallon capacity but no data are available as to the quantities used by the crane each time.

Generally, both Services refueled the crane once a day. As the test progressed, both Services managed to complete refueling in about 35-60 min. To expedite this procedure a power pump and hose system should be used, as demonstrated by the Navy. In addition, a compatible fuel module should be considered that uses the International Standards Organization (ISO) corner fittings. This would help eliminate, for the Navy at least, the need to change lifting devices on the crane, since the Navy uses a sling with the ISO locking pins at the end of each leg.

Planning and coordination are necessary to prevent unnecessary disruption of lighters unloading the ship. Deck crews should be drilled in safety and speed to minimize refueling time. At shift change or such time as an operational halt may be necessary, the lighter bringing in the fuel can be moored to the opposite side of the ship from the last lighter being loaded. Activities that can be accomplished concurrently, such as having slings ready and tag lines attached to the fuel pods while the COD is still making its final container lift, need to be planned and coordinated to reduce delays.

Hatch Cover Operations. As discussed in Volume I, there were one- and two-hatch type operations. That is, a hatch was either opened or closed (one-hatch operation) or one hatch was closed followed by a second hatch that was opened. The steps involved were:

- Change from 20-ft spreader bar or chains to the 40-ft spreader bar,
- Attach lifting blocks to the hatch cover (unless already attached from a previous lift),

- Attach 40-ft spreader bar to the lifting blocks/hatch cover (unless already attached) and tag lines,
- Lift the hatch cover,
- Land the hatch cover on a temporary storage area or close the open hatch,
- Detach the 40-ft spreader bar from the hatch cover or the crane (depending upon whether the next hatch cover operation involves that hatch or not), and
- Change back to the 20-ft spreader bar.

The average times by operational phase for a single hatch operation are contained in Table 3.2. These times include both the first-time efforts as well as the best ones. As may be observed, the overall average for each phase is relatively high. Cycles began with a change from the container lifting device and terminated when the container lifting device had been placed back on the crane.

TABLE 3.2
AVERAGE TIMES REQUIRED FOR
COD SINGLE HATCH OPERATIONS

Operational Phase	Average Time Required (In Mins)	Unit Involved
I	27	119th Trans.Co. (TS)
II	29	NAVCHAPGRU
III	20	NAVCHAPGRU
I(R)	21	119th Trans.Co. (TS)

Actually, the single hatch operations varied widely, from 9.7-47 min. In some cases as much as 15 min. was spent just changing from the 20-ft spreader bar to the 40-ft one. In another case 20 min. was spent changing back from the 40-ft spreader to the 20-ft one. An examination of the elements described above for this type operation revealed that such times should be discarded since factors not related to the hatch cover operation were involved. Such times were well outside of the normal distribution. Based upon observations of 23 single hatch operations, approximately 15 to 18 min would be a typical amount of time spent for a single hatch operation. Table 3.3 provides the average times for each element of a single hatch operation (discarding outliers), along with the fastest time recorded (19 August).

TABLE 3.3
SEGMENT TIMES (IN MINS) FOR COD SINGLE HATCH OPERATION

	Change Spreader Bars	Attach Spreader to Hatch Cover	Hatch Cover Lift-to- Land	Spreader Crane Detached	Change Spreader	TOTAL
Test Average	3.49	(4.59)	6.21	2.12	3.50	15.32
Fastest Cycle (Closed a Hatch Cover)	1.98	*	2.88	2.27	2.53	9.66
* Already attached to the hatch cover as a result of the previous operation (opening the hatch). The "Attach Spreader to Hatch Cover" time of 4.59 min. is included above for information to apply to those cycles as appropriate.						

Normally during the test a spreader bar was either attached or detached in a single hatch operation but not both. For comparison between the fastest time and the test average in the above table, the spreader hatch cover attachment time (indicated in parenthesis) is not included in the total at the right. The type of operation represented is a close-hatch-cover situation. An open-hatch-cover situation would require adding the 4.59 min. and subtracting the 2.12 min. above (spreader crane detached), since the spreader bar would be left attached to the hatch cover for the next operation (a close-hatch-cover event). Thus, for opening a hatch cover 17.79 min., or 18 min., would be representative while about 15 min. would be needed to close it.

The most time consuming requirement for any hatch cover operation was the mating of the spreader bar with the hatch cover lifting locks. This part of the cycle took anywhere from 2 to 11 min. A lucky hit vastly improved cycle times. Perhaps with more experienced crane operators and deck crews this time could be greatly reduced.

The other type of hatch operation was the two-hatch event in which a hatch would be closed and a second one opened. The steps in that type of cycle are:

- Detach the 20-ft spreader bar and rotate the crane to attach the 40-ft spreader bar,
- Attach the spreader bar to the hatch cover (unless it was unused and had been left attached to the hatch cover),
- Lift the hatch cover and place it back on the hatch,
- Detach the spreader bar from the hatch cover and attach it to the next hatch cover,
- Lift the second hatch cover and place it nearby, and
- Detach the 40-ft spreader bar (left engaged to the hatch cover) from the crane and reattach the 20-ft spreader bar.

Average times for the two-hatch operations observed are contained in Table 3.4. The cycles represent times recorded for 16 events taken during each phase of the test. Most occurred during the night shift. A cycle was taken from the change of spreader bars until the change back to the original bar so that container operations could continue.

TABLE 3.4
AVERAGE TIMES REQUIRED FOR COD TWO-HATCH OPERATION

Operational Phase	Average Times (In mins.)	Unit Involved
I	56.50	119th Trans. Co.(T.S.)
II	43.85	NAVCHAPGRU
III	28.00	NAVCHAPGRU
I(R)	23.00	119th Trans. Co.(T.S.)

As with the other type of hatch cover operation, the elements of the cycle are of interest. The actual lifting and landing of the 34-ton hatch covers were a relatively fast matter. In fact, the hatch covers are really being lifted during only 30 percent of the cycle. The remaining time is spent preparing for the lift, that is about 30 percent of the time attaching the spreader bar to the hatch-cover and about 40 percent changing spreader bars, clearing the hatch cover of tools and equipment, attaching the lifting blocks, and fastening tag lines. Table 3.5 provides a breakdown of the cycle elements and average times for each segment (again, outliers have been discarded). For comparison the fastest cycle is also included (20 August).

TABLE 3.5
SEGMENT TIMES (IN MINS) FOR COD TWO-HATCH COVER OPERATIONS

	Change Spreader Bar	Attach Spreader to Hatch	Hatch Cover Lift-to- Land	Attach Spreader to 2nd Hatch	Hatch Cover Lift-to- Land	Re-Rig for Oper- ations	Total
Test Averages	6.81	5.17	8.68	6.25	6.27	5.25	38.43
Fastest Cycle	2.0	3.0	4.0	4.0	3.0	4.0	20.0

Three other two-hatch operations were in the 26-29 min. time frame, indicating that improvements can be expected over the test averages. It is reasonable to expect that with good organization, such as completing preparatory activity before the cycle begins (clearing the hatch cover of tools) and accomplishing as many deck support activities as possible (fastening taglines, installing the lifting blocks, etc.) concurrently with crane activities so the crane is not forced to wait, the cycle averages could be reduced to 30 min. or less.

The attachment of a spreader bar to a hatch cover is a time consuming task that deserves attention. The time lost is roughly equivalent on a two-hatch operation to one full container discharge cycle. At present, there are no known devices available that could be helpful.

COD Relocations. The COD had to relocate twice during each phase of the test, except Phase I(R) when it remained stationary. Elements of the COD relocation cycle were:

- Change rigging from the container lifting device (spreader bar or container sling) to chains;
- Rig, lift, and locate the first hatch bridging span;
- Rig, lift, and locate the second hatch bridging span;
- Change rigging, attach rigging to the instrument van, lift, locate the instrument van, and change rigging back to chains;
- Remove tiedowns, move crane, and tie it down again;
- Rig, lift, and locate the third hatch bridging span;
- Rig, lift, and locate the fourth hatch bridging span; and
- Re-rig for container operations or hatch openings.

The variability of the times for the above steps ranged from about 79 min. to 145 min. During the test a lengthy hatch opening operation followed

the 145 min. relocation which tended to exaggerate the total COD non-operational time during one of its first few moves. On the average, however, the time for all COD relocations was about 116 min. By disregarding the artificiality of relocating the COD instrument monitoring van, this time is reduced to about 100 min. Problem areas associated with COD relocations primarily relate to activities like chocking and unchocking, tie-down functions, rigging and unrigging. Faster preparatory activities such as attaching taglines, more training, better deck organization, and better rigging practice are needed. The actual movement of the crane from one hatch to the next usually required 5 min. or less. The lift-to-land segments of moving hatch bridging spans similarly required about 6 min. at most. Table 3.6 provides a breakdown of the cycle elements. To simplify the table, functions such as rigging for the lift of a certain span are included in the column which addresses moving that span, the crane or instrument van, as the case may be. Only one outlier, 15 min. to initially change rigging, was discarded from the six events considered.

TABLE 3.6
SEGMENT TIMES FOR COD RELOCATIONS

	Change Rigging	Move Span 1	Move Span 2	Shift Instru- ment Van	Move Crane	Move Span 3	Move Span 4	Re-rig for Opr.	TOTALS
Average Times	3.05	16.83	17.55	14.47	32.25	12.22	12.38	6.96	115.71
Fastest Time	2.0	17.0	8.78	13.35	28.20	10.85	5.63	5.83	91.64

COD Container Operations

Hatch Crews. Crane-on-deck capabilities and limitations can easily be misinterpreted from some of the results of the test. For example, in the early periods of the test the Army was slowed by unfamiliarity with the tie-down devices that were used on the crane and hatch bridging spans and, in general, with the deck gear needed to work the ship; by inexperience with handling lighterage under a system dependent upon a rapid exchange of lighters; and by the first-time learning experience of having to do a number of operational steps successively instead of several things concurrently. The Navy similarly had to undergo this learning experience and adjustment but had at least the benefit of observing the Army's trials before they had to face the same events.

The Navy hatch crew was larger than the Army's crew. The Navy used about 13 people per hatch while the Army used a crew of about 7-9 personnel including crane operator, signalman, hatch foreman, and stevedores. The Army has identified this manpower shortfall as a deficiency. Observations tend to support this conclusion. While there is some question regarding the effectiveness of four or six or even eight 180-lb men directing the course of a 20-ton pendulating load at the end of a 90-ft line, minor control and guidance are possible when pendulation is not significant. This control is especially needed in the lighter so that the container loading rate can be maximized

and pendulation damage minimized. Army lighter crews generally did not offer much assistance to stevedores. Although stevedore crews were sometimes short-handed, lighter crew members would watch instead of assist with tag line handling or loading. Once tag line handlers had completed loading a lighter, they were transferred to another incoming lighter. On occasion delays were incurred waiting for the stevedore exchange to take place. A faster means of transferring or eliminating the need to transfer stevedores is required. In the test the transfer was supposed to be done using a safety boat, but this was not always possible.

A second function that increases hatch crew work load is the mooring of lighters, which also requires attention from the hatch crew. Instead of having an LCU alongside for 4-6 hr at a time as with breakbulk operations, the frequency is more on the order of one every 20-30 min.; for an LCM8 this frequency is about every 6-16 min. instead of every 1-2 hr. While the crane is reaching for its next load, the hatch crew has to oversee the casting-off of the last loaded lighter and the mooring of the next. At the same time since the spreader bar has to be attached to the next container, tag line handlers are needed to assist in guiding the spreader bar over the container to be lifted. Without people on deck for this purpose, someone must be dispatched from the hold to support the lighter succession requirement. This can create delays both in mooring (i.e., not knowing a new lighter is there) and in latching time because the spreader bar lacks enough tag line handlers to guide the pins into the corner fittings.

Additional hatch crew members could also be used in other capacities that would increase productivity. Minor repairs and adjustments to spreader bars are required from time to time that required the crane to halt and wait. With a back-up spreader bar or container slings, the damaged spreader bar could be repaired/adjusted by part of the crew while the crane continued its container operations with the back-up. Relief in extreme weather is necessary more frequently so a supernumerary capability is also needed. With additional help, steps in working-ship activities could be accomplished which would expedite hatch cover removals or crane relocations by clearing the deck, preparing slings and lifting devices and partially unlash the hatch bridging spans. In this way more concurrent activity would decrease delay times and bring the crane back to container handling operations sooner.

More efficient accomplishment of the above type activities does not require more technical knowledge or new equipment, but better management and skills from training and experience. By the end of the test participating units had demonstrated that they had acquired improved skills and a better appreciation of how to achieve faster ship operations. However, units need realistic and demanding training opportunities so that further improvements can be made and skills passed on to future trainees. The increased productivity offered through containerization of cargo can not be realized with wasteful use of time or bad organization. Training and drilling are required to learn the best and fastest methods needed.

Weather. In the analysis of crane cycle times several key questions were investigated to assess their influences. Weather, in so far as sea state was concerned, was not a major factor except one instance of some lighter motion by a LARC-XV that made completion of a lift inadvisable and substitution of another lighter necessary. In the seas experienced crane motion due to sea state was also not an important factor. Wind, lightning, and rain did halt operations for personnel safety reasons. It is not possible from evidence

in the data base or observations recorded to state conclusively that the COD was affected by wind, rain, or lightning more than the barge-TCDF. At its anchorage the ship was a stable and reliable platform¹ for the crane throughout the test.

First Day Results. For comparison of lessons learned during the course of the test, first day results for each phase were evaluated. The Army operated the COD during Phases I and I(R), the Navy during Phases II and III.

Army Operations. Figures 3.1 and 3.2 show the distributions for day and night operations during Phase I and Figures 3.3 and 3.4 show the distributions for Phase I(R).

For the Army, total productivity jumped 66 percent (from 61 containers to 101) despite the fact that the night shift in Phase I(R) (see Figure 3.4) was only a partial shift (9.5 of 12 hr, including a brief maintenance period), because the COD ran out of containers before the night shift was over. The improvement in crane cycles during the day shifts from 8.06 min. per cycle in Phase I to 7.08 min. in Phase I(R) was about 12 percent faster or roughly 1½ more container cycles per hour. But the total number of containers off-loaded represented a 66 percent increase in Phase I(R) over Phase I by minimizing lighter delays, other waiting periods, and working-ship activities. More time was used for productivity with respect to effective crane employment.

Navy Operations. The Navy crew on its first day effort also did very well. The first day shift of Phase II had a 7.68 min. mean average time and the night shift 7.90 min. Again, the night shift samples were relatively small (12). The median times in both cases was 7 min. Figures 3.5 and 3.6 reflect the distribution of these cycle times.

On the first day of Phase III the Navy crew reached the peak COD productivity for the exercise of 147 containers. This represented about a 55 percent increase in productivity over their Phase II rate. Figures 3.7 and 3.8 show the distribution of crane cycle times for day and night shifts the first day of operations in Phase III. The improvement in mean cycle times from Phase II (7.68 min.) and Phase III (6.07 min.) was about 21 percent indicating greater crew experience and better deck operations in terms of maximizing crane-container transfers.

Night operations showed similar improvement. The mean improved from 7.90 min. for container to 6.90 min. or about 13 percent better cycle time. At the same time productivity went up about 60 percent, again indicating better deck organization and management.

¹ For additional data on crane performance see Naval Coastal Systems Center, Preliminary Report: Container Off-Loading and Transfer System (COTS), Crane-on-Deck (COD) and Hatch Cover Bridge Test. A Report on Installation, Test and Evaluation of LOTS Phase II (Navy), COD System conducted as part of Joint LOTS Test, 6-21 August 1977. (DT-II D/OT-II A) Unclassified.

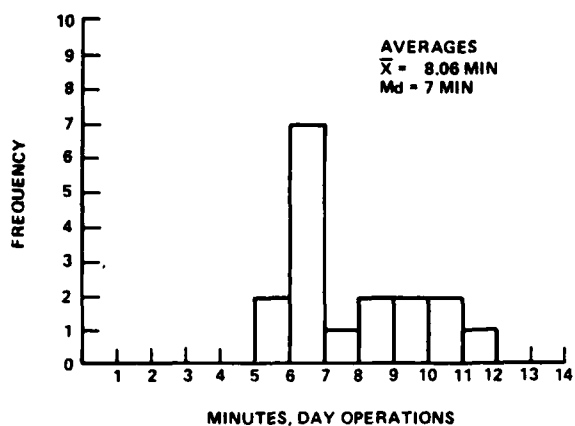


FIGURE 3.1. PHASE I COD OFF-LOADING CYCLE DISTRIBUTIONS 6 AUGUST 1977 - DAY OPERATIONS (Excludes Cycles greater than 12 min.)

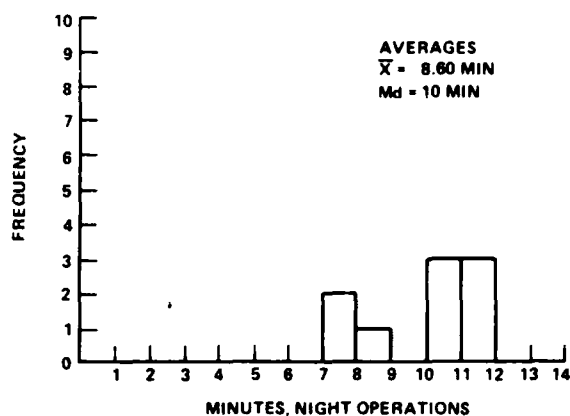


FIGURE 3.2. PHASE I COD OFF-LOADING CYCLE DISTRIBUTIONS 6 AUGUST 1977 - NIGHT OPERATIONS (Excludes Cycles greater than 12 min.)

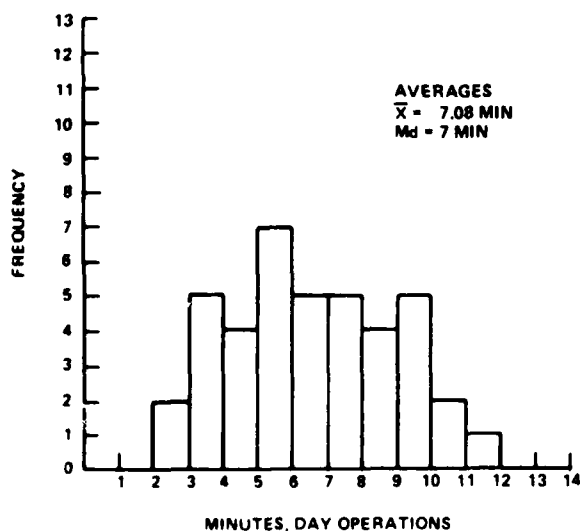


FIGURE 3.3. PHASE I(R) COD OFF-LOAD CYCLE DISTRIBUTIONS - DAY OPERATIONS (Excludes cycles greater than 12 min.)

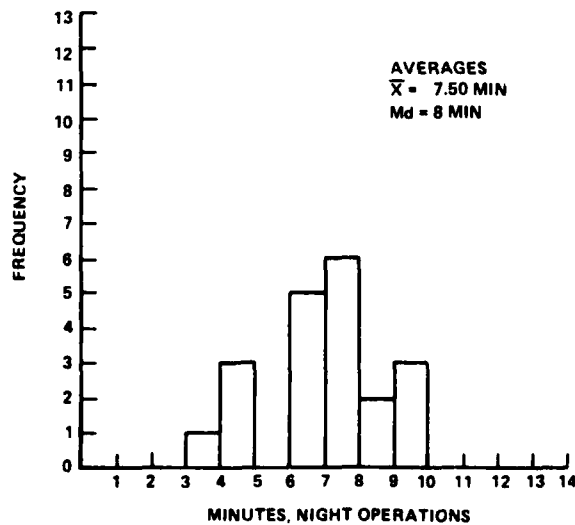


FIGURE 3.4. PHASE I(R) COD OFF-LOAD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

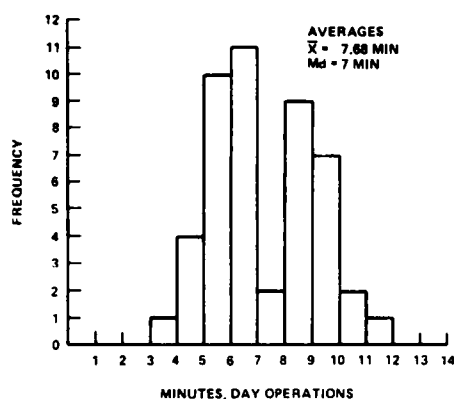


FIGURE 3.5. PHASE II COD OFF-LOAD CYCLE DISTRIBUTIONS 11 AUGUST 1977 - DAY OPERATIONS (Excludes cycles greater than 12 min.)

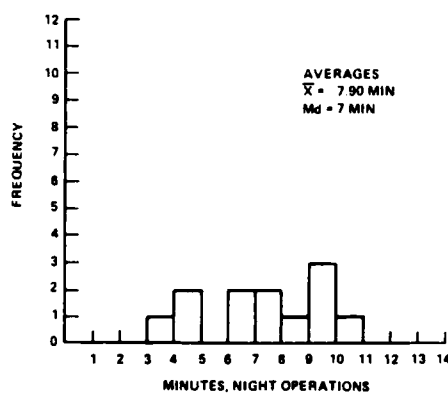


FIGURE 3.6. PHASE II COD OFF-LOAD CYCLE DISTRIBUTIONS 11 AUGUST 1977 - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

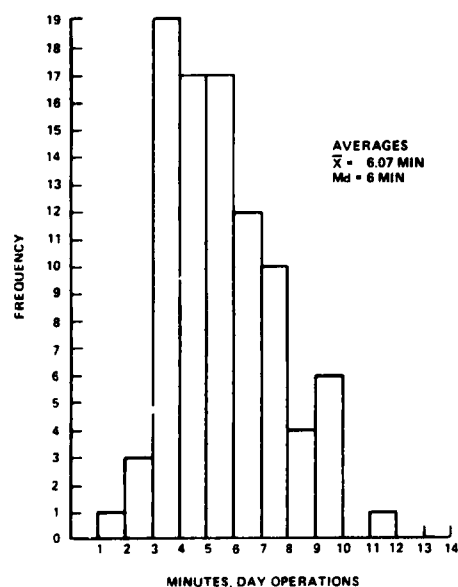


FIGURE 3.7. PHASE III COD CYCLE DISTRIBUTIONS 16 AUGUST 1977 - DAY OPERATIONS (Excludes cycles greater than 12 min.)

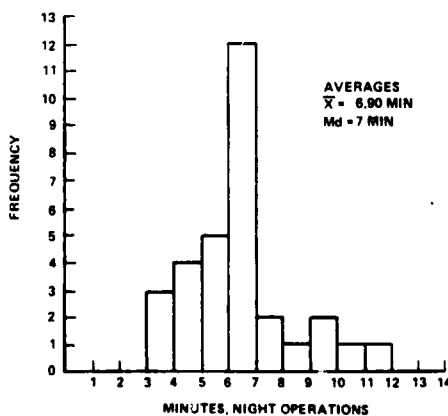


FIGURE 3.8. PHASE III COD CYCLE DISTRIBUTIONS 16 AUGUST 1977 - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

Observed Improvements. After five shifts of activity for each crew of both Services analysis indicates overall productivity improvement on the order of about 60 percent. The contrast in both mean and median crane cycle times constituted an improvement of between 12-21 percent for crane operators, depending upon the shift. However, the big difference was in more effective deck organization and coordination so that the crane's boom need not be unnecessarily halted. As noted, both Army and Navy crews made considerable improvement. Faster hatch openings/closings were made, lighter delays were minimized, and fewer operator errors were made. However, both Services demonstrated a need for further training and drills in handling containers expeditiously aboard ship.

Table 3.7 summarizes the first day results for each phase.

TABLE 3.7
FIRST DAY RESULTS BY PHASE FOR CRANE-ON-DECK OPERATIONS
(IN MINUTES)*

Service Operating COD and Phase of Test	Day Operations		Night Operations		Off-Load Productivity
	Mean	Median	Mean	Median	
Army-Phase I	8.06	7	8.60	10	61
Army-Phase I(R)	7.08	7	7.50	8	101
Navy-Phase II	7.68	7	7.90	7	95
Navy-Phase III	6.07	6	6.90	7	147
* Excludes all cycle times greater than 12 min.					

Overall Phase Results for 119th Trans. Co. (T.S.) (Container). Figures 3.9 and 3.10 show the crane cycle distributions for all of the day (3) and night shift (2) off-load operations in Phase I. Again the 12 min. cut-off time was used to screen out most non-crane related delays. Compared to the first day, crane mean cycle times actually increased by more than half a minute for day operations and more than 2 min. for night operations although there are too few cycles in the night shifts for a valid comparison. The medians of both reflect a shift of about a minute. Two possible explanations for this are that the Army made a dedicated all-out effort the first day and secondly the first day's off-loading included all of the on-deck and upper level containers. Subsequent containers were not within the operator's view and, therefore, were slower to latch.

Figures 3.11 and 3.12 show the crane cycle distributions for day and night operations during retrograde periods. It should be noted that the mean cycle times are faster for daytime retrograde operations than for daytime off-loading. In that regard these observations are made. By the time retrograde began, the day crew had gained three full shifts of operational experience and the night crew two. Another factor may have been that the crane operator used a visual target in backloading, in that he could see the cell guides and watched the relative angle for lowering the container.

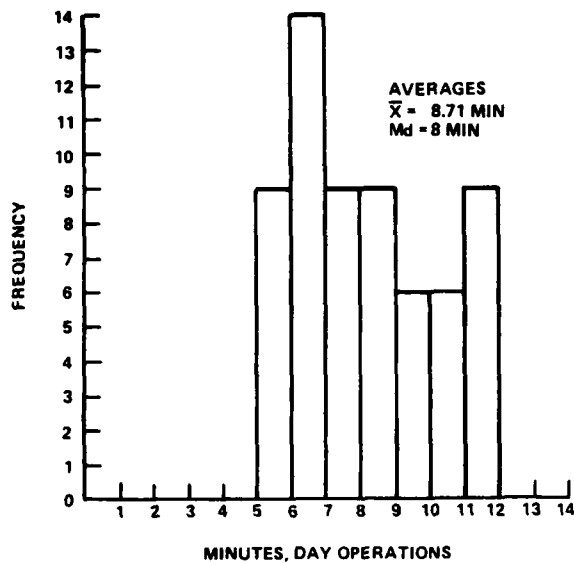


FIGURE 3.9. PHASE I COD CYCLE DISTRIBUTIONS OFF-LOAD OPERATIONS - DAY OPERATIONS (Excludes all cycles greater than 12 min.)

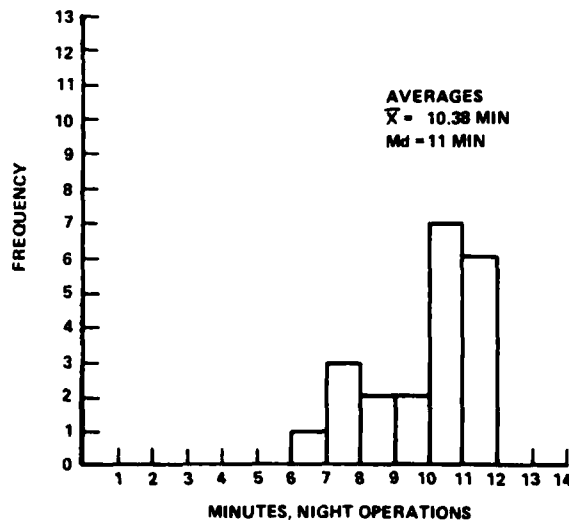


FIGURE 3.10. PHASE I COD CYCLE DISTRIBUTIONS OFF-LOAD OPERATIONS - NIGHT OPERATIONS (Excludes all cycles greater than 12 min.)

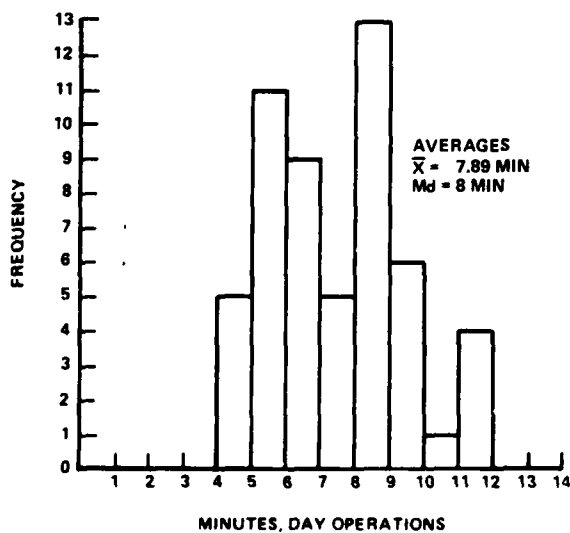


FIGURE 3.11. PHASE I COD RETROGRADE DISTRIBUTION CYCLES - DAY OPERATIONS (Excludes cycles greater than 12 min.)

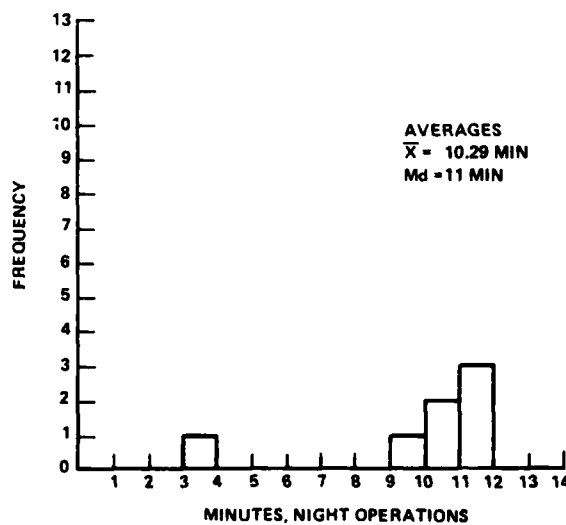


FIGURE 3.12. PHASE I COD RETROGRADE DISTRIBUTION CYCLES - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

Again the sample sizes for night retrograde operations were small and the difference between night off-loading and retrograde was insignificant (10.38 and 10.29, respectively). The median in both cases was 11 min.

Overall Results for Navy Units. Figures 3.13 and 3.14 show the off-load productivity for all day and all night operations during Phase II. Overall the mean averages reflect an insignificant difference (7.52 min. for day versus 7.56 min. for night). Except for the first day shift's operations for which the Navy crew had been highly motivated, the off-loading productivity rates of the remaining two day shifts and two night shifts were about the same.

Phase II retrograde cycle distributions are depicted in figures 3.15 and 3.16. Average crane cycles for daytime retrograde operations, as in the case with the Army, were less than for daytime off-loading; that is, 7.09 min. per daytime retrograde cycle versus 7.52 per daytime off-loading cycle. For night operations, however, the retrograde cycle (7.92 min. for the mean) increased slightly over the night off-loading cycle (7.56 min.). The Navy Phase II crane cycle times in every comparable case were faster than the Army's Phase I times on the average of about 24 percent. However, the means for what were essentially the learning periods for both Services were from 7.5-9 min. for daytime off-loading and 7.5-10.4 min. for night off-loading. For retrograde the cycles were about 7-8 min. for daytime and 8-10.3 min. for night time.

Phase III was the best period for COD crane cycles. The crane's daytime off-loading average dropped to 6.13 min. per cycle and the night cycle to 7.33 min. (See Figures 3.17 and 3.18.) The daytime cycle average represented an 18 percent improvement over Phase II operations but only 3 percent improvement for night time operations. Overall, daily discharge productivity in terms of numbers of containers off-loaded totaled about the same for the two phases. But Phase III incurred some weather interruptions, therefore, less crane operating time was used to achieve the same number of containers discharged.

For retrograde operations in Phase III (See Figures 3.19 and 3.20) cycle times increased about a minute from those in Phase II. The Phase III times were in the 8-9 min. range for both day and night backloading. Near the end of Phase III retrograde period, the pace of the operation had slowed in anticipation of completion and rain and winds also caused periodic cessations. The Phase II retrograde cycle times were better than at all other periods.

Summary of COD Crane Cycle Times. Table 3.8 summarizes the off-load and retrograde average cycle times by phase. The averages were calculated from data in the Joint Test Directorate automated data base. Cycles greater than 12 min. were excluded in order to deal primarily with crane off-load/retrograde activities and to analyze working ship requirements and delays separately.

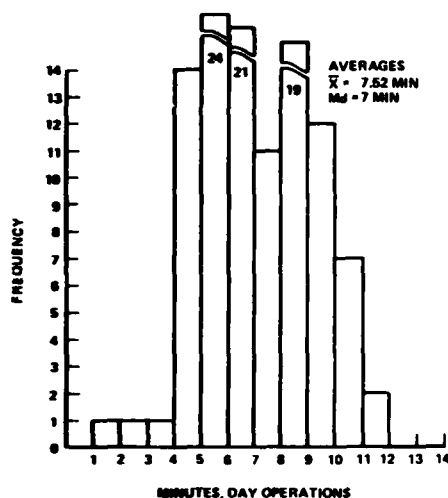


FIGURE 3.13. PHASE II COD OFF-LOAD CYCLE DISTRIBUTIONS - DAY OPERATIONS (Excludes cycles greater than 12 min.)

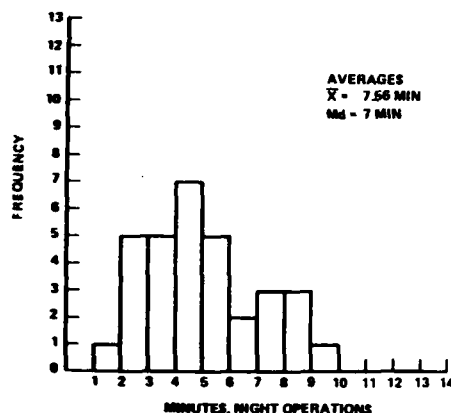


FIGURE 3.14. PHASE II COD OFF-LOAD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

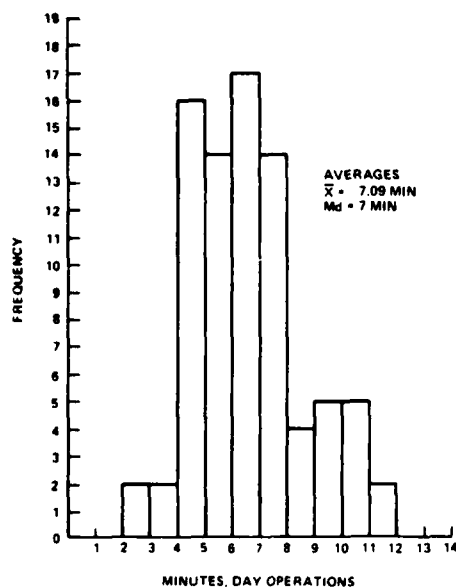


FIGURE 3.15. PHASE II COD RETROGRADE CYCLE DISTRIBUTIONS - DAY OPERATIONS (Excludes cycles greater than 12 min.)

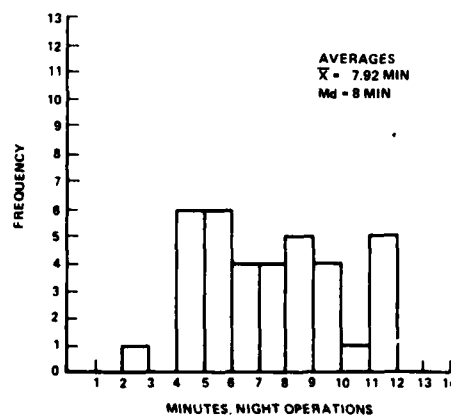


FIGURE 3.16. PHASE II COD RETROGRADE CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

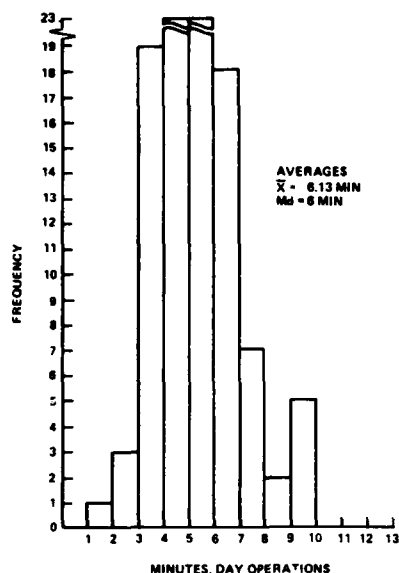


FIGURE 3.17. PHASE III COD OFF-LOAD CYCLE DISTRIBUTIONS - DAY OPERATIONS (Excludes cycles greater than 12 min.)

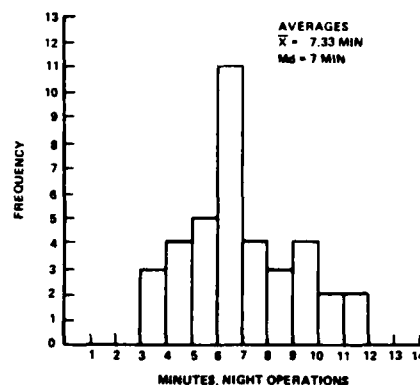


FIGURE 3.18. PHASE III COD OFF-LOAD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

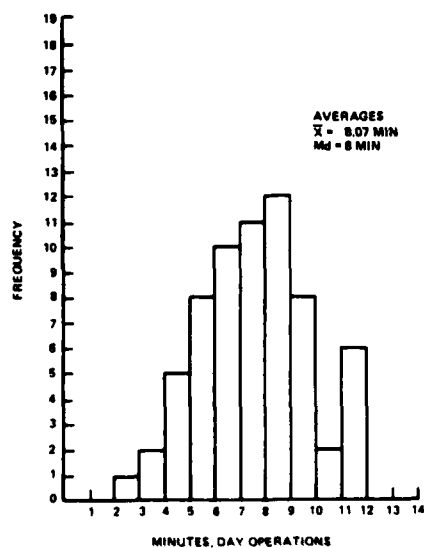


FIGURE 3.19. PHASE III COD RETROGRADE CYCLE DISTRIBUTIONS - DAY OPERATIONS (Excludes cycles greater than 12 min.)

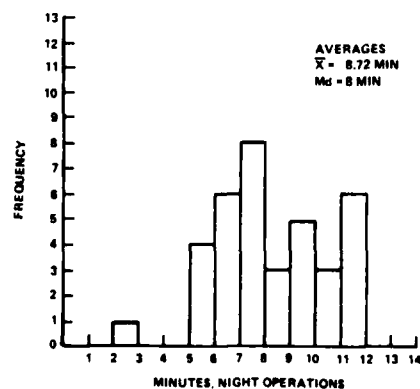


FIGURE 3.20. PHASE III COD RETROGRADE CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

TABLE 3.8
AVERAGE CRANE-ON-DECK CYCLE TIMES BY PHASE

Service Operating COD and Test Phase	OFF-LOADING				RETROGRADING			
	Day Operations		Night Operations		Day Operations		Night Operations	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Army-Phase I	8.71	8	10.38	11	7.89	8	10.29	11
Navy-Phase II	7.52	7	7.56	7	7.09	7	7.92	8
Navy-Phase III	6.13	6	7.33	7	8.07	8	6.72	8
Army-Phase I(R)	7.08	7	7.50	8	--	-	--	-

Effects of Container Weights. Sensitivity analyses were conducted on the possible effects of container weights with respect to crane performance. Six weight categories were selected, 26 empty or near empty containers, 320 light containers at about 5-6 tons, 38 medium containers at 10-12 tons, and 103 heavy ones at about 22 tons.

The results of the computer runs showed a wide spread of cycle times with a negative correlation in some cases. Operations were too sporadic and sample sizes too small to provide definitive results. Based upon the data samples taken, variations in the weight of 20-ft containers could not be determined to have an appreciable effect on average crane cycle times.

Effect of Darkness on Crane Operations. While the foregoing analyses have addressed day and night operations, in reality the night shift actually had about 3½ hr of daylight to work in, including periods at the beginning and end of the shift. Accordingly, comparisons of crane cycle distributions between the daytime period of 0900-1600 and a night time period of 2200-0500 were made. Table 3.9 shows the comparative times by phase for mean and median averages. Figures 3.21 - 3.28 provide the cycle distributions for each phase.

TABLE 3.9
COMPARISON OF MEAN AND MEDIAN AVERAGES BY PHASE DURING
DAYLIGHT AND DARK PERIODS FOR COD CONTAINER HANDLING (IN MINUTES)

Service Operating COD and Test Phase	0900 - 1600 HR		2200 - 0500 HR		MINS. FASTER DAYLIGHT HOURS	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
Army-Phase I	8.48	8	10.44	11	1.96	3
Navy-Phase II	7.45	7	8.27	8	.82	1
Navy-Phase III	6.36	6	7.13	7	.77	1
Army-Phase I (R)	6.71	6	6.71	7	0	1

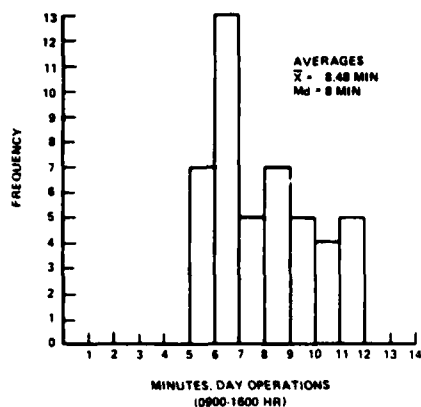


FIGURE 3.21. PHASE I COD CYCLE DISTRIBUTIONS - DAY OPERATIONS (Day versus Night Operations)

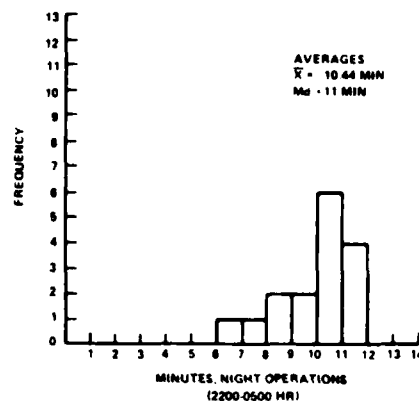


FIGURE 3.22. PHASE I COD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Day versus Night Operations)

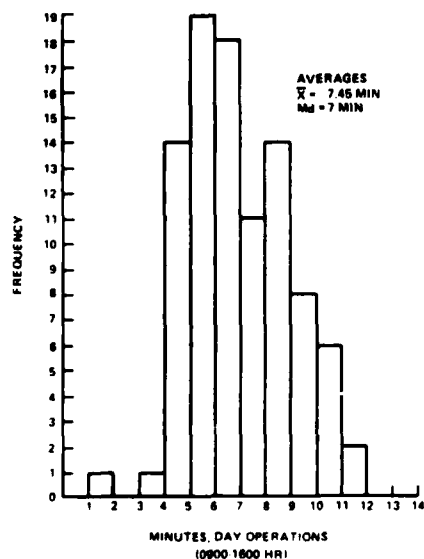


FIGURE 3.23. PHASE II COD CYCLE DISTRIBUTIONS - DAY OPERATIONS (DAY VERSUS NIGHT OPERATIONS)

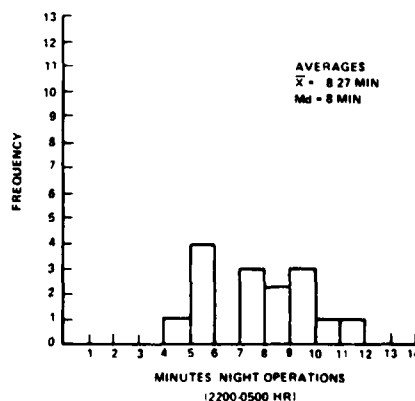


FIGURE 3.24. PHASE II COD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (DAY VERSUS NIGHT OPERATIONS)

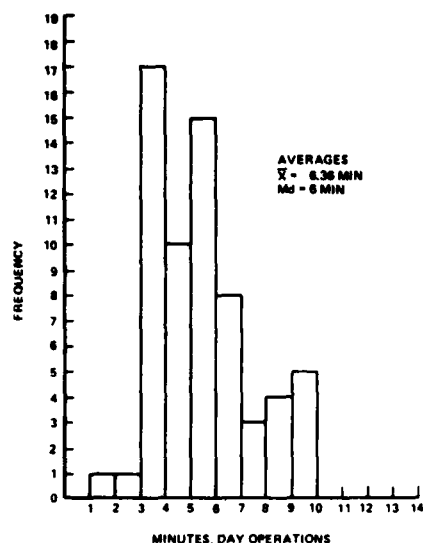


FIGURE 3.25. PHASE III COD CYCLE DISTRIBUTIONS - DAY OPERATIONS (Day versus Night)

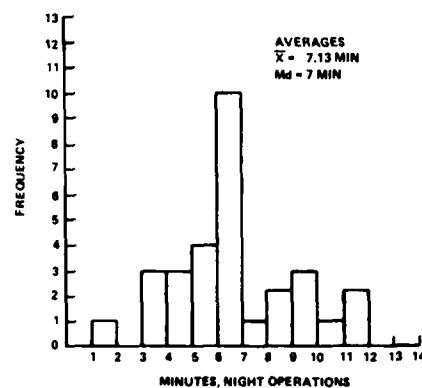


FIGURE 3.26. PHASE III COD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Day versus Night)

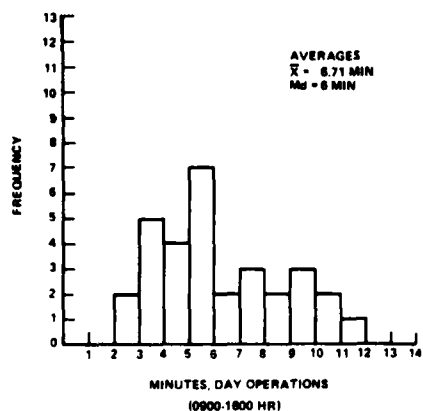


FIGURE 3.27. PHASE I(R) COD CYCLE DISTRIBUTIONS - DAY OPERATIONS (Day versus Night)

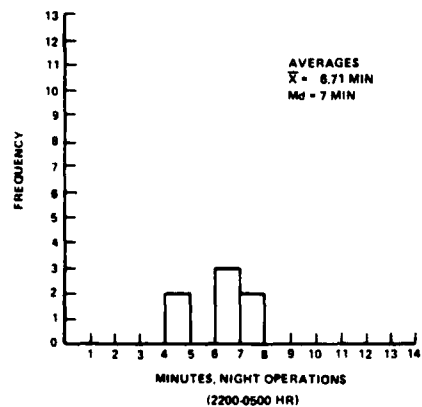


FIGURE 3.28. PHASE I(R) COD CYCLE DISTRIBUTIONS - NIGHT OPERATIONS (Day versus Night)

Poor lighting conditions were a major factor in night operations during the early phases of the test. However, by using 300 watt marine lamps, powered by the ship and augmenting the regular ship's lighting, improvements were made but never were fully satisfactory. An additional aid was the use of flashlights for signaling.

Communications between crane operators and their signalmen to begin with were irregular and often confused. The problems experienced with signaling in the daytime were compounded at night. This is an area where both services need training opportunities to seek improvements in techniques and equipment.

In general, it was noted that the average cycle time for night operations slowed by about 15 percent. (Phase I(R) values were discarded in the calculation because the night sample size was too small.) While more precise measures are certainly desirable, it is clearly evident that some slowdown of activity is almost inevitable as a result of night operations. The degree operations will be degraded depends upon the ship and lighting conditions, but as noted above there are other contributing factors.

COD Cycle Segments

To examine a crane cycle, components of the cycle were timed to determine where and what segments most influenced the whole cycle. These components covered periods from when the lifting device was:

- Grossly over the container to attachment to the container;
- Movement from the hatch area to the lighter or, if retrograding, from the lighter into cell;
- Unlocking the lifting device in the lighter or, if retrograding, unlocking in the cell; and
- Return to grossly over the next container.

Two different lifting devices were used at the COD, a regular container spreader bar that was manually locked and unlocked and a set of container slings. The container slings were made of chains, the legs of the chain paired and separated by a metal bar. (See Figure 3.29). An ISO locking pin was affixed to the end of each leg to mate with the container's ISO corner fittings. The Army primarily used the spreader bar while the Navy employed the container slings.

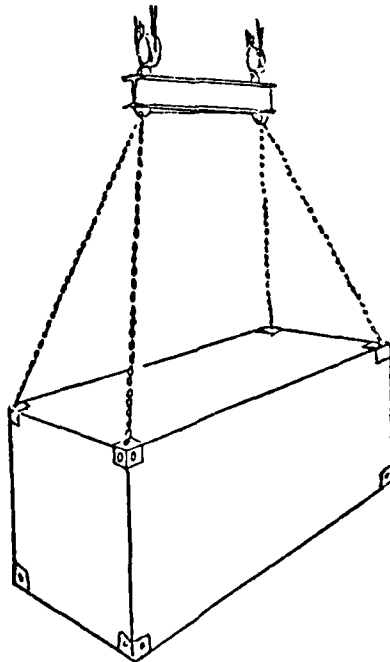


FIGURE 3.29 CHAIN SLING USED IN LOTS TESTS

For the most part, delays were deleted from data samples collected (by ORI, Inc.). The first few container lifts of the crews were also excluded in order to eliminate extreme times due to obvious learning periods. Table 3.10 provides the times collected at various phases of the operation. Crane movements were clocked to the nearest second.

The times did not cover entire shifts but included periods ranging from routine to heavy activity. However, they are generally representative of test operations and compare closely with the times and averages of those periods taken from the automated data base. No detailed timings were made on the first day of Phase III.

TABLE 3.10
COD CYCLES BY TIMED SEGMENTS

Phase	Type of Operation	Lifting Device	Shift	Intervals (In Minutes)				Total
				Attach Lifting Device	Lift-to Land Container	Detach Lifting Device	Return to Cycle Start	
I	Off-load	Sprdr Bar	D	2.54	3.25	.68	2.00	8.47
I*	Off-load	Sprdr Bar	D	2.62	4.69	.33	2.41	10.05
II	Off-load	Slings	D	1.86	3.86	.61	1.22	7.55
II	Off-load	Slings	N	1.76	3.09	.66	1.89	7.40
II	Retrograde	Slings	N	1.92	5.97	1.26	2.40	11.55
III	Retrograde	Slings	D	1.12	5.96	.74	2.06	9.86
I(R)	Off-load	Sprdr Bar	D	1.93	2.99	.31	1.48	6.71

* 40-ft containers only

From the above times it can be noted that for spreader bars about 25-30 percent of the cycle is spent trying to mate the spreader bar locking pins with the corner fittings. For slings the attachment ratio varied from 15-25 percent of the cycle. In every case, however, attachment of the sling to the container was faster than the spreader bar. Interestingly, a new crane operator can often be detected by the times he required to make the connection.

For detachment of lifting devices, the spreader bar was twice as fast as the sling, that is, approximately 20 seconds per lift. The differences in crane rotation times is negligible. The lift-to-land times in the retrograde reflects the somewhat more difficult requirement of positioning the 20-ft containers below decks in a 40-ft cell as opposed to landing containers into lighters where there was more tolerance for pendulation.

Forty-Foot Containers. The cycle rates for the 40-ft containers is based upon a sample size of only eight lifts. After the first lift, which took about 12 min., the cycles went rather smoothly. The fastest time for one 40-ft container was 6 min. 21 secs.

COD System Compatibility With NSS Containerships

A Navy Study² analyzed 94 NSS containerships in the US flag fleet to determine their suitability for discharging by a COD system. Table 3.11 provides a summary of those results.

TABLE 3.11
NSS CONTAINERSHIP SUITABILITY FOR
DISCHARGING BY A COD SYSTEM

Rating	Number of Class Designs	Number of Ships
Desirable	4	13
Acceptable	4	16
Marginal	9	45
Undesirable	7	20

Deck obstructions exist that require a ship survey prior to use of the COD on 22 of the 45 ships listed as marginal. An additional 19 of the marginal

² Letter Report from Naval Coastal Systems Laboratory, Panama City, Florida, 28 January 1977, to Commander Naval Sea Systems Command.

ships require structural modifications of the main deck or removal of numerous buttresses to permit COD deck operations. The remaining four ships had three of their hatches raised 2 ft 4 in. above their other hatches making it difficult or impossible for a COD to relocate along the deck of the ship. An additional 20 ships were listed as undesirable. Four of these ships require extensive deck modifications; another four ships had insufficient structural strength to support the COD; another four ships would be unstable with the COD on board and had deck obstructions that would interfere with the movement of the COD. There was insufficient data on the remaining eight ships for NCSC to perform an adequate analysis. Only 31 percent of the containerhips were rated as acceptable or desirable for discharging by the COD.

Crane Availability

The COD that was employed in the LOTS test was leased since the Services did not at that time own a crane large enough to use as a COD. To establish a COD capability implies that the Services have to buy or lease a large number of cranes. Buying the cranes is expensive since a minimum of two cranes are required to expeditiously unload each ship and as many as 29 ships could be required. Maintenance of this many cranes and a lack of interim use are major drawbacks to DoD ownership. No transfer of cranes between ships at the objective area is contemplated since currently there is no LOTS crane large enough to make the transfer. The main drawback in leasing the cranes is having a guarantee that they will be available when needed especially in a quick-reaction non-mobilization emergency. Obtaining a sufficient number of cranes to support a LOTS operation presents significant and, as yet, unanswered questions.

COD System Displacement of Deck Stowed Containers

Since the C.V. STAG HOUND had a partial load in the LOTS test, the loading plan for the ship did not attempt to minimize the number of containers displaced by the COD. Stowed on the deck of bay 7, which can carry fifty-four 20 ft containers, was a Navy Coastal Systems Center instrumentation van and the main body of the crane. The COD boom was stowed over bays 5 and 6 (an area that was three containers wide, three containers high and four containers long (a space equivalent to thirty-six 20-ft container units). A total of ninety 20-ft container spaces, which was more than required, was left vacant for the COD.

Utilizing the container stowage for the C.V. STAG HOUND, shown in Figure 3.30, reduces the number of containers displaced by the COD (Manitowoc 4100W, see Figure 3.31) from 90 to 50. The container spaces indicated by dots in Figure 3.30 were not used in the test. These spaces provide stowage space for the 40 additional containers. In the plan stacking containers only two high on bay 7 provides clearance for the crane boom to rotate. Also, an operating crane needs an unobstructed circle with a 19-ft radius, measured from the crane's center of rotation. The distance from the center of rotation of the crane to the containers on either side of the crane is over 20 ft. The boom of the crane is 7.8 ft wide and it is stowed in an area that is slightly over 8 ft wide. Stowage of bridging beams not being used is under the boom of the crane.

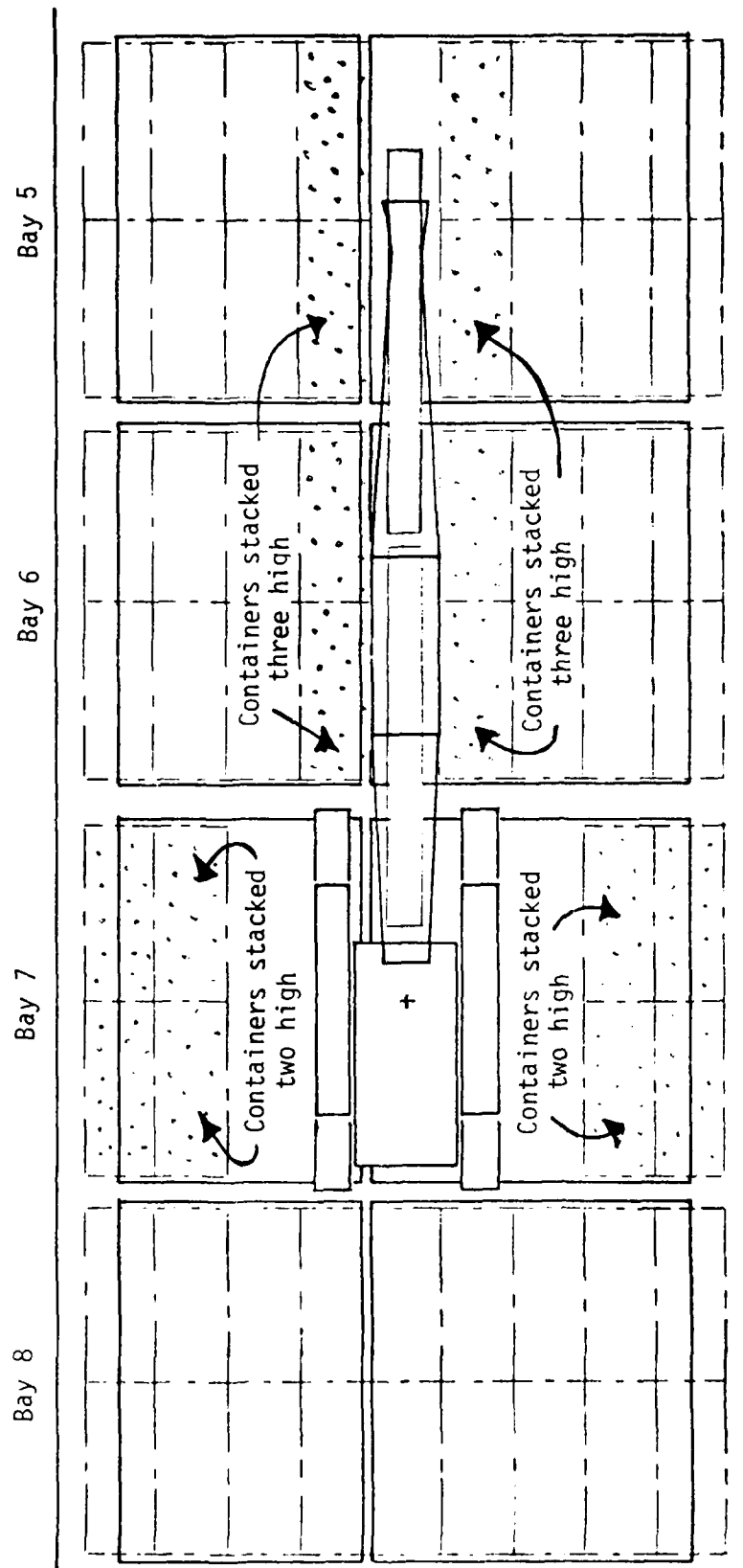


FIGURE 3.30 CONTAINER DECK STORAGE PLAN FOR BAYS 5 THROUGH 8 ON THE C.V. STAG HOUND



FIGURE 3.31. COD IS LOADED. The crane-on-deck method for off-loading a NSS containership was proven effective. The cranes (similar to the type shown above) and hatch bridging kits are not on hand.

The C.V. STAG HOUND has a capacity of 1,070 20-ft container equivalents with 1,014 of these containers located between the forward and aft superstructures of the ship. The remaining 56 containers are located behind the aft superstructure. As shown above, one COD displaces 50 on-deck containers, so two CODs would displace 100 containers. The capacity of this ship when discharged by two CODs is 1,014-100 or 914 containers.

COD Crane Resources and Hatch Bridging Kit Availability

A total of 140³ of the two most desirable cranes, the Manitowoc 4100W and the American 9310, for the COD system were identified within the United States. These cranes have been located by the Navy. For emergency purposes requisitioning or some other arrangement would be necessary to procure them for use as CODs.

However, response time could be badly degraded for lack of hatch bridging kits. The kits (one per crane) require a number of large "I" beams (two per beam, four beams per kit, two kits per two crane system). Therefore, as many as 16 "I" beams per ship would be required. Since marshaling materials in a contingency time frame could be a major problem for a large size force, these hatch bridging kits need to be constructed and pre-positioned at East and West Coast ports where the container ships and cranes would be loaded.

Upon introduction of the Navy's ship-TCDF system, these same kits may be suitable also for crane supports on other hulls called into service or used just as cranes-on-deck to support infrequent requirements on a one- or two-ship basis to lesser LOTS sites, thereby reducing TCDF deployment requirements. Thus, the relative cost of the hatch bridging kits could be applied to support the two programs, crane-on-deck and ship-TCDF. As the ship-TCDF system (discussed in more detail later) comes on line, the crane-on-deck requirements will decrease. It is not anticipated that the crane-on-deck method of discharge/retrograde would be replaced since it provides an added operational flexibility and means to provide a surge capability or back-up to off-shore sites or marginal ports.

³ The Naval Ammunition Production Engineering Center, NAVSEA COD System Crane Survey, Final Report, page 28, 1 July 1976.

BARGE-TCDF

General

Over the course of the 15 days of LOTS containership operations the Army barge-TCDF made 1,313 transfers. Of these, it off-loaded 64 percent (844) and retrograded 36 percent (469). The barge-TCDF off-loaded the highest single quantity of containers (184) in a 24-hr period. Altogether the TCDF handled about 53 percent of all transfers made at the containership.

To summarize its operations, the barge-TCDF got off to a late start when winds and currents carried the facility away from the ship while mooring was being attempted. However, once moored, the facility off-loaded 43 percent more containers the first day and 30 percent more in all of Phase I than the COD, but retrograded five percent less.

At the TCDF the problems encountered during Phase I were not much different from the COD except that Army personnel were more familiar with the TCDF. Organizational difficulties associated with TCDF operations requiring step-by step procedures had the effect of slowing the crane and creating confusion as to what should be done next. As a result crane operating time at the TCDF was lost because possible concurrent activities were not done concurrently and preparations were not made ahead of time. In addition, the TCDF had problems with lighter delays. During this phase the LACV-30 had priority at the crane and this contributed to confusion and delays with respect to lighter successions. (This is discussed in more detail later.)

In Phase II the Navy experienced the same deck organizational and learning problems but they did not have the familiarity with the crane the Army had. However, on the second day of operations, they bettered the Army's TCDF Phase I 24-hr high mark by 23 percent and exceeded overall productivity on the TCDF to that time by 21 percent. During Phase II the off-load productivity of the TCDF exceeded that of the COD by four percent, but the COD retrograde productivity exceeded TCDF productivity by seven percent.

In Phase III the Army again operated the TCDF and by this time had worked out many of its management and organizational problems. During this phase the crew from the 119th Trans. Co. (Terminal Service) (Container) established a 24-hr record peak of 174 containers, a 63 percent improvement over the Navy TCDF mark. This number was also 18 percent higher than the COD peak of 147 containers the same day, but the COD experienced some lighter delays also. All containers planned for off-loading by the TCDF were accomplished on the second day of Phase III; shortly thereafter thunderstorm activity began to delay retrograde operations. Few containers were backloaded during the first night of retrograde because of a weather hold until nearly 0300 hr.

During Phase III the TCDF retrograded 13 percent and off-loaded 3 percent more containers than the COD, but most of this productivity (60 percent) was accomplished the first 1½ days with favorable conditions or just at the start of the thunderstorm activity. The remaining 40 percent at the TCDF was

accomplished on an intermittent basis. During the last two days of Phase III with the weather problems, the TCDF transferred 13 percent fewer containers than the COD. During this period the TCDF handled almost all retrograde while the COD had a small amount of off-load in addition to its retrograde.

In Phase I(R) the Army crew reached its peak period of productivity at the TCDF. In 24 hr the TCDF off-loaded 184 containers. The load involved had containers stacked three high on deck and did not involve any long moves. Actually, for the TCDF the ship was configured more realistically during this one day phase than in the previous three phases. As previously noted, the load was concentrated in one area on the ship and that part of the ship was configured as if it were fully loaded.

The TCDF experienced some rough water about mid-morning and shut down for a brief maintenance period. The night crew experienced similar problems with rough water but not nearly as bad.

Table 3.12 is a summary for the productivity of the barge-TCDF during the test. For the shifts worked column, the times contain all activity and not just transfer times.

TABLE 3.12
BARGE-TCDF PRODUCTIVITY FOR VARIOUS
PHASES OF THE TEST

Operational Phase	Number of Containers Off-loaded	Number of Containers Retrograded	Phase Totals	Number of Shifts (12 hr each)	Containers Transferred Most Productive Shift
I	199	132	331	9.33	55 Retro.
II	233	183	416	9.79	67 Off-ls.
III	228	154	382	5.50	118 Off-ls.
I(R)	184	-	184	2.00	114 Off-ls.
Totals	844	469	1,313	26.62	

Barge-TCDF Working Ship Analysis

Refueling. The same problems experienced with the planning and coordination of COD activities were experienced at the barge-TCDF, but to a somewhat lesser degree. The DeLong platform on which the crane is mounted has more room to work and store equipment so there is less interference than with the COD. In Phase I the Army crane operator and one other man operated the hand pump system. Depending upon how much fuel was pumped, about 30-40 min. was spent refueling and another 15 min. was necessary to off-load the fuel pods into an LCM8. Counting time to first bring in an LCM8 with the full fuel pods and then to off-load them onto the barge, more than an hour could be

lost daily on refueling alone. Data on the refueling process are incomplete but there are periodic reports that suggest at least an hour a day was required.

The Navy in Phase II similarly spent an hour to an hour and a half refueling the barge-TCDF the first two days. Subsequently, these times were reduced to about an hour, counting all activities associated with the refueling process.

Hatch Cover Operations. Hatch cover operations involved the same situations for the TCDF as for the COD. The TCDF had both one and two-hatch operations with the same steps involved for each. However, unlike the COD, the TCDF had considerably more single hatch operations than two-hatch ones since it had to relocate more often. Table 3.13 provides the average times for single hatch operations by phase.

TABLE 3.13
AVERAGE TIMES REQUIRED FOR BARGE-TCDF
SINGLE HATCH OPERATIONS

Operational Phase	Average Time Required (In Min.)	Unit Involved
I	23	119th Trans. Co. (TS)
II	26	NAVCHAPGRU
III	16	119th Trans. Co. (TS)
I(R)	14.00	119th Trans. Co. (TS)

Often a hatch opening or closing became involved with other factors, such as an administrative break for personnel. Thus, it is helpful to examine the segments of a hatch operation to evaluate the times required for each step. Table 3.14 provides average times for each step, based upon 33 events timed. There were about four instances in which outliers were discarded in the rigging activities that would have otherwise distorted the findings. The events discarded were not related to the operation and the remaining elements of the delayed cycles were used. Also included for comparison are the elements of the fastest cycle timed.

TABLE 3.14
SEGMENT TIMES (IN MIN.) FOR BARGE-TCDF SINGLE HATCH OPERATION

	Change Spreader Bar	Attach Spreader to Hatch Cover	Hatch Cover Lift-to-Land	Spreader-Crane Detached	Re-rig for Operations	Total
Test Average	5.67	4.57	5.55	2.01	3.48	21.28
Fastest Cycle	3.25	.58	1.75	.92	1.68	8.18

As may be noted from the table above, the fastest single hatch operations time (taken from the first day of Phase III operations) is only 38 percent of the average. As fast as that average is by comparison, there were actually six events of only 10 min. or less. All of these cycles occurred late in Phase II or early in Phase III, indicating the results of learning experience. Some cycles required as much as 67-72 min. early in the test. (These early learning times were not included in the averages calculated above.)

Analysis of one and two-hatch operations (opening-closing) indicates that in considering a one-hatch operation, it is more efficient and less disruptive if two-hatches can be worked instead. That is, time can be saved if operations are coordinated so that one hatch can be closed and the next opened as part of one working ship interruption rather than two. Thus, it is preferable to off-load as many weather deck containers as can be reached so that hatch cover handling can be doubled up whenever possible. Table 3.14 provides the segment times and fastest cycle times for two-hatch operations.

TABLE 3.15
SEGMENT TIMES (IN MIN.) FOR BARGE-TCDF TWO-HATCH COVER OPERATIONS

	Change Spreader Bar	Attach Spreader to Hatch	Hatch Cover Lift-to- Land	Attach Spreader to 2nd Hatch	Hatch Cover Lift-to- Land	Re-Rig for Lift-to-Operations	TOTAL
Test Average	5.27	4.91	6.32	4.05	4.17	4.10	28.82
Fastest Cycle	2.25	1.52	2.13	1.85	2.45	1.95	12.15

Closing one hatch requires an average of about 21 min. To off-load/retrograde some containers and then open the next hatch requires an amount of time to handle the containers plus an additional 21 min. Thus, the hatch operations require a total of 42 min. while a two-hatch operation as shown in Table 3.15 requires only 29 min. a savings of 13 min., whenever loading/retrograding permit.

The above average times for both single and two-hatch operations show opportunity for additional improvement. The most promising areas of improvement relate to the changing of spreader bars, both before and after the lift. Compared to the fastest times, about 6 min. could be saved by better planning and deck organization, such as ensuring the lifting blocks are in, where the spreader bar is to be removed, the hatch is clear of equipment, the crane operator knows where to stow the hatch cover, etc. That alone would reduce cycle times by 20 percent. For the attachment of spreader bars to hatch covers some time could also be saved by ensuring that the best crane operator and signalman are being utilized at the time, provided a choice is available.

Barge-TCDF Relocations. As discussed in Volume I, the barge-TCDF made two types of moves, along one side of the ship and around to the other

side of the ship. Presumably, if there were two TCDFs, no movements from one side to the other would be required. However, to illustrate the times involved for this type of move and for regular shifts along a side of the ship, Table 3.16 is included below.

TABLE 3.16
BARGE-TCDF RELOCATION TIMES (IN HRS)

Operational Phase	Around Ship	Along Side of Ship
Phase I - Army	1.64	.48
Phase II - Navy	1.62	.87
Phase III - Army	1.30	.63
Averages for all Phases	1.56	.65

The above times include the total time the TCDF is out of commission from container operations. The steps for a relocation involved:

- Securing the crane and spreader bar,
- Positioning pusher boats for propulsion and guidance,
- Casting off lines, as required,
- Moving the barge to a new location,
- Mooring at the new location, and
- Reactivation of the crane and crew.

Barge-TCDF Container Operations

Hatch Crews. The TCDF hatch crew for both Services was the same size as that used at the COD, the Army had 7-9 and the Navy about 13, which included stevedores, crane operator, signalman and hatch foreman. It was noted that with the smaller Army crew, cargo checkers were used from time-to-time to assist in handling tag lines.

The mooring of lighters was easier at the TCDF than the COD because the lighter crew could assist there was sufficient freeboard for a crewman to transfer onto the DeLong (which has about a 7-ft freeboard). This was possible with LCUs and LCM8s. Nevertheless, it was a hatch crew responsibility to support lighter moorings and unmoorings along with their primary responsibilities for the loading and final positioning of containers in the lighter. In Phases II and III a causeway ferry was used alongside the barge-TCDF, which eased the lighter crew transfer problem and they assisted in the mooring process. The causeway ferry also helped to guide the lighter into

position as well as providing additional working space for the tag line handlers.

The TCDF like the COD could use additional hatch crew members. A small trouble-shooter team could eliminate a number of delays relating to periodic spreader bar adjustments, particularly with the guides. An extra lifting device per crane should also be considered. It has been suggested that additional crane mechanics are required in the container company (there are three now and two more are proposed by the Army LOTS test evaluators) because of the separation of cranes between ship and shore. This requirement is considered valid. In addition to the crane mechanics, more stevedores were needed and steps have been taken to convert some billets to terminal operations specialists (stevedores) and add others. This change has produced a net increase of 16 percent in personnel but should provide the manpower resources badly needed for crew relief, working ship preparatory activities, and maintenance/crane support.

The communications between signalmen and crane operators was not much better at the TCDF than at the COD in terms of consistent and correct procedures. One fairly common problem was that more than one person, especially officers and non-commissioned officers would also start signaling (often incorrectly) at the same time, rather than correcting the signalman on duty. Along with radio contact with the crane operator, both the Army and Navy used flashlights for signaling at night. Sole reliance on this means became a necessity in Phase III when the crane operator's headset developed a malfunction. The use of lighted signaling wands like those employed with night helicopter operations should be considered for directing the crane operator.

Weather. In terms of weather, sea state was the most significant influence on barge-TCDF operations although there was little of this that was measured and reported in detail. While thunderstorm activity halted operations, it halted all crane operations everywhere because of the potential lightning hazard. The thunderstorm and shower activity, for the most part, was of brief duration.

Sea states one and two were reported in Phases I and II, but it was not until Phase III that brief conditions of sea state three were experienced. For the most part the TCDF was not operational during those periods noted in Table 3.17.

TABLE 3.17
BARGE-TCDF ACTIVITY WITH RESPECT TO SEA STATE 3

Periods Sea State 3 Operated	Wind Speed (knots)	Wave Height (Feet)	Times Barge-TCDF Operational	Average Cycle Times (mins)	Remarks
1200 17Aug	15-22	2-4	No	-	Second daily maintenance break taken.
1400 17Aug	unknown	2-4	Yes	8.2	Retrograded 5 containers then halted due to weather.
1600 17Aug	18-25	2-4	No	-	
0600 18Aug	25-30	2-4	No	-	Shut down operations at 0503 due to weather.

There were other instances in which the TCDF was forced to halt activity because of sea conditions. In one case the wake of a passing submarine was reported to have caused the barge-TCDF to temporarily halt operations until the water calmed down. In another instance during Phase I(R) the barge-TCDF took an additional maintenance break (one was held before the shift began) after experiencing some choppy seas until the barge-TCDF had swung around into the lee of the ship. The latter delay cost about 25 min. About 1½ hr earlier the maximum wave heights had been reported at 2.5 ft, although the average was only 1.08 ft.

It can not be determined whether the TCDF was operating in the lee or what the wave conditions were at the time the TCDF off-loaded the five containers mentioned in Table 3.17. However, it is significant to note that the barge-TCDF ceased operations due to rough water. From these examples it can be reasonably postulated that the Army DeLong B barge-TCDF as rigged for this test is unable to operate safely in sea state 3 conditions. In view of the experiences noted in Phase I(R) it would also appear that in the upper regions of sea state 2 the barge-TCDF operational capabilities are questionable.⁴

The question of sea state capabilities/limitations is not addressed by Army required operational capability (ROC) documents. However, it does impinge directly on Army capabilities to plan and conduct LOTS operations. Sea states particularly during late fall, winter, and early spring months at some locations, particularly in the North Sea, would critically limit such operations. Thus, it is important to identify the limitations of the barge-TCDF with respect to sea state in terms of both operational feasibility and site selection.

Current Naval research and development efforts in wave dampening equipment indicate that the effects of near shore sea states can be reduced. When available the Army could incorporate wave dampening equipment as a means of improving barge-TCDF stability in LOTS operations. As a first priority, the Army should participate by monitoring and supporting the Navy barge-TCDF tests in order to identify and document sea state operational limits. The sea state data available from the LOTS test are generally inconclusive as to when conditions approaching sea state 3 halt TCDF operations.

First Day Results. To identify periodic improvements in barge-TCDF operations the automated data base was used to provide mean and median averages for first day operations by phase. As with the COD, a cutoff of cycles greater than 12 min. was used to filter out exceptional delays and delays for working ship activities which are separately considered. The Army operated the barge-TCDF in Phases I, III, and I(R) while the Navy operated it only in Phase II. Table 3.18 summarizes first day productivity results.

⁴ It should be noted that the Navy's COTS program is concerned with identifying this limitation and has further testing and evaluation of a crane on a DeLong B section scheduled for CY1979.

TABLE 3.18
FIRST DAY RESULTS BY PHASE FOR BARGE-TCDF OPERATIONS

Service Operating Barge-TCDF AND TEST PHASE	DAY OPERATIONS (IN MINUTES)		NIGHT OPERATIONS (IN MINUTES)		CONTAINER OFF-LOAD PRODUCTIVITY	
	MEAN	MEDIAN	MEAN	MEDIAN	DAY	NIGHT
ARMY - Phase I	7.05	7	8.89	9	47	40
NAVY - Phase II	8.58	9	7.96	8	45	38
ARMY - Phase III	4.75	4	6.73	6	118	56
ARMY - PHASE I(R)	4.71	4	5.97	5	114	70

Army. Figures 3.32 and 3.33 illustrate the Phase I day and crane cycle productivity. This is compared to Figures 3.34 and 3.35 for Phase III and 3.36 and 3.37 of Phase I(R). Based upon these results it would appear that the Army showed a 48 percent improvement in cycle times for day operations while productivity increased 146 percent. The subsequent cycle times and productivity of Phase I(R) appear to support the improvements noted.

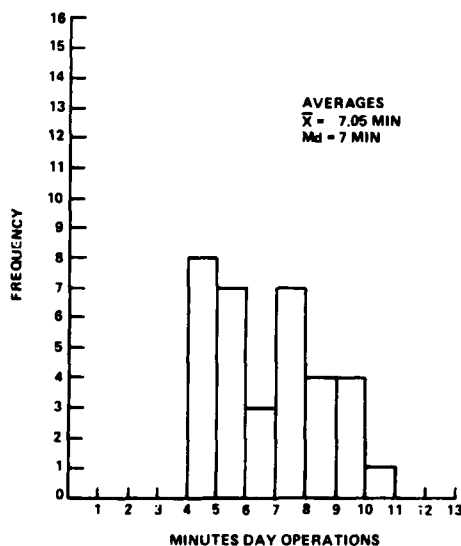


FIGURE 3.32. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR 6 AUGUST 1977-DAY OPERATIONS (Excludes cycles greater than 12 min.)

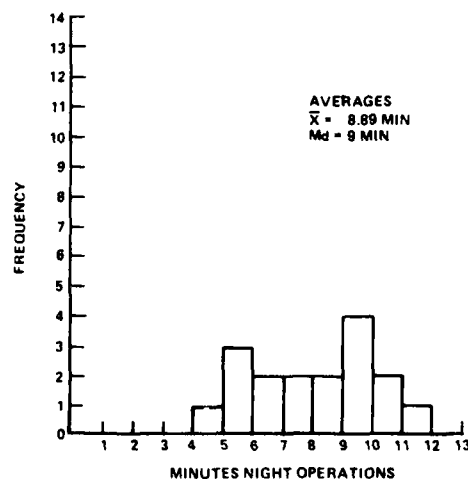


FIGURE 3.33. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR 6 AUGUST 1977-NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

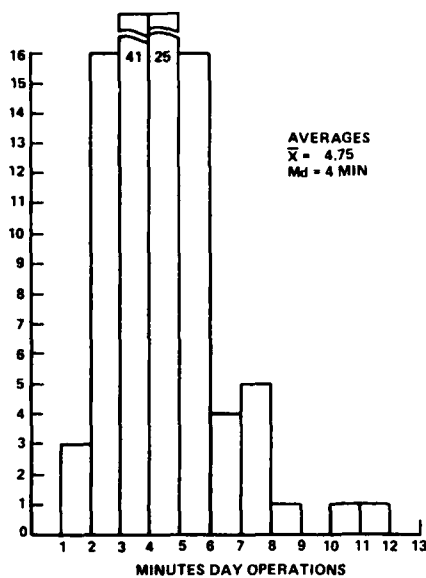


FIGURE 3.34. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR 16 AUGUST 1977 - DAY OPERATIONS (Excludes cycles greater than 12 min.)

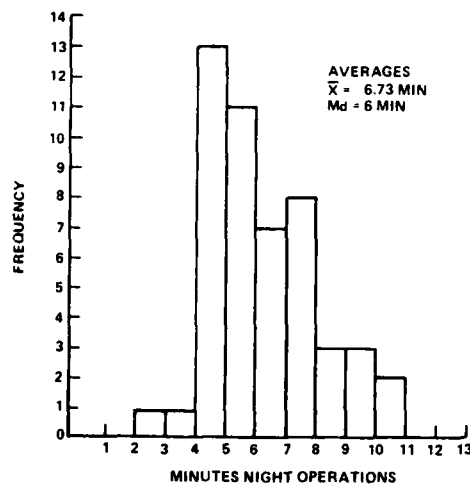


FIGURE 3.35. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR 16 AUGUST 1977 - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

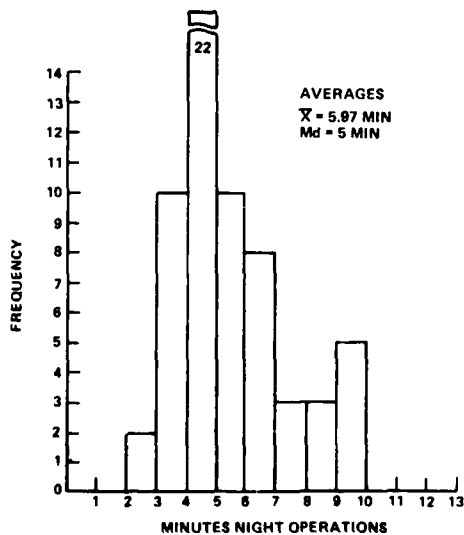


FIGURE 3.36. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE I(R) - DAY OPERATIONS (Excludes cycles greater than 12 min.)

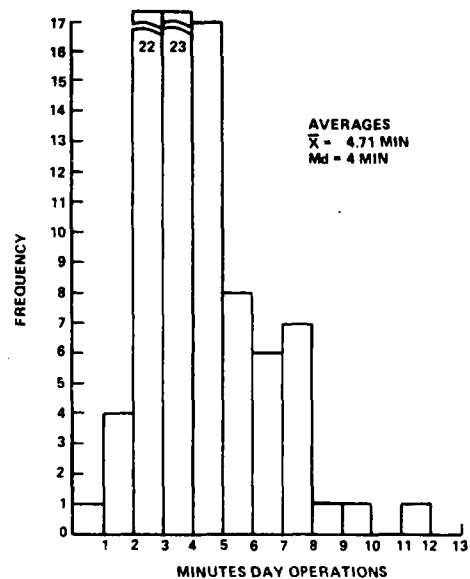


FIGURE 3.37. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE I(R) - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

Some caution should be exercised before accepting the improved rates as norms. In Phase III and, to a certain degree in Phase I(R), the Army LOTS crews were highly motivated. In Phase III the Army was operating adjacent to the Navy and a degree of competitiveness was evident. In Phase I(R) the motivator was the knowledge that the exercise would be terminated when the ship had been emptied. Accordingly, in a sustained operation these motivational factors would not be present; thus, for this test these peak rates are regarded as surge type efforts. In a prolonged, actual operation there would also be some surge efforts that might equal or exceed these LOTS test efforts, but neither should be considered as a sustained capability. Finally, the weather and sea conditions in these cases were for the most part very good during off-loading, although Phase I(R) did have two brief periods of sea and wind disruptions.

Navy. The Navy only operated the barge-TCDF in Phase II so that a similar time and learning comparison could not be made. Figures 3.38 and 3.39 illustrate the cycle distributions for their first day effort. It is evident between the day and night operational times that the Navy was improving to the extent that this was the only time when the overall night cycle average time was faster than the day cycle. In terms of container discharge productivity the Navy and the Army off-loaded about the same number (83 Navy versus 88 Army). The Army first day cycles were about 1½ min. faster on the day shift but about 1 min. slower at night. Thus, the Army would gain about one container for every 16 they off-loaded, assuming all other operations off-set each other.

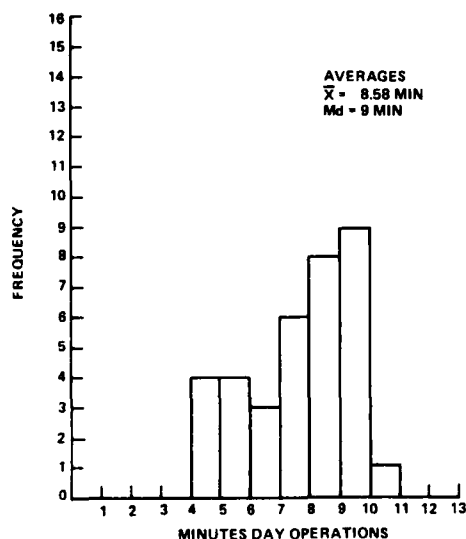


FIGURE 3.38. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR 11 AUGUST 1977 - DAY OPERATIONS (Excludes cycles greater than 12 min.)

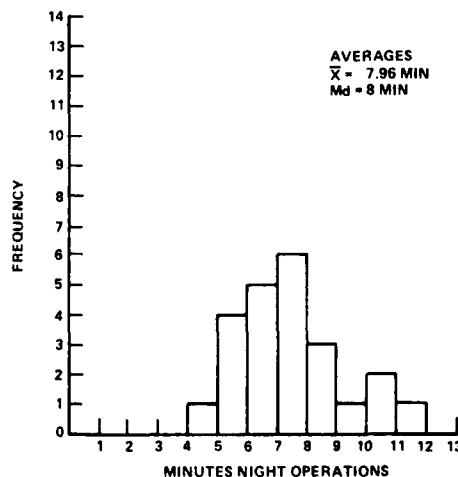


FIGURE 3.39. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR 11 AUGUST 1977 - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

Improvements. As with the COD, the barge-TCDF showed excellent improvement in cycle times but to attain the significant jump in productivity, especially as noted with the Army, the key was in more responsive lighter operations, better deck organization, and improved coordination of support activities. These types of operational changes resulted in more crane cycles per shift and less overall crane dead time.

Overall Barge-TCDF Results for 119th Trans. Co. (T.S.) (Container).

Figures 3.40 and 3.41 show the barge-TCDF off-loading cycle distributions for all Phase I day and night operations. The means represent about 3/4 of a min. difference between the two shifts, while the medians are about 1 min. apart. The distribution between the fastest and slowest cycles varies by as much as 9 mins. The overall phase results show about a 10 percent slowdown from the first 24-hr period's day shift activities while the night shift improved about four percent.

Figures 3.42 and 3.43 give the barge-TCDF retrograde cycle distributions for Phase I day and night operations. The overall retrograde day cycles are 11 percent faster than the overall day off-load cycles. A manual review of the data collection sheets indicates organizational problems managing lighters during the off-load were experienced. The retrograde night cycles were only five percent slower than the night off-loading cycles, but caution is in order due to sample size. The distributions shown in 3.43 point out the sparsity of values for calculating the night operation results. A manual review was also made of the Phase I retrograde data, especially for night activities. It revealed lengthy delays and apparently included the effects of training some new operators. Delays not considered involved problems with the powered taglines and the spreader bar, a couple of lengthy lighter delays, and difficulties retrograding containers off LACV-30 because of wave action (0248-0343 night of 8-9 Aug, waves estimated 2-3 ft).

Phase I for the most part was a matter of familiarization and learning. Operations were sporadic and confused. Therefore, for the most part lengthy delays associated with learning problems were screened out in the graphs depicted to provide a better perspective on system potential. The cycle distributions indicated in the day retrograde figure, for example, are more symmetrical, indicating a better grasp of the operation. In Figures 3.44 and 3.45 for Phase II, the symmetry is much more apparent in the off-loading operation and continues through the retrograde period. This reflects better operating continuity, coordination, and teamwork at the ship.

Phase III shows an overall off-loading improvement of 37 percent in barge-TCDF day cycle times and a 21 percent improvement for night cycles. This is considerably better than Phase I. Similarly, as may be seen in Figures 3.46 and 3.47, there is a 9 percent improvement for day retrograde cycles and a 24 percent improvement for night cycles for Phase III over Phase I.

One detracting element to the Phase III statistics is that the operations were accomplished over a relatively short period of time. Off-loading was actually completed early in the third shift of Phase III. Some retrograding was done that shift but weather forced a halt to operations for

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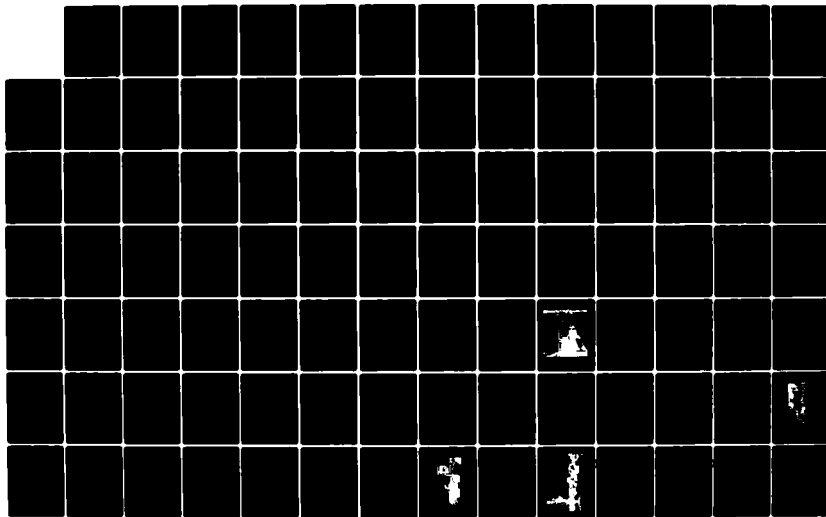
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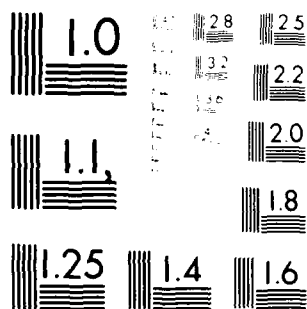
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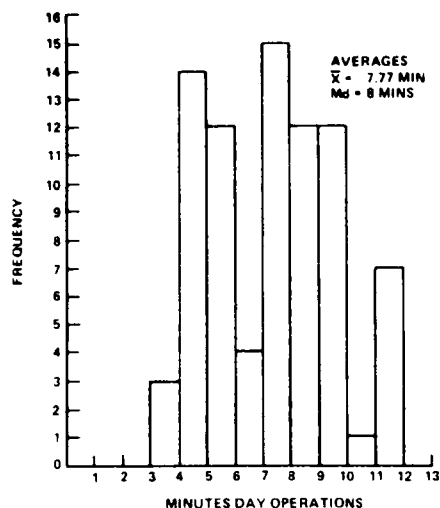


FIGURE 3.40. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE I - DAY OPERATIONS (Excludes cycles greater than 12 min.)

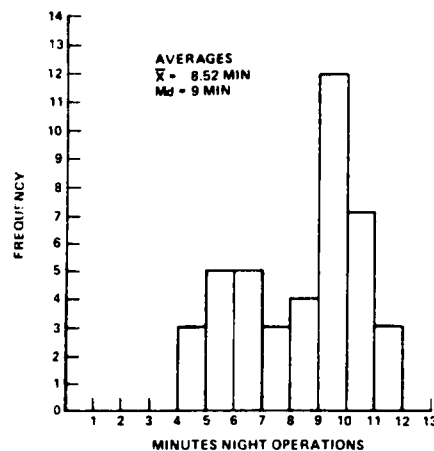


FIGURE 3.41. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE I - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

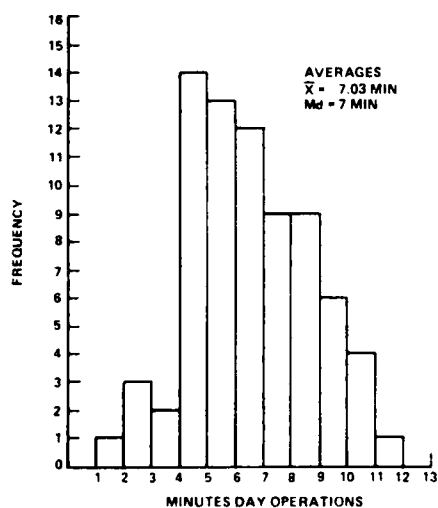


FIGURE 3.42. BARGE-TCDF RETROGRADE CYCLE DISTRIBUTIONS FOR PHASE I - DAY OPERATIONS (Excludes cycles greater than 12 min.)

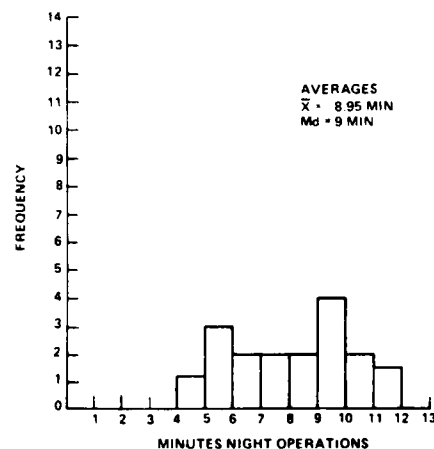


FIGURE 3.43. BARGE-TCDF RETROGRADE CYCLE DISTRIBUTIONS FOR PHASE I - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

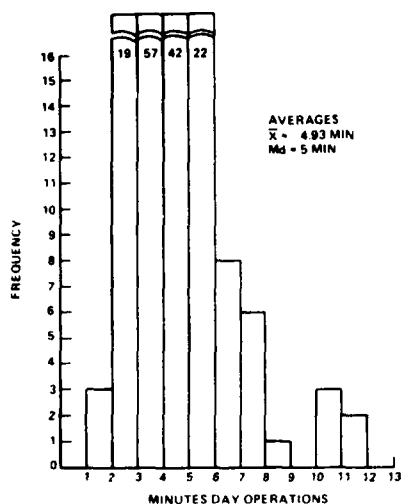


FIGURE 3.44. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE III - DAY OPERATIONS (Excludes cycles greater than 12 min.)

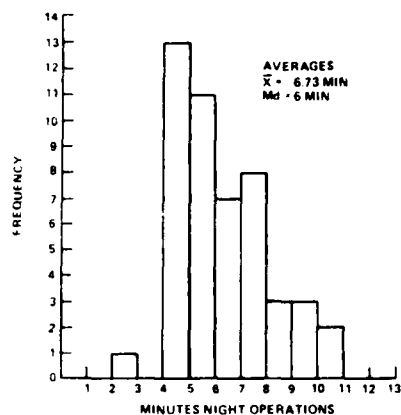


FIGURE 3.45. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE III - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

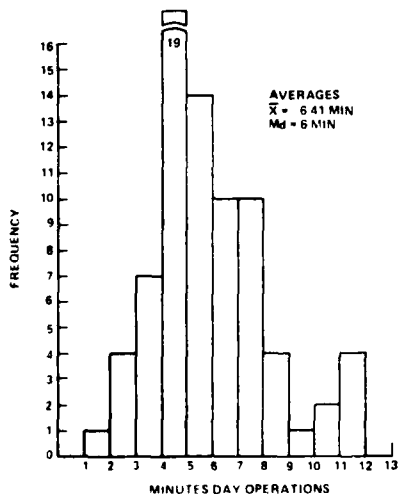


FIGURE 3.46. BARGE-TCDF RETROGRADE CYCLE DISTRIBUTIONS FOR PHASE III - DAY OPERATIONS (Excludes cycles greater than 12 min.)

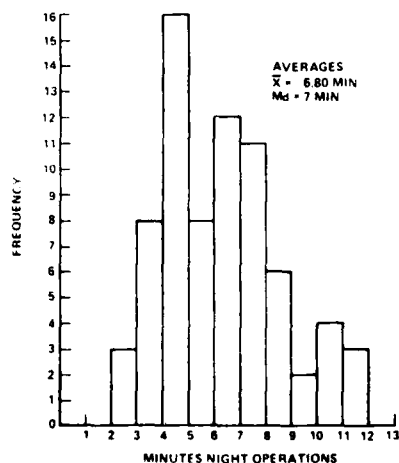


FIGURE 3.47. BARGE-TCDF RETROGRADE CYCLE DISTRIBUTIONS FOR PHASE III - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

that day and provided interruptions for the duration of Phase III. Thus, some question remains with respect to sustaining such a pace in prolonged operations.

Overall Barge-TCDF Results for Navy Units. The Navy barge-TCDF off-load cycle distributions for Phase II were comparable with the Army's Phase I results. The Army was 2 percent faster for day shift operations but the Navy was 3 percent faster during night operations. Figures 3.48 and 3.49 indicate normal cycle distributions, suggesting more consistency in the Navy operations.

Figures 3.50 and 3.51 show the cycle distributions for the Navy's retrograde half of Phase II. The average retrograde day cycles were nearly the same as the day off-loading cycles, but the night retrograde cycles slipped about 20 percent from the night off-loading rate.

The Navy results are interesting from the standpoint that they were an inexperienced team with the barge-TCDF. In this regard, given fair weather and sea state one conditions, about 90 containers per day per barge-TCDF could be expected from an inexperienced crew.

Darkness Versus Daylight Operations. As with the COD, a comparison was made of operations conducted during hours of darkness versus those conducted in daylight. The hours chosen were 0900-1600 and 2200-0500. Cycles greater than 12 min. were excluded. Figures 3.52-3.59 show the barge-TCDF cycle distributions for each of the above periods by each phase. Table 3.19 summarizes the means and medians by phase. Calculations are based upon data contained in the automated data base.

TABLE 3.19
COMPARISON OF MEAN AND MEDIAN AVERAGES (IN MINUTES) BY PHASE
DURING DARKNESS AND DAYLIGHT PERIODS FOR BARGE-TCDF CONTAINER HANDLING

Service Operating Barge-TCDF and Test Phase	0900 - 1600 HR		2200 - 0500 HR		MINS. FASTER DAYLIGHT HOURS	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
ARMY - Phase I	7.61	6	9.21	10	1.60	2
NAVY - Phase II	8.13	8	8.06	8	-1.07	0
ARMY - Phase III	4.99	5	6.81	6	1.82	1
ARMY - Phase I (R)	4.98	5	5.94	5	.96	0

From the average times in the table above the differences cited in Table 3.20 were determined. As may be noted, the medians do not reflect the same operational sensitivity as the means. That is, the effects of the extreme values are cancelled, whereas the means include those influences which are important overall in evaluating ship discharge times.

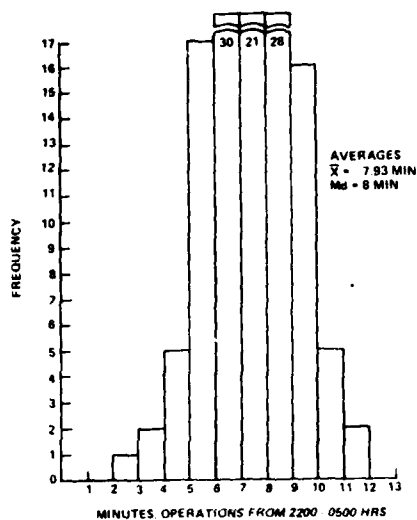


FIGURE 3.48. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE II - DAY OPERATIONS (Excludes cycles greater than 12 min.)

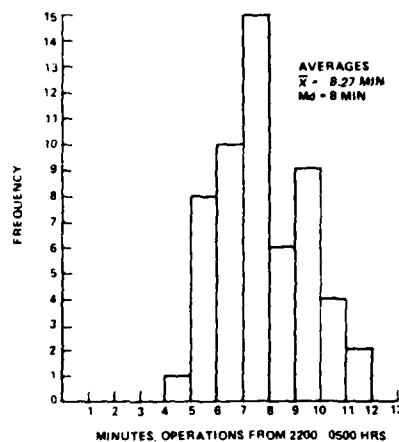


FIGURE 3.49. BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS FOR PHASE II - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

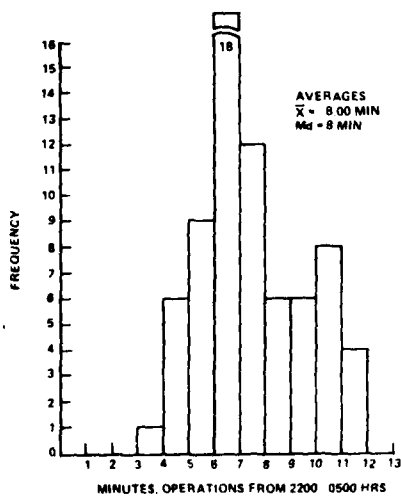


FIGURE 3.50. BARGE-TCDF RETROGRADE CYCLE DISTRIBUTIONS FOR PHASE II - DAY OPERATIONS (Excludes cycles greater than 12 min.)

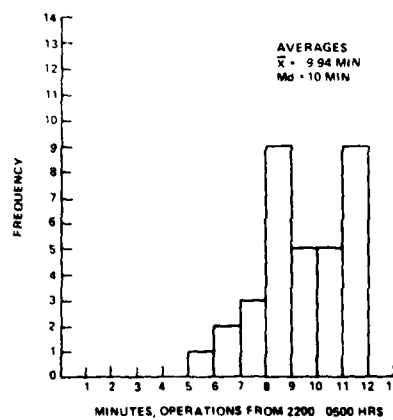


FIGURE 3.51. BARGE-TCDF RETROGRADE CYCLE DISTRIBUTIONS FOR PHASE II - NIGHT OPERATIONS (Excludes cycles greater than 12 min.)

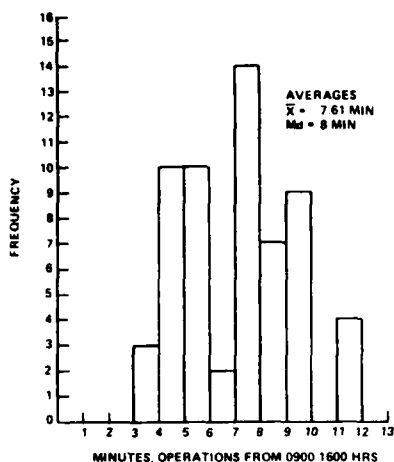


FIGURE 3.52. PHASE I BARGE-TCDF OFF-LOAD CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DAYLIGHT OPERATIONS (Excludes cycles greater than 12 min.)

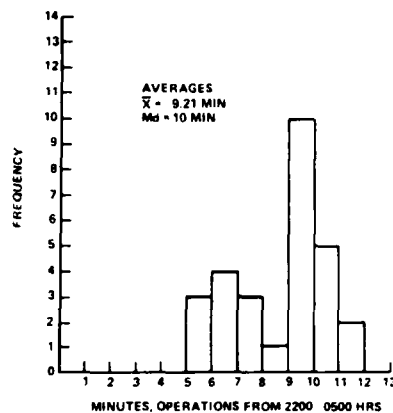


FIGURE 3.53. PHASE I BARGE-TCDF OFF-LOAD CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DARK OPERATIONS (Excludes greater than 12 min.)

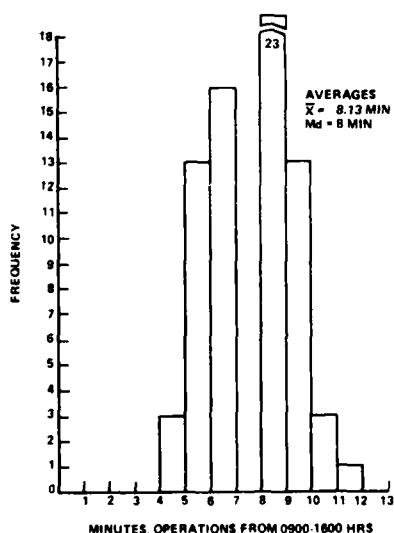


FIGURE 3.54. PHASE II BARGE-TCDF OFF-LOAD CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DAYLIGHT OPERATIONS (Excludes cycles greater than 12 min.)

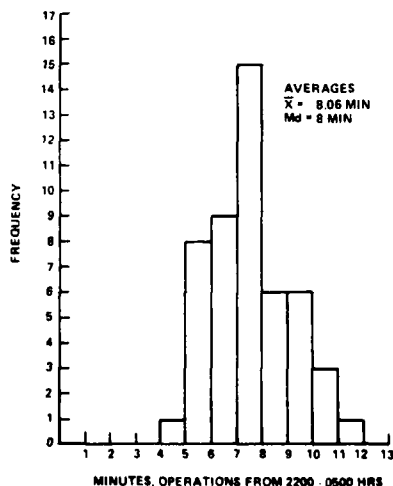


FIGURE 3.55. PHASE II BARGE-TCDF OFF-LOAD CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DARK OPERATIONS (Excludes cycles greater than 12 min.)

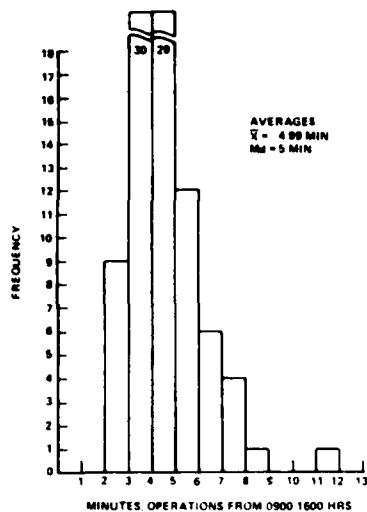


FIGURE 3.56. PHASE III BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DAYLIGHT OPERATIONS (Excludes cycles greater than 12 min.)

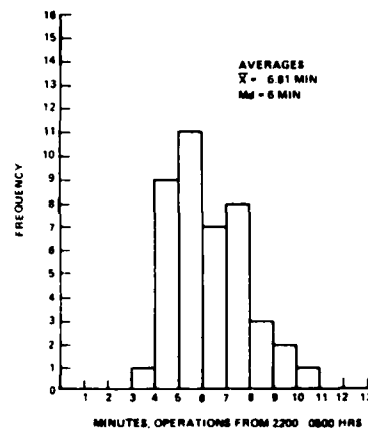


FIGURE 3.57. PHASE III BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DARK OPERATIONS (Excludes cycles greater than 12 min.)

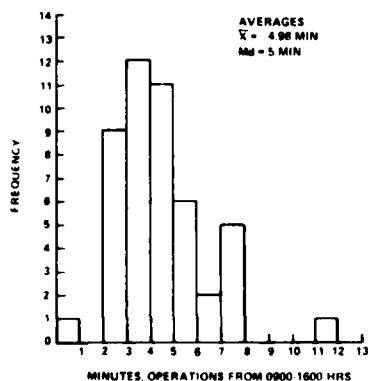


FIGURE 3.58. PHASE I(R) BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DAYLIGHT OPERATIONS (Excludes cycles greater than 12 min.)

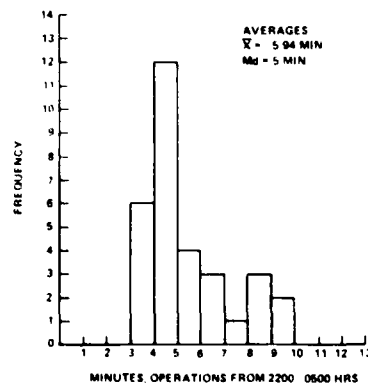


FIGURE 3.59. PHASE I(R) BARGE-TCDF OFF-LOADING CYCLE DISTRIBUTIONS - DARK VERSUS DAYLIGHT OPERATIONS - DARK OPERATIONS (Excludes cycles greater than 12 min.)

TABLE 3.20
BARGE-TCDF CYCLE DIFFERENCES
BETWEEN DAYLIGHT AND DARKNESS

Service Operating Barge-TCDF and Test Phase	Mean Differences (Percent faster in Daylight)	Median Differences (Percent faster in Daylight)
ARMY - Phase I	20	25
NAVY - Phase II	-1	0
ARMY - Phase III	36	20
ARMY - Phase I(R)	19	0

From Table 3.20 it can be noted that for the Army daylight operations were about 25 percent faster. For the Navy there was almost no difference, but why this is so cannot be readily explained from the data. If darkness does have this type of operational effect (a 25 percent reduction), then perhaps every measure possible to keep the cranes productive during daylight hours should be exercised. For example, if maintenance can be deferred to the evening, it should be.

Summary of Barge-TCDF Results. Table 3.21 summarizes barge-TCDF off-loading and retrograde cycle averages by phase for day and night shift operations (as opposed to Table 3.19 which considers only certain hours on each shift). The averages were calculated from data in the Joint Test Directorate automated data base and excluded cycles greater than 12 min. to filter out non-off-load/retrograde activities and delays which are treated separately.

TABLE 3.21
AVERAGE BARGE-TCDF CYCLE TIMES (IN MIN.) BY PHASE

Service Operating Barge-TCDF and Test Phase	OFF-LOADING				RETROGRADING			
	Day Operations		Night Operations		Day Operations		Night Operations	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
ARMY - PHASE I	7.77	8	8.52	9	7.03	7	8.95	9
NAVY - PHASE II	7.93	8	8.27	8	8.00	8	9.94	10
ARMY - PHASE III	4.93	5	6.73	6	6.41	6	6.80	7
ARMY - PHASE I(R)	4.71	4	5.97	5	-	-	-	-

Container Weights. An analysis was made to determine any correlation between container weights and cycle times. With the crane-on-deck there was nothing to suggest that this could be the case. However, with the barge-TCDF in Phases III and I(R) there is some indication to show that heavy 20-ft containers required more handling time than empties and lightly loaded ones. The difference averaged about 1 min. However, the sample sizes involved were small and do not conclusively establish this to be a certainty. This is an area that should be followed up in future tests as it has implications for barge-TCDF discharge operations of heavy loads such as ammunition.

Barge-TCDF Cycle Segments

Components of the barge-TCDF crane cycle were analyzed to determine how much time was spent on the various elements within the cycle. As in the case of the COD, these components, based upon a continuously running clock, covered periods from when the lifting device was:

- Grossly over the container to attachment to the container;
- Movement from the hatch area to the lighter or, if retrograding, from the lighter into the cell;
- Unlocking the lifting device in the lighter or, if retrograding, in the cell; and
- Return to grossly over the next container.

Table 3.22 summarizes the reduction of cycle elements by phase. Both Phases I and II reflect the lack of crew skill. The area of most noticeable improvement as the test progressed was in the attachment of the lifting device to the container. Latching time took approximately 30 percent of a crane cycle. There was almost an 80 percent improvement in Phase III over Phase I. At first, nearly half of every cycle was spent just trying to attach the lifting device to the container. In Phase II the Navy initially used the container sling and did not experience the learning problems the Army had trying to latch a container.

TABLE 3.22
BARGE-TCDF CYCLES BY TIMED SEGMENTS

PHASE	TYPE OF OPERATION	LIFTING DEVICE	SHIFT	INTERVALS (IN MINUTES)				
				ATTACH LIFTING DEVICE	LIFT-TO-LAND CONTAINERS	DETACH LIFTING DEVICE	RETURN TO CYCLE START	TOTAL
I	Off-Load	Sprdr Bar	N	4.43	2.57	.51	.97	8.48
I	Retro	Sprdr Bar	D	1.56	3.41	.31	1.21	6.49
I	Off-Load*	Sprdr Bar	D&N	2.94	5.07	.23	1.48	9.72*
II	Off-Load	Sprdr Bar	D	1.65	3.09	.32	1.74	6.80
II	Off-Load	Slings	D	2.39	3.42	.14	1.36	7.30
II	Retro	Sprdr Bar	D	1.98	4.28	.25	1.30	7.81
III	Off-Load	Sprdr Bar	D	.89	1.82	.12	1.14	3.97
III	Retro	Sprdr Bar	D&N	1.12	4.75	.41	1.84	8.12
I(R)	Off-Load	Sprdr Bar	D	1.76	1.87	.31	.77	4.71
* 40-ft Containers								

During retrograde the TCDF crane operator could observe the attachment of the lifting device to the container and in the lighter thereby latch faster than below decks during off-load. But this improvement was more than off-set by the increased time needed to fit the container into a specific cell slot during retrograde. The latter operation took two to three times longer in Phase III, for example, than for the lift-to-land element of an off-load type container transfer.

Several factors influenced lift-to-land times. The slowest lift-to-land segment was for the 40-ft containers. Because of their size they were handled slowly at first but after a couple of test lifts, they were moved faster. Retrograde lift-to-land times were slow, especially at night not only because crews were able to use the guides on one end of the bay only when exact fitting was necessary. For the most part landing containers in lighters was not too difficult with one possible exception. The LACV-30 required more careful positioning of containers than did the other lighters and appeared to take longer, but it is not possible using the data base to assess this effect. During the test about a 30-50 percent improvement was noted in the lift-to-land times between early Phase I and II operations compared to subsequent Phase III and I(R) operations.

Forty-foot Containers. The cycle rates at the barge-TCDF (9.72 min.) were comparable to those of the COD (10.05 min.) although the sample sizes in both cases were small (seven at the TCDF and eight at the COD). The fastest cycle was accomplished at night and took 5.75 min.; the slowest cycle (the first attempted by a night crew) was about 14 min. It appears that the slower cycles for the 40-ft containers were due to apprehension in handling the larger, heavier loads. The equipment did not appear strained even for a 34-ton lift from the centerline of the ship.

Causeway Ferry Use

The employment of a causeway ferry at the barge-TCDF was of mixed benefit. On the one hand, the craft provided an alternate drop point for the crane, freeing it from dependence upon the availability of other lighters. However, the causeway ferry could not be maximum loaded (athwartships stowage) because the Lightweight Amphibious Container Handler (LACH) required different stowage (longitudinal) in order to straddle the container. Thus, more frequent repositioning of the causeway ferry was necessary which caused brief delays.

Secondly, a causeway ferry (normally 360-450 ft long) requires a relatively powerful form of propulsion and is difficult to control, especially in tidal cross-currents. Consequently, mooring and casting-off were often slow, causing delays at the crane unless maintenance or some other type activity was on-going. In addition barge-TCDF relocations were also delayed because of the extra positioning time associated with the causeway ferry. In Phase II, 17 delays were identified relating to causeway maneuverings, averaging about 24 min. each and totaling about 6.75 hr.

A causeway ferry element is part of the COTS program. Included in the redesigned causeway ferry system is a more powerful water jet propulsion

unit to make the craft self-propelled. This powered ferry might overcome much of the delay time in mooring or clearing the ship.

Effect of Waves on TCDF Operations

During backloading the afternoon and night of 17 August the TCDF was shut down because of wave action. Although backloading containers is more difficult in a seaway than off-loading them, the incident is described here in some detail, since it is judged typical of the way sea state affects TCDF operations.

At a time just prior to the shutdown, the waves were estimated to be 1½ to 2 ft high. The sea state was judged to be between 1 and 2. The wind was about 10 knots, blowing somewhat north of west. With the ship riding the tidal current, its bow faced at about west, the TCDF and the lighters that served it were exposed to the full effects of the waves.⁵ The lighters that served the COD, on the other side of the ship, were almost completely in the lee of the ship, and moved much less.

At this time the barge rolled 1 degree each side of level and pitched somewhat less. After 15 min. of trying in a brief lull, the container on the LACV-30 was latched onto. The second container was latched onto after six tries. During the worst wave condition the relative motion between the spreader bar and the container was as much as 6 ft and in this circumstance it was impossible to connect the spreader bar and the container. When the relative motion in heave was diminished to about a foot during a lull, the connection was made. The unloading of these two containers from the LACV-30 took 29 min. A second LACV-30 followed and took 18 min. to unload. On the first container it required eight tries for the spreader bar to be connected. For the second container a third try was successful. Following one more LACV-30 load, an LCM8 came alongside the causeway ferry and tied up at the TCDF barge. At this point the decision was made to cease operations. Waves were now judged to be 3 ft high. Their tops occasionally were even with the causeway deck. The relative motion between the container on the lighters and the 1,050-lb spreader frame, which had to be connected to the container, was in three dimensions, with angular, vertical, and linear motion all possible.

⁵ The lighters serving the TCDF would in any event have been less apt to be in a lee, because they were further away from the ship than those serving the COD. This was because of the 60-ft width of the TCDF barge and a four-section causeway ferry (21 ft wide) used as a landing stage. Thus, the lighters were more than 81 ft away from the side of the ship at the TCDF, but directly alongside at the COD.

In the LOTS operation, the crane operator usually had the assistance of tag line handlers to help with the final alignment. Usually tag line handlers are able to force the spreader bar the last few inches into the needed position. When the load was pendulating from the effects of a seaway the tag line handlers were not strong enough nor well enough coordinated with one another to control the pendulum action. In these conditions the crane operator was not assisted. He had to estimate and anticipate when his load was in the right place and promptly lower it in the last foot or so. This effort often took a number of tries and the impacts of the heavy spreader bar were not easy on the containers.

Rigging of TCDF for Operating in a Seaway

Special Constant Tension Power Tag Lines. The design of the LOTS test was flexible with respect to the use of power tag lines. In the test power tag lines were used intermittently in the initial phases of unloading by the TCDF but not by the COD. After the deck-stowed containers had been unloaded and below deck cargo was started, the power tag lines on the TCDF began to foul as the spreader bar was lowered into a bay to pick up a container. The problem became progressively worse as the distance down into the cell increased. Finally the use of the power tag lines was abandoned altogether.

Power tag lines were intended to serve two functions. This was the function of turning the container in azimuth so that it would be set onto a lighter in a direction appropriate to the lighter and its unloading. If left to swing without the power tag lines, the container's natural position, because it is suspended from two side by side boom-tip sheaves, would be perpendicular to the crane-boom centerline. The power tag lines permitted the crane operator to adjust the container direction. This was convenient and quick for some of the early TCDF operations when, for example, the crane boom was at an angle of 45 degrees to the axis of the barge with a container over a lighter. For these early operations the containers were easily turned by the power tag lines to be athwartship on the LACV-30s, or turned to be fore-and-aft on the LCM8s and LCUs.

The second function of the power tag lines was to simultaneously cut down pendulation and to permit control of the suspended load in a horizontal arc toward or away from the crane. The power tag lines accomplished this with the use of a pair of constant-tension winches mounted on the aft end of the crane. From the winches two lines led through fair-lead pulleys at the outer end of a cross-member on the crane boom. From there the lines went to the ends of the spreader bar. Tension in the two lines pulled the load toward the crane so that the main load-carrying wires that suspended the load from the boom tip were no longer quite vertical. The angle away from perpendicular actually was small -- a few degrees -- because the tension of the pair of power tag lines was kept low, on the order of 1 ton or less. The effect of this three-point suspension was to minimize pendulation. Within limits, oscillation of the boom tip does not result in the load swinging because the tag lines prevent it.

The use of power tag lines on a crane is a developmental area being conducted by the Navy under the COTS program. From the LOTS test data base the

effectiveness of power tag lines for controlling pendulation cannot be assessed. In the COTS program the power tag lines are part of an overall system to sense and control the transfer of containers even in a sea state three. Conceptually the program is promising and initial testing has provided favorable results. The powered tag lines used in the LOTS test required additional operator skill and were largely experimental. Thus, there were some expected first-time use problems. This should not detract from further development since there are favorable aspects to this type of approach.

MANAGEMENT OF CONTAINERSHIP OPERATIONS

Army

Throughout the test it had been apparent that the throughput bottleneck was at the ship and that better coordination was needed. In Phase I(R) the company commander of the 119th Transportation Co. (Terminal Service) (Container) stationed himself aboard ship for both the day and night shifts, and personally directed ship discharge operations. During that period, one of the highest daily discharge rates was achieved and more containers could have been handled if they had been aboard. The company command post remained ashore with the majority of the unit's operational equipment. While there was no apparent disruption to the unit's operations, there could have been and it points to a gap in the company's organizational structure. The unit is not authorized an executive officer to act in the commander's absence. Subsequent to the test an operations officer has been temporarily added to the unit's table of organization,⁶ but not an executive officer. The addition of the operations officer to the company will help fill some voids in officer supervision of around-the-clock unit operations. The company has operations spread over a large water and surface area. Individual platoon commanders or their NCOs made **management decisions** within their limited scope of the operation which had an impact on the throughput of the entire system. Continuous system planning, coordination, and supervision are required by the company commander or his operations officer. During the test without an executive officer and an operations officer the company commander was limited in his ability to react, man his command post, and visit key operational sites.

For continuous day and night operations requiring close control and coordination the unit needs an overall manager for both shifts. At the same time the company commander has responsibilities for meeting with subordinates, higher headquarters, and adjacent commands for coordination and direction. This was apparent even in the LOTS test and it left little time for planning, observing ashore and afloat units, supervising, and implementing decisions. While an operations officer can provide some shift coverage for the company commander, the two need to work together on daily problems which could seriously degrade throughput capability, such as scheduling refuelings, coordination of maintenance, retrograding and stowage aboard ship, other ships to be worked, employment of lighters, shift changes and other operational matters and interface activities not necessarily at the containership. The continuity of command needs to be maintained at the same time. Herein lies the value of an executive officer. Few **other military units are equally as active at night** as they are during the day. Nor do they have the variety of high productivity/high value equipment of a terminal service (container) company, or the impact on the logistics support of a deployed force. The company commander has to be able to plan and conduct daily operations, react to emergencies, supervise all of his **unit's activities**, and maintain continuous operations around the clock.

⁶ A terminal service (container) company now consists of a company commander (a captain), operations officer (a lieutenant), two container discharge platoon commanders (lieutenants), two clearing and marshaling platoon commanders (lieutenants), and a documentation platoon commander (lieutenant).

The battalion staff assumed some of the company's functions and responsibilities, specifically for beach clearance and marshaling yard operations. In addition to this, however, the battalion staff had an element working aboard ship for controlling lighter operations. As a result, the division of responsibilities was not clear. The battalion staff became involved in making decisions normally made by the company commander and his officers. This approach could have helped overcome the management (manpower) shortfalls but it had some inherent difficulties.

First, the timing for lighter succession is critical to crane productivity and in Phase I lighter delay times were a major problem. Control and responsiveness have to be keyed on keeping the cranes active. The specific reasons for the lighter delays are not clear -- whether there was a breakdown at lighter control, between lighter control and the lighters, or between the ship's platoon and lighter control, or all of these. These questions cannot be readily answered from the data base or from general observations. However, it is reasonable to conclude that without the layering of another command between the ship's platoon and the lighters, a more responsive system might have evolved. Whatever arrangement is made for lighter control, the lighter unit commander must be responsible for ensuring that a lighter is available at each crane at all times. This is an operational procedure which the units involved need to better arrange.

A second decision area that complicated the working relationship between the company and the battalion was the use of lighters, particularly the LARC-XV and the LACV-30. The LARC-XV is limited to one container weighing 15 short tons or less. The LACV-30 can carry two 20-ft containers, but it can do so only if their combined weight does not exceed 23.5 short tons when the craft is fully fueled. Thus, for both lighters container selection was important. The problem usually came up when the crane, having completed the loading of one lighter, began its next cycle before the loaded lighter had cleared the mooring point. This operation commenced without the crane crew necessarily knowing the type of lighter to be loaded next. As noted earlier, every crane cycle involves the difficult and time-consuming step of latching the spreader bar to the next container. The sooner that step can be accomplished, the faster the cycle will be. While this was happening, the next lighter would either be approaching the ship or mooring. If the container that was latched (and perhaps already lifted) was too heavy for the new lighter, the container had to be set down and all previous time and effort were wasted. If the objective was to maximize every LACV-30 load, then a search for a second light container was necessary.

The policy (not established by the container company) during Phase I was to give the LACV-30 priority over all other lighters for loading and off-loading. This policy had the effect of worsening the load limitation problem described above by increasing the frequency of LACV-30 appearances through its "head of the line" privileges. In addition, this policy also resulted in "wave-offs" of other lighters which could have been more responsive to the cranes if they had been allowed to continue mooring instead of giving way to an approaching LACV-30. Another possible effect of the priority system is that voluntary responses from other lighter operators were inhibited as it was noted that lighters tended to loiter at some distance from the ship and appeared to be reluctant to approach for mooring.

It is concluded that the additional management support (as subsequently proposed by the Army and now awaiting final Army Staff approval) by the addition of an operations officer in the terminal service (container) company is badly needed. Also, the high level of activity, mission importance, scope and complexity of operations, and need for continuity of command merit consideration of the addition of an executive officer.

Additionally, it is concluded that certain operational decisions unintentionally contributed to the low productivity of the ship crane systems. These decisions related to:

- The division of operational responsibility between the terminal service company and battalion staff for container-ship discharge and lighterage control, and
- The establishment of a priority system favoring LACV-30 use in Phase I. The resultant effect was that the ship crane units, the throughput system bottlenecks, were required to be responsive to the lighters rather than the other way around.

The Army should consider the desirability of elevating the rank of the company commander from captain to major. When operating separately from battalion, the terminal service (container) company will be supported by units also commanded by captains, such as a port construction company, as well as other support units. This situation has been recognized by the Marine Corps which has made its shore party group (reinforced company) commander a major. The mission is somewhat different in that he is initially responsible for combat support but not shipboard operations. However, other functions and responsibilities are quite similar.

Navy

Navy shipboard management during Phase II was similarly hampered by lack of prior experience on board a containership, but operations progressed quite well. The Navy used a higher level of management (lieutenant commander and lieutenant, O-4 and O-3) than the Army (lieutenants, O-1 and O-2, but often with captains at lighter control). The Navy also had larger hatch crews. Primarily, however, the Navy shipboard organization (hatch crews) was task organized for the test and was not a formal organization as was the case with the Army. Thus, the Navy management levels and approaches were not rigidly structured.

The Navy doctrinally has established procedures for the conduct of ship-to-shore operations in support of an amphibious assault operation. These familiar procedures were followed in the test and, consequently, the Navy experienced fewer lighter control problems than the Army. Nevertheless, the Navy also had occasional lighter delays.

Customarily in an amphibious assault serials are reported to a primary control station when they are loaded and when the serials depart the ships. This procedure was also followed with respect to the discharge of containers in the LOTS test. Consequently, the Naval Beach Group TWO command post ashore was continuously well-informed of the status of container transfer operations. This type of information system was excellent for maintaining a real-time picture of shipboard container activity and for tracing individual containers.

STATUS OF CONTAINERSHIP DISCHARGE PROGRAMS

Army

Since the LOTS main test the Army, which is responsible for terminal operations over the beach and in-port, has continued with the planned acquisition of barge-TCDFs on the basis of a requirement of two per company. During FY 79 a second barge-TCDF will be assembled using the LOTS test shoreside 300-ton crane and another B DeLong section. Three more container companies are planned with a requirement for six additional barge-TCDFs by the end of FY 81. If any container company requires a 300-ton crane ashore to off-load landing craft, such as would be required for a bare beach operation, one of the barge-TCDFs would have to be disassembled. However, as long as a barge-TCDF system can be deployed, then the two DeLong sections needed ashore for a pier to off-load landing craft could also be deployed. In that case a 140-ton crane on the pier would suffice instead of requiring the 300-ton crane.

Where the Army approach is not clear is the case in which the TCDFs or DeLong piers could not be deployed in time to meet required operational dates. A heavy-lift or conventional breakbulk ship can deploy the 300-ton cranes and a COD system could be used for ship discharge. However, once deployed the capability to switch the 300-ton cranes back into barge-TCDF combinations has not been demonstrated. The 300-ton cranes without counterweights (weighing about 98 long tons in this configuration) must be lifted onto load spreaders on the DeLong. The load spreaders, which also serve to raise the crane high enough so that it can reach the center-line of a containership, are high, making it impractical for a drive on alternative at the beach. Hence, a heavy-lift floating crane is required to place the 300-ton crane onto this platform. Such a capability is not now a part of the LOTS equipment package and may not be available in the objective area.

The need to switch the shore-side 300-ton cranes back to barge-TCDFs may not be desired. For example, in an area of frequent choppy water or sea swells, the barge-TCDF method of containership discharge may not be viable. The Army barge-TCDF was acquired as an interim capability pending Navy development of a containership discharge system under the COTS program. Thus, a self-sustaining COD system or a TCDF comprised of container cranes on a ship's hull may be the preferred option.

Navy

The development of DOD container supported distribution systems is under the overall cognizance of OSD MRA&L, and development of a container discharge system has been assigned to the Navy. The Navy has included the project in its Container Off-loading and Transfer System (COTS) program administered by Naval Facilities Engineering Command, the principle developmental activity. The COTS program is primarily focused on support of amphibious assault follow-on echelon discharge and resupply support for the Marine Corps. However, the containership discharge system to be developed by the Navy must include Army requirements as well. The COTS development program has other elements to include floating breakwaters and ancillary equipment, elevated causeway and self-propelled causeway, RO/RO ship discharge system, and other projects. Navy system elements are being designed to support operations in sea state three

conditions and include a Rider Block Tagline System for a crane and the design of a vertical motion compensation system. The Navy containership discharge system is being accelerated to accomplish developmental testing in the FY 81 timeframe with procurements to follow immediately thereafter. A series of developmental tests has been programmed leading up to the operational tests. Previously, there was no commitment to adopt either the crane-on-deck approach or crane on a self-propelled hull. However, that decision was made in favor of the self-deployable hull but for the most part the equipment being developed under the COTS program is suitable in either case. A full operational evaluation is planned for about FY 82-83.

OSD MRA&L

The function of OSD MRA&L is to provide a strong central point for overall management and coordinative attention for Surface Container Supported Distribution Systems with respect to container system adaptation development.⁷ OSD MRA&L has established a Joint Container Steering Group (JCSG) with General/Flag rank from the Military Services, Defense Logistics Agency, and the Director, J-4 (Logistics) Joint Staff. In addition, the Military Sealift Command, Military Traffic Management Command, and Military Airlift Command each have an advisory representative to the JCSG. Chairmanship and support of the JCSG is provided by OSD MRA&L. The JCSG responsibilities are primarily to monitor and recommend. While the container supported distribution systems program covers a number of functional areas, the most challenging aspect undoubtedly is the development of a capability to discharge NSS containerships in a LOTS environment.

At present funding for the Navy program is adequate for the planned level of research. Procurement of equipment, however, has a low priority and would not cover all Service requirements. However, the Navy program should produce a ship discharge system capable of operating in sea state three conditions, whereas the Army's interim barge-TCDF is suspect in upper sea state two conditions.

The Army barge-TCDF, besides being weather and sea state sensitive, is also deployment constrained. It is, however, the only DOD system available until the Navy program is completed and fielded (FY 81 - FY 82 timeframe). The Army, in addition to its DeLong barge/pier section deployment problems, is constrained by the number of heavy lift ships in the US Merchant Marine for deploying its lighterage. LCUs, for example, are productive lighters but require a lift capability of 180 long tons (only three ships in the US flag fleet can handle this lift). LCM8s and LACV-30s, on the other hand, can be deployed on conventional breakbulk ships but only one or two per ship.

In a LOTS operation the Services have a number of common requirements. Among these are: the repair of cranes and handling equipment, POL and maintenance support of lighters, the care and feeding of crews, transportation to and from the shoreside facility, and general support. MARAD has informally suggested to various Service representatives and to ORI that consideration should be given to the use of a dock landing ship (LSD).

⁷ From the background statement of DOD Instruction 4500.41, Subject: "Transportation Container Adaptation and Systems Development Management."

Several LSD type vessels are in the NDRF and will eventually be sold for scrap. The ships possess: troop berthing and messing facilities for more than 200, which would eliminate hatch and crane shore-to-ship transportation and delays; shop facilities for the repair of lighters, cranes, and other major end items; communications equipment; refueling capabilities for cranes and lighters; a helicopter platform for transport of personnel and high priority items; winches for warping operations; and a well deck that could carry three pre-loaded LCUs or other equivalent lighters or floating cargo. The well deck could be used to shelter lighters in inclement weather. The drawbacks to these ships are that they are of World War II vintage for the most part and in need of considerable repair. Their top speeds are in the 15-18 knot range. Crewing could also be a problem.

OSD MRA&L is the focal point for consideration of all Service requirements in the containership transfer system being developed. In this regard program direction is needed since the Navy's COTS program, which is funded solely by the Navy, is oriented to support Naval mission requirements. For example, where there is the possibility of several hull types under consideration for selection of a container discharge facility, the most logical choice in terms of Navy requirements might be the most economical one, such as putting cranes on a tanker hull. This is because the Navy has other (amphibious) shipping to provide the peripheral support requirements cited above. Navy guidance has been solely to examine crane platforms. OSD MRA&L should examine the cost and benefits of the alternatives developed by the Navy and support one which best meets the needs of all the Services.

OSD support for full funding of a containership transfer system is also needed. Navy procurements will support only Navy-Marine Corps requirements. Army support requirements have not been included in the planned buys which would leave the Army with a marginal, fair weather capability. These matters need to be fully coordinated at the Service level and then presented to OSD MRA&L for program action.

CONTAINERSHIP OPERATIONS REVIEW

Phases I and II were largely learning experiences for Army and Navy crews. While crane cycle improvements were noted at both the COD and barge-TCDF, the major source of these improvements was simply better organization and management on all levels. From this there resulted improved coordination of working ship activities, the minimizing of lighter delays, and more frequent crane transfers. This is evidenced first for the Army by the fact that at the COD there was a 13 percent improvement in crane cycle time (combined day and night) and a 66 percent increase in container off-load productivity in the final phases of the test over early test results. For the Navy, at the COD there was a 17 percent improvement in crane cycle time (combined day and night) and a 55 percent increase in container off-load productivity. At the barge-TCDF the Army had a 34 percent improvement in crane cycle time and a 111 percent improvement in off-load productivity. The Navy did not operate the barge-TCDF a second time, so there is no comparison to be made.

Retrograde operations fared worse than off-load operations. Although in an actual operation the retrograde of empty containers would in time become as important as off-loading, for this test it was handled as an administrative readjustment to prepare for the next phase. Instead of empty containers (or containers filled with cargo such as brass and reparable), fully loaded ones were used. In terms of crane operations, container weight generally had no significant effect. By the time a Service got to a retrograde period, its hatch crew was considerably more experienced. Nevertheless, fewer containers were always retrograded than off-loaded, presumably because of the need to more precisely locate a container in a cell than in a lighter and possibly because maintaining a rapid rate during retrograde might seem to Service personnel less necessary than off-loading. In fact, retrograde will be critical to the use of containerships to keep the intermodal system in balance and operable. While retrograde may not be critical in the early first weeks (some estimates are that before 30 days retrograde will not be necessary), it must become a part of planning and operations as soon as possible.

Table 3.23 summarizes the off-load and retrograde cycle times for cranes at the ship for day and night operations. The calculations are based upon cycles of 12 min or less, timed from the unlocking of one container to the unlocking of the next. As a result, they exclude interruptions for hatch opening/closing operations, crane relocations, meal breaks, refuelings, scheduled and unscheduled maintenance (other than minor adjustments), weather delays, and certain lighter delays.⁸ These latter interruptions are highly variable and subject to unit leadership, experiences, and the ship employed

⁸ Lighter succession times and lighter delays are discussed in the section which follows. For all intents and purposes, whether a lighter delay could be included in the automated data base calculation used here would depend upon the crane cycle interval together with the amount of delay caused by the lighter. If the total event time did not exceed 12 min, the cycle was used. For example, a fast cycle, of say 4 min coupled with a halt for an 8 min lighter delay, would be counted with its delay, since the 12 min upper limit was not exceeded and the crane's total cycle time would be 12 min, in this particular case.

and, as noted above, have a greater influence upon ship discharge times than the possible 1-2 min variability of crane cycle times. Nevertheless, the results in Table 3.23 do provide an indication of the achievable crane cycle averages for inexperienced (Phase I and II) and experienced (Phase III and I(R)) crews. (Consolidated in Section VIII are the planning factors derived from these results.)

TABLE 3.23
DATA BASE CRANE CYCLE SUMMARY

OPERATIONAL PHASE	DAY				NIGHT			
	COD	COD	TCDF	TCDF	COD	COD	TCDF	TCDF
	OFF-LD	RETRO	OFF-LD	RETRO	OFF-LD	RETRO	OFF-LD	RETRO
PHASE I	8.71	7.89	7.77	7.03	10.38	10.29	8.52	8.95
PHASE II	7.52	7.09	7.93	8.00	7.56	7.92	8.27	9.94
PHASE III	6.13	8.07	4.93	6.41	7.33	8.72	6.73	6.80
PHASE I(R)	7.08	-	4.35	-	7.50	-	5.74	-

Where a ship's platoon will best reveal its organization and efficiency is with those working ship activities that detract the cranes from container transfers. Table 3.24 provides a summary of the average times for each of the major activities by crane type and an expected rate for an experienced deck crew. The latter rates do not represent the fastest cycle times but do heavily consider the typical results of Phase III and Phase I(R) events and the better ones in Phase I and II.

Army Operations

Data and analyses of Army operations were largely influenced by the state of training of the 119th Transportation (Terminal Service) (Container) Company. The unit began operations aggressively but lacked experience with handling containers on an actual containership of this type. Periodically some frustration was evident in dealing with some of the fundamental problems of organization, latching containers, selecting the right containers, and, in general, making operations mesh smoothly. After watching the Navy undergo many of the same learning experiences and by readjusting their own mode of operations, the Army greatly improved container throughput in Phase III.

TABLE 3.24
SUMMARY BY PHASE OF WORKING-SHIP AVERAGES (IN MIN)

OPERATIONAL PHASE	CRANE-ON-DECK				BARGE-TCDF			
	SINGLE HATCH OPEN/CLOSE	TWO- HATCH CLOSE/OPEN	CRANE* RELOCA- TION	CRANE REFUELING (DAILY)	SINGLE HATCH OPEN/CLOSE	TWO- HATCH CLOSE/OPEN	CRANE RELOCA- TION	CRANE REFUELING (DAILY)
PHASE I	27	57	145	66	23	31	28	60
PHASE II	29	44	71	45	26	43	52	56
PHASE III	20	28	119	Unk	16	22	37	Unk
PHASE I(R)	21	23	-	-	14	23	39	-
Expected Rate	16	28	65	50	16	29	35	50

* Excludes time to relocate instrument van. Times could be improved if a faster means to rig the spans is developed.

Army personnel soon realized that to obtain the quantitative discharge rates possible with containerization it was necessary that timing be keyed to keeping the cranes active. Better lighterage control was obtained and deck operations were greatly expedited as hatch crews learned what had to be done and how to accomplish as many concurrent activities as possible. While crane cycle rates on the barge-TCDF improved by 34 percent, overall productivity improved more than four times that amount (146 percent) with better deck organization and crews that were able to anticipate and react. At the crane-on-deck Army crane cycles improved 17 percent while total productivity jumped 66 percent (still 2/3 that of the Navy's best effort).

The initial phase of the test Army training in certain container operations was noticeably deficient. The hatch crew appeared to be unfamiliar with the Peck and Hale type rigging used at the COD. There was little anticipation of what the next move would be, who was to do it, and how it was to be done. There was no coordination of familiar activities such as crane refuelings and barge-TCDF relocations, so lengthy executions and extended delays resulted. Signaling became a problem at night because of bad lighting. Also, the signals used were not always consistent nor well understood between operators and signalmen. The lack of sufficient manpower among cargo handlers (stevedores) caused delays and compounded other operations besides container transfers to include handling lines for mooring lighters, lashing and unlashings and conducting other working ship activities. Since there were no training facilities to acquire these skills, the LOTS test provided the training opportunity sorely missed.⁹ With learning came improved results. To retain these skills, however, the container terminal service company needs to conduct regular training drills with rigid time and safety standards on each aspect of deck operations such as crane refuelings, hatch openings, crane relocations, etc. For that type of training the Army needs to seek appropriate training facilities, such as a containership hull. The management of lighter operations in Phase I contributed to low throughput rates by adding delay time to the cranes and, in effect, caused the cranes to become responsive to the lighters. This was especially apparent when the crane had to wait for lighters and to choose light containers in order to accommodate amphibian load limitations. The assignment of a priority to the LACV-30 compounded the crane problems of load limited lighters and very likely inhibited the responsiveness of operators of other types of lighters. Also, the separation of responsibility between battalion staff and the terminal service company for shipboard, beach and lighter operations resulted in unnecessary confusion and delays.

Terminal Service Company (container) needs the augmentation of an executive officer at least to back-up the company commander during periods of absence and for maintaining command continuity during round-the-clock operations. Augmentation in the form of a company operations officer (temporarily

⁹ It should be noted that some equipment used ashore was received just a couple of months before the test, barely time for the paint to dry before being used in the test. Thus, there were a number of administrative burdens as well as time and training facility limitations that complicated preparations.

included now in the TOE) is needed to supervise and plan shipboard operations of both cranes, coordinate the employment of lighters, plan the retrograde of containers aboard ship, assist in the planning and preparation of shoreside facilities (discussed later), deployment of unit equipment, requirements for incoming and departing ships and other operational planning and organizational responsibilities. The Army should consider elevating the rank of the company commander to major since the company's assets are on the order of several million dollars and an experienced officer is needed to ensure and sustain the high productivity possible (expected to be on the order of two to four times that of a breakbulk unit).

From the results of the test it is apparent that large scale round-the-clock container exercises are badly needed by the Services. The requirement to establish a ship-to-shore throughput system, to obtain the management skills of directing all the elements of the system, to produce the critical timing sequences where elements of the system must interface with each other, to improve techniques for night operations, and to retain the troop expertise of rapidly working a high productivity vessel need to be exercised annually to attain the benefits of containerization. Different types of operational problems such as timing at each container transfer point, balancing resources with deployment limitations, employment of personnel, the stressing of units and equipment, and confidence in mission capabilities do not become evident without a full scale exercise using large numbers of loaded containers.

Navy Operations

The Navy proved that it could task organize a unit capable of conducting a LOTS or LOTS-type operation. Using fundamental ship-to-shore procedures set forth in amphibious doctrine, the Navy had a good framework for operations and management. Nevertheless, the Navy had many of the same situations of learning new procedures and getting organized as the Army, including a number of lighter delays as well.

Navy techniques for the most part were similar to the Army's with the exception of a chain container sling (primarily used at the COD) and a causeway ferry alongside the barge-TCDF. The Navy had better control over its lighterage and maintained good radio discipline.

The use of a causeway ferry alongside the barge-TCDF to act as a drop point if no other lighters were available helped free the crane from lighter dependence, but required excessive crane delays for maneuvering. At least one fully loaded causeway ferry resulted from each shift, strongly suggesting that lighter successions and responsiveness could have been improved.

The use of chain slings facilitated and expedited the latching problem experienced with spreader bars. Navy crane operators, who had less experience in this type of crane operation than their Army counterparts, were able to better the Army results of Phase I by 35 percent, possibly because of the container sling.

Crane-On-Deck

The crane-on-deck method for container transfers proved to be a sound approach. The COD was not hampered in the mild sea state conditions experienced, although once some gusty winds banged a container into the side of an LCU and lightning and hard rain periodically halted crane operations everywhere. When the barge-TCDF was forced to halt because of local wave action, the COD was able to continue. COD sea state operating limitations could not be determined during the LOTS test for lack of rough seas.

The 200-ton lifting capacity crawler crane had no problems operating on the Navy hatch bridging equipment. The crane was able to work both sides of the ship from its centerline position although it was not able to take full advantage of this capability due to the presence of the barge-TCDF. Otherwise, lighter delays could have been eliminated by the mooring of an empty lighter on the opposite side loading was taking place. With this type of queue system operations and management could have been greatly facilitated.

The COD is inherently restricted by the inability of the crane operator to view the lighter moored alongside. This requires excellent teamwork among the crew, especially between signalmen and crane operators. In this respect the COD was penalized by inexperienced signalmen and crane operators and its cycle times suffered accordingly.

Further complicating COD operations was the requirement to pass tag line handlers (referred to as "jumpers") from one lighter to the next. This was (supposed to be) done by the use of a safety boat before the container landed. A fast and simple means of transferring tag line handlers is needed for safety and to eliminate crane delays.

As a system, the crane-on-deck method has not been operationally developed nor is the system likely to be implemented. If the COD is to be used in any capacity, hatch bridging kits, which are relatively inexpensive, need to be procured and positioned at locations yet to be determined. This latter course could be followed regardless of crane procurement/leasing decisions and could have application in conjunction with a TCDF crane-on-ship hull program, but in the interim it is especially needed to augment the barge-TCDF which is deployment constrained and sea state sensitive.

Barge-TCDF

The barge-TCDF in most cases had higher daily productivity and transferred 20 percent more containers than the COD. It also had the highest 24 hr rate (184 versus 147 for the COD) and was the crane system most familiar to participants. Like the COD, its efficiency also was penalized by having to work with a different type crane system (in this case, the COD). The barge-TCDF would not have been forced to make lengthy moves around the ship and most of the time (exceptions being when the ship swung around with the tide) at least one barge-TCDF could have enjoyed the calmer water on the lee side of the ship.

Because it has a relatively small (150 ft by 60 ft) platform the barge-TCDF crane was more subject to pendulation caused by wave action than the COD. It had to halt operations because of ships passing nearby, conditions in the sea state (upper) two and (lower) three range, and occasionally for choppy water (sea state not identified). Since this is one of the major areas of weakness with the barge-TCDF (another being its deployment), the Army needs to closely monitor research and analyses programmed by the Navy in CY 1979. The Army also should consider the use of wave dampening equipment also a Navy development to improve TCDF performance.

The barge-TCDF crane operator had the advantage of being able to see the lighter he was loading or discharging (which the COD operator couldn't), as well as the containers on deck and some in the hold (that the COD operator could also have seen). Relocation of the barge-TCDF were more frequent (once per bay) than the COD (once per every other bay); but they required less time (about 35 min per relocation from bay to bay versus about 100 min for the COD). Tagline handlers could work on and off the barge-TCDF when loading lighters, eliminating the need for a boat to support the transfer. Mooring was easier for lighters at the barge-TCDF than the COD but lighters also were further from the wave sheltering effects of the ship.

In conclusion, as part of a LOTS system the barge-TCDF has a critical deployment weakness due to its size and weight and it is sea state sensitive. However, it is highly productive in fair weather and it is the only ship discharge system in an operational unit.

For the near term DOD support is needed to accelerate the Navy development of a less sea state sensitive, self-deployable containership discharge facility which meets all requirements of the Navy and Army.

IV. LIGHTER OPERATIONS

SECTION SUMMARIES

Lighter Successions

Ship discharge is dependent upon the activity of cranes. Crane delays almost always were the source of system bottlenecks. A major crane delay was lighter succession, that is, the interval of time from one lighter casting off until the mooring of the next lighter. Early in the test the lost crane time attributable to lighter succession was often as large as the crane productive time. The spread in the averages was usually from 11 minutes to 1 minute; however, a cut-off of 15 minutes was used to eliminate non-representative outliers. Consequently, the mean average time for over 90 percent of the lighter successions was 5.2 minutes (instead of 8.5 minutes with the outliers). Day time average was 4.4 minutes, while the night average was 6.5 minutes. The slowest average succession was the LARC-LX, averaging 6.7 minutes. The fastest was the LCM8, averaging 4.2 minutes.

While productive crane time could only be lost by lighter succession delays, fast or improved lighter succession time did nothing to expedite or improve crane cycle time. Thus, the throughput impact of lighter succession times cannot be fully judged simply by looking at averages. Lighter succession times have to be closely watched and managed so that crane delays do not occur.

Lighter Capacities

Lighter capacities varied according to existing sea states and unit operational policies. The 1466-class LCU carried 4-7 containers and the 1646-class LCU carried 4-5; the LCM8, 1-2; the LARC-XV, 1; the LARC-LX, 2; the LACV-30, 1-2; and a 4-section causeway ferry, 4 per section (12-16 if loaded athwart craft, up to 90 short tons). The LACV-30 was found to be load limited to 23.5 to 26.5 short tons, depending upon how much fuel was aboard; consequently, selection of suitably weighted containers was sometimes a problem if 2-container loads were planned.

Resource Requirements

Numbers of lighters needed to support a LOTS operation varies depending upon the size of the lighter load, its speed, and the ship distance off-shore. As a rule of thumb, to obtain 95 percent crane productivity time, 1.5 additional lighters (regardless of type) is needed for a queue from .5 to 4 nautical miles (nmi) off-shore. Thus, for a one ship discharge operation at the 1.4 nmi test distance from shore, the requirements would have been either 6-7 LCUs, or 6-7 LACV-30s, or 8 LCM8s, or 9 LARC-LXs, or 11 LARC-XV-

The number of the LCUs with their larger container carrying capacities (4 to 4.5 average, depending upon class) and slower speed (7-9 kts) remain approximately the same as the number of LACV-30 (1.5 container average and 27 kts speed) regardless of off-shore distance. In distances greater than 4 nmi off-shore four or more container loads per conventional landing craft are needed to off-set the 27 kt speed of the LACV-30, unless heavy containers such as ammunition (19.5 short ton average weight, see ORI, Inc. TR 1468¹) are used, which reduces the LACV-30 load to one per trip. In distances relatively close to shore (1-2 nmi) speed has little effect on lighter cycle time.

Fuel Consumption

Fuel consumption as a function of containers delivered was also examined. The most economical lighter was the newer class (1646) LCUs (9 gals. per container). The least economical was the LACV-30 (46 gals. per container).

GENERAL

This section of the report presents an analysis based on measurements and observations of lighter operations during the LOTS test. The test was conducted in predominantly calm weather, so the results apply to generally ideal weather conditions. No assessment was possible of such important problems as the slowdown or stopping of lighter operations as sea state increases. Further, with only a single test site used, effects of changes in factors like beach gradients (important, for example, in such matters as a choice between amphibians and landing craft for future procurement) could not be analyzed.

The analyses that follow address the interaction of the lighters and the ship crane systems and develops the segments of the lighter cycle. The latter were developed for the purpose of estimating total lighter requirements in support of container operations and as a basis for statements of unit capabilities. Lighter system support requirements are not addressed, since they are beyond the scope of the analysis plan. POL consumption only is examined since economy in its use is an important consideration.

¹ ORI, Inc., Analysis of LOTS Requirements to Support a Non-Mobilization Contingency Situation (U), SECRET, ORI, Inc. Technical Report No. 1468, dated 5 January 1979.

EFFECTS OF LIGHTERS ON SHIP DISCHARGE RATES

General

The maximum rate of ship discharge is geared to the movement of the crane booms. In the LOTS test the ship cranes were almost always the bottleneck of the entire LOTS operation. A major contributing cause for delays was that the cranes often had to wait for an empty lighter to succeed one that had just been loaded, and on some occasions the loading process itself was observed to be somewhat slowed by procedures used with the different lighter types. This section discusses lighter loading and the relation of lighters - and their management - to ship-crane productivity.

The ways a lighter can affect ship unloading can be divided into three categories:

- The largely avoidable delays occurring when the crane is ready to discharge cargo into the lighter, but no lighter is nearby. Assuming that sufficient lighters are available, such delays can be controlled or eliminated by appropriate management of the lighter waiting line or queue.
- Delays that occur even when replacement lighters are close by, as a filled lighter moves away from its loading position and an empty one maneuvers to substitute itself for the filled one. For limited periods during later phases of the LOTS test, this succession time interval was short enough so that the crane was not interrupted significantly as it was still engaged with necessary parts of its operating cycle that did not require the lighter.
- Differences in the time it takes to actually load containers into one lighter type as compared to another. However, such differences appear to be small and, in any event, tend to be masked by differences in crane operator skill, changes in weather, and the like. Thus, these differences are difficult to separate from the "noise" in the data.

The delays caused by the first two categories - the avoidable delays when a lighter was not available, and the maneuvering delays that were judged mostly unavoidable - have no threshold separating them in the data. Both are part of the lighter succession time, measured for the purposes of the present analysis² from when one lighter was cast off and ready to depart, to the time the next lighter was moored ready to receive a load. The delays during the time the lighter is at the ship being loaded fits in the third category. This total period is measured from the time the lighter is tied up and ready to receive cargo until the lighter is cast off and ready to depart.

² An alternative definition, used in Volume I, the descriptive section of this study, measured the time beginning when the first lighter was clear of the ship. This incorporated the cast-off time as part of the time alongside the ship, instead of succession time. The two appear to differ by about one full minute.

LIGHTER SUCCESSION TIMES

Importance of Minimizing Lighter Succession Time

In the first few days of the LOTS test crane productivity was substantially reduced by slow lighter succession times. Later on the time loss was reduced and sometimes eliminated. The succession times initially averaged between 5-6 min. For the discussion which follows 6 min. is assumed as a round figure.

During part of the 6 min. succession time the crane is able to continue with the segments of its repetitive cycle that take place in the ship's hold which do not require a lighter. To put the matter into perspective assume that for three of the 6 min. the crane is, in fact, doing productive work. Then there is necessarily a delay lasting the remaining 3 min. each time one lighter succeeds another. For a lighter type that has a capacity of only one container (e.g., the LARC-XV) a 3 min. delay would cut crane productivity substantially. For example, if the crane cycle were 5 min. per container, the one-container lighter would impose an extra 3 min. on the crane cycle, making it 8 min. The crane productivity would be $5/8$ (or $62\frac{1}{2}$ percent) of what it would be with no lighter-succession delay. For a lighter that carries a larger quantity of containers, for example an LCU that carries five, a delay of the same duration would be much less important. It would occur only for every fifth container. The productivity would be reduced only to $25/28$ ths³ (or 89 percent) of its no-succession-time productivity potential. These figures indicate the importance of minimizing lighter succession time. They are intended as being illustrative rather than representative, since in the test the lighter succession times varied substantially. As will be seen later, averages for the early part of the test show still slower times. As the test progressed the crane cycle times improved and succession times were substantially reduced. This improvement occurred through a combination of increased awareness of succession-time importance that resulted in better lighter control and by the increased skill in maneuvering and tying up that came with practice.

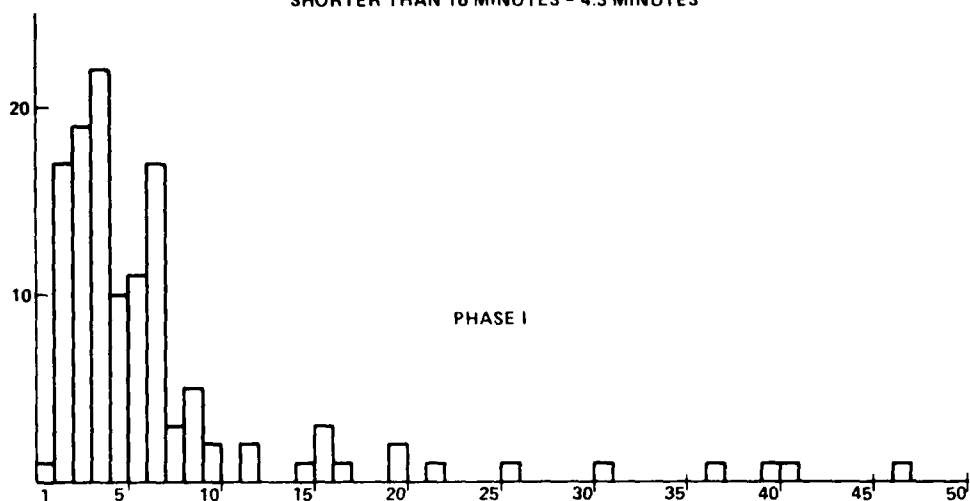
Analysis and Lighter Succession Times - Effects of Learning

The values of lighter succession time measured in the test varied widely. Figure 4.1 illustrates some typical data. The figure shows distributions of the succession times of lighters at the TCDF for the two phases of bare beach operations -- Phase I and I(R). Characteristically, there is an asymmetric grouping of the times, with a tail extending to the right. At the extreme right of Figure 4.1, beyond the scope of the graph scale, there are still more data points. Such extremes, over $3/4$ of an hour, clearly are not properly part of the "set" of times that should be included as lighter succession times.

The chart illustrates the point that an average that includes all the long periods -- the three not graphed in the figure are over 80 min. long --

$$^3 \frac{5 + 5 + 5 + 5 + 5}{8 + 5 + 5 + 5 + 5} = \frac{25}{28} = 89\%$$

MEAN OF 110 LIGHTER SUCCESSION MEASUREMENTS
SHORTER THAN 16 MINUTES = 4.3 MINUTES



MEAN OF 74 LIGHTER SUCCESSION MEASUREMENTS
SHORTER THAN 16 MINUTES = 3.5 MINUTES

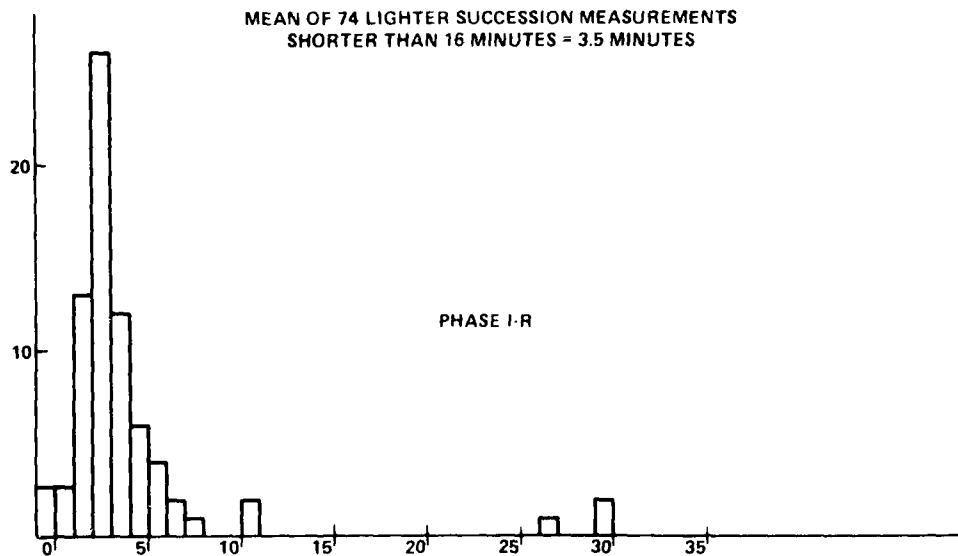


FIGURE 4.1. DISTRIBUTIONS OF MEASURED LIGHTER SUCCESSION TIMES
AT TCDF DURING BARE BEACH PHASES

1

would not be appropriate for analysis purposes. This is because these data reflect unusual delays which were not always noted by the data collectors and unduly affect the averages. Intermediate values (above 20 min., for example) similarly affect the averages but are still considered outside the boundary of representative values. Accordingly, an arbitrary cut-off at 15 min. was established for the remainder of the succession time analysis.

In the material that follows, data from the computerized data bank are used. The data include all available successions times at the COD and TCDF during periods of forward container movement except for those over 15 min. long, and certain incomplete records. The data below the cut-off value were judged to be representative and included over 90 percent of the available data-bank entries. Cutting off the data in this manner reduced the overall mean from 8½ min. with no cut-off to 5.2 min. with cut-off.

Analysis of Measured Succession Times

Table 4.1 shows average values for the succession times as measured, segregated by different lighters and different shifts of the test. The table shows that:

- There is a substantial spread in the averages -- from 11 min. down to 1 min.
- There is a downward trend with time, indicating a learning process (further comments follow).
- Averages for the COD (where there was observed to be a more difficult problem in approaching and tying up) were 2.3 min. longer than for the TCDF. (The overall mean for both together was 5.2 min.).
- Shift 1 (day) times averaged 4.4 min.; shift 2 (night) averaged 6.5 min.
- The slowest lighter in terms of lighter successions was the LARC-LX, averaging 6.7 min.; the fastest the LCM8 averaging 4.2 min. The data on the LCM8 corroborates observations that the LCM8 capability to accelerate and decelerate quickly permitted them to get away from the loading area promptly and to control their movement into place for loading.

Net Loss of Crane Time Due to Lighter Succession

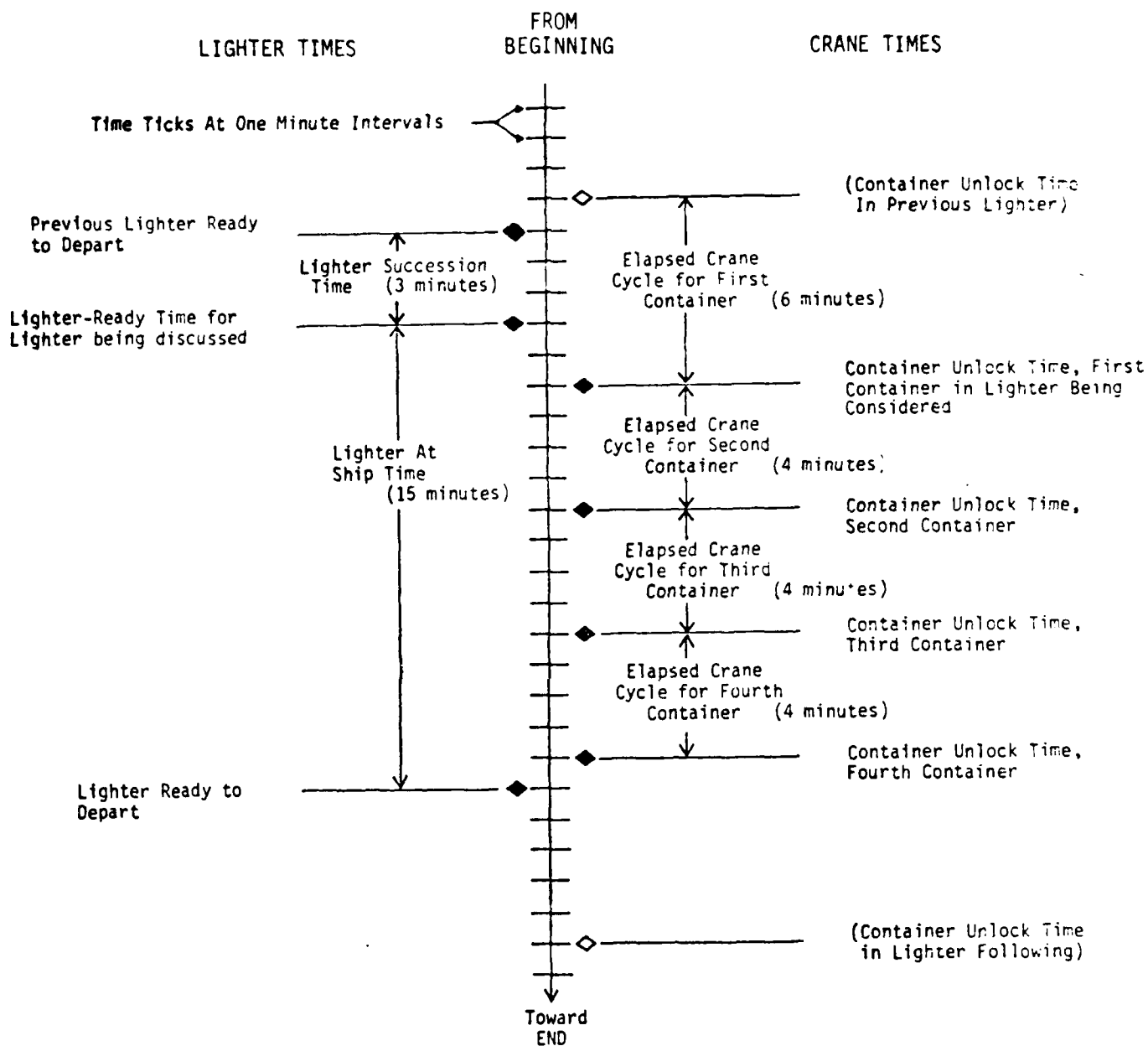
Having discussed the average amounts of lighter succession time as measured under various circumstances, the question then is how much time the crane actually loses. A part of the crane cycle -- the time the crane spends in moving the spreader back to the ship hold, fastening on to a new container, and lifting the new container toward the lighter location -- is productive.

Figure 4.2 is a schematic diagram showing an example of the overlap being considered. The left part shows the events in the part of the total lighter circuit time that occurs at ship side. There are two segments for each lighter, measured in the LOTS test as the elapsed times between the specified events shown. The two segments are here called the lighter succession time and the lighter-at-ship time. The diagram singles out these two times for one lighter. In an operation a series of lighters would follow one another

TABLE 4.1
LIGHTER SUCCESSION TIMES AS MEASURED
FOR FORWARD CONTAINER MOVEMENTS

Times are for lighter successions shown in data bank.
Successions over 15 min. excluded, also incomplete records.
"n" denotes quantity of lighter successions.

DATE	SHIFT	LACV30		LCMH		LCUS		LARC XV		LARC LX		PER SHIFT	
AUG.		n	avg. mins.	n	avg. mins.	n	avg. mins.	n	avg. mins.	n	avg. mins.	sum	wtd. n's avg.
DATA FOR COD													
6	1			3	10.7	4	11.0			9	9.2	16	10.0
	2					1	15			3	9.7	4	11.0
7	1	3	5.3	3	4.7	2	6.0					8	5.3
	2					2	14	3	4.7	3	7.0	8	7.9
8	1			4	4.0	2	10.5	4	3.3	5	3.6	15	4.6
	PHASE I	3	5.3	10	6.2	11	10.9	7	3.9	20	7.7	51	7.4
11	1					13	5.8					13	5.8
	2					3	9.7					3	9.7
12	1					5	7.0					5	7.0
	2					8	10.4					8	10.4
13	1			2	3.5	1	3.0					3	3.3
	PHASE II			2	3.5	30	7.5					32	7.3
16	1			5	3.8	20	5.15					25	4.9
	2			5	8.0	4	6.3					19	8.1
17	1					5	6.4					5	6.4
	2					2	13.0					2	13.0
18	1					2	9.0					2	9.0
	PHASE III			10	5.9	33	6.4					43	6.3
20	1			9	2.9	5	3.0			2	2.0	16	2.8
	2			2	10	3	12.3	1	13	5	8.2	11	10.1
	PHASE I (R)	3	5.3	11	4.2	8	6.5	1	13	7	6.4	27	5.8
TOTAL FOR COD		3	5.3	33	5.3	82	7.4	8	5.0	27	7.3	153	6.8
DATA FOR TCDF													
6	1	19	4.0	9	3.9			8	4.5	1	10	37	4.2
	2	9	6.7	3	6.0			2	6.5	3	5.7	17	6.4
7	1	5	3.8	4	3.5			2	6.0	3	6.7	14	4.4
	2	9	6.2	1	5.0			4	7.5	2	6.0	16	6.4
8	1	12	5.2	6	3.5			6	2.8	2	4.5	26	4.2
	PHASE I	54	5.1	23	4.0			22	4.9	11	6.2	110	4.9
11	1												
	2			2	5.5	3	9.0					5	7.6
12	1			5	5.4	11	6.45					16	6.12
	2			3	5.3	4	7.8					7	6.7
13	1			2	3.0	4	4.0					6	3.7
	PHASE II			12	5.0	22	8.6					34	6.0
16	1			4	2.0	27	2.9					31	2.8
	2					11	4.7					11	4.7
17	1					13	3.5					13	3.5
	PHASE III			4	2.9	51	3.4					55	3.3
20	1	8	4.0	14	1.8	10	4.7					32	3.2
	2	20	3.8			2	3.1	16	3.6	4	3.5	42	3.7
	PHASE I (R)	28	3.9	14	1.8	12	4.5	16	3.6	4	3.5	74	3.5
TOTAL FOR TCDF		82	4.6	53	3.5	85	4.4	40	4.4	14	5.5	273	4.3
TOTALS													
TOTAL		85	4.7	86	4.2	107	5.9	40	4.5	42	6.7	426	5.2



*Time Progresses Downward on Chart, Earlier Times Being At Top

FIGURE 4.2. ILLUSTRATIVE EXAMPLE OF RELATIONSHIP BETWEEN KEY LIGHTER AND CRANE EVENT TIMES.

and any interruption between lighters would simply result in a larger than usual value for the lighter succession time. In the diagram the lighter is alongside the ship 15 min. and four containers are loaded into it.

In the right half of the diagrammatic representation are the crane times. The first event shown (indicated as an open diamond) is for the unlock time of the last container in the previous lighter. The elapsed time from that event to the next event shown, the unlock time for the first container in the present lighter, is 6 min. Elapsed times for next three containers are each 4 min.

In the diagram, then, the work with the first container took 2 min. longer than that for each of the three succeeding ones. During part of the crane cycle for the first container one lighter succeeded the previous one. The measured time for the succession was 3 min. The important point here is that only two of the 3 min. of succession time was "wasted". The process of substituting a lighter for the previous one cost the crane only 2 min. of operating time, not three. Early in the LOTS test the lost crane time attributable to lighter succession was often as large as the useful time (particularly for one and two container lighter loads), but near the end of the test lost crane time was reduced to a small fraction of the productive time. Such loss is clearly more important when lighters with a capacity of one or two containers are used than when the lighter capacity is greater. (For a 5.4 min. per container crane cycle, for example, the percent of productive crane time with 1, 2 or 4 container lighters is 78 percent, 88 percent, and 94 percent, respectively*.

Lighter Succession Learning

By Phase I(R) the Army had achieved considerable improvement in lighter succession times. A lighter was positioned close enough to move in and tie-up as the other lighter moved away from the ship. This procedure along with improvement in skills acquired as the test progressed resulted in reduced average lighter succession times, as shown in Figure 4.3. The chart shows shift average succession times at the TCDF and COD.

The charts show generally downward trends with learning time. The top chart for the TCDF also shows a difference between night and day operations of a full minute or more. Not enough data points were available to show a learning trend for night operations at the COD, but overall the times were also higher than for day operations.

* Computed as follows: $5.4 \text{ min.} / (5.4 + 1.5) = 78 \text{ percent}$; $10.8 \text{ min.} / (10.8 + 1.5) = 88 \text{ percent}$; $21.6 \text{ min.} / (21.6 + 1.5) = 94 \text{ percent}$. For a 5-container lighter load the increase is not large: $27 \text{ min.} / (27 + 1.5) = 95 \text{ percent}$.

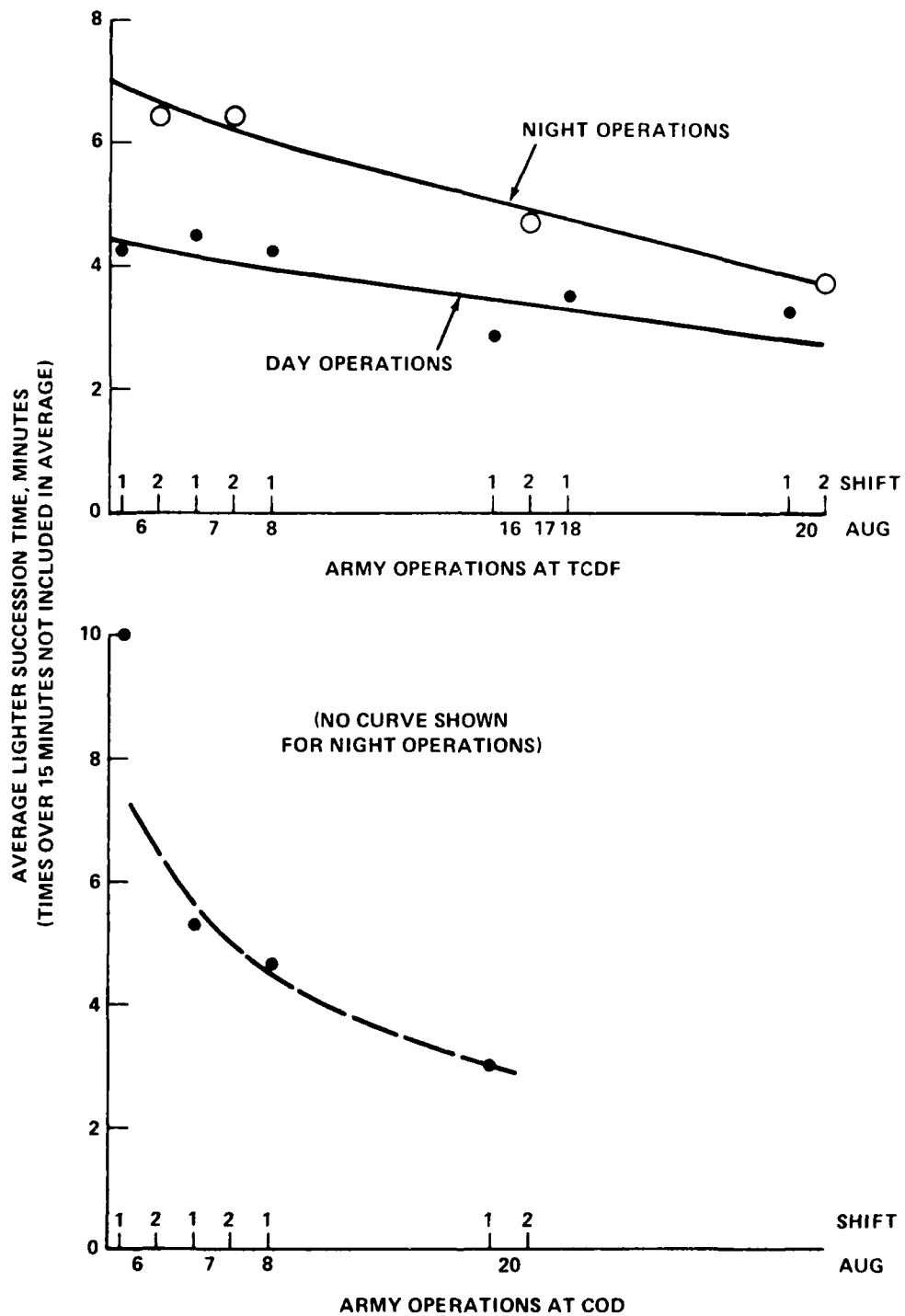


FIGURE 4.3. LIGHTER SUCCESSION TRENDS IN ARMY SHIP CRANE OPERATIONS

Conclusions Concerning Lighter Succession Effects

The conclusion is drawn for future operations that with proper appreciation of the effect of lighter succession time on crane productivity and with efficient management and control of lighter activity, the net loss in crane time from this source can probably be reduced to a negligible amount. Until that possibility has been proved in practice and follow-on training tests, an average loss of about a minute and a half net crane time per lighter exchange, the overall average attained during the last day of the test, should be planned for.

CAPACITIES AND OPERATING CHARACTERISTICS OF LIGHTERS

Impacts of Lighter Capacity

In the previous discussion the quantity of containers per lighter was seen to have an impact on the output of the ship-crane system. The impact on the lighter system itself -- how many lighters are needed -- is much more direct. It is discussed later as a separate topic in this section on lighters. The following paragraphs discuss how many containers the various lighters can carry under varying conditions.

Capacity Limits and Related Operational Factors for Various Lighter Types

The various types of lighters used in the LOTS test each had stated cargo carrying capacities. For all there was a space limit when the lighter was used for loaded containers. For the LARC-XV and the LACV-30, total weight carrying capacity was also an important limiting factor. Table 4.2 shows the key limits for the lighters available for the LOTS test. Other aspects of these and other limitations are discussed below under headings for individual lighters.

TABLE 4.2
LIGHTER CAPACITIES FOR 20 FOOT CONTAINERS
(BASED UPON TEST RESULTS)

Type	Qty. of Containers	Total Container Load Limit (S/tons)
LCU		
1600	4-7	None
1610	4-5	None
LCM #	1-2	None
LARC-XV	1	15
LARC-12	2	None
LACV-30	1 to 2	25.5 (w/full fuel tanks)
4-Section Causeway Ferry*	Athwart craft: 12 to 16 Long axis: 4	50 tons

*Per Section

1466-Class LCU. The older design LCU carried as many as seven 20-ft containers during the LOTS test but for most of the test carried four or five. Obviously the containers had to be closely spaced in order to achieve seven. The point can be raised that for loading in a seaway, a generous space between containers cuts down the probabilities of impacts and speeds loading. Some slowing down of the ship crane cycle was observed when more than five containers were loaded, even under the calm weather and sea state conditions prevailing during most of the test.

For landing at the beach crane near low water, the draft of the LCU was an important consideration. During low tidal periods the number of containers loaded was reduced to assist the craft in getting over sand bars and beaching. A container weighing 15 short tons changes the average draft of a 1466-class LCU by about 2 in.

There is space aboard the 1466-class LCU for three 40-ft containers abreast. This was not tried during the test and may be practical when wave action is negligible. Normally, only two 40-ft containers are transported by an LCU.

LCU 1610 and Later Classes. The 1610-class LCU is longer, has less beam, and has a drive-through capability achieved by the placement of the pilot house to one side rather than at the stern. The available space, while narrower than for the older class, in principle could accommodate seven carefully placed 20-ft containers. This was not considered practical and was not attempted in the LOTS test. It is appropriate at this time to consider the capacity as five under ideal conditions and four for average sea states. Two 40-ft containers can also be carried by this LCU.

Another limitation on container-carrying by this class was the extra reach required of the crane-on-jetty to reach the fifth MILVAN at the stern of the beached LCU. The extra length of this LCU made the needed crane reach too long for a heavy container. At one state of the test an LCU was brought almost parallel to the shoreline so the crane could reach the container. This is not practical or safe at anytime in a surf zone. No more than four containers should be loaded on the 1610-class LCU when working with the jetty crane.

LCM8. The capacity of this lighter was two 20-ft or one 40-ft container under the ideal conditions of the LOTS test. At higher sea states the loading of the second container could be time consuming or otherwise impractical. During Phase II the Navy LCM8's were confined to one 20-ft container as a matter of policy in consideration of the sand bars and beach slope. The result was to use more LCM8s than were necessary during some periods of more favorable conditions. Less rigidity in application of this policy should be considered. In Phases III and I (R) two-container loads were often used.

LARC-XV. There is space for only one 20-ft container. The vehicle is not rated for loads greater than 15 tons and must be handled with care in moderate weather and sea states. For these reasons the craft are primarily used for transporting breakbulk cargo and are marginal for transporting containers up to 15 short tons.

LARC-LX. Two 20-ft or one 40-ft container can be carried in the LARC-LX. The well deck of this lighter slants down sharply toward the bow ramp so that it is not flat for supporting the extreme end of one container. However, this did not present a problem. If necessary, dunnage could be used to fill in the gap.

LACV-30. The LACV-30 has a weight-carrying limit dictated by the air pressures in the cushion. Its gross weight, including its own weight, fuel, cargo and operating personnel must be considered. In general terms, this gross cargo weight cannot exceed approximately 31.7 short tons. This limit, spelled out earlier by data provided by the manufacturer, was borne out in the LOTS test.

The so-called "cargo weight" includes nearly 2 tons of load spreaders, tie-downs, and fenders, and almost another $\frac{1}{2}$ ton for crew and unusable fuel. Thus, the total weight of operating fuel and container cargo for a LOTS-type operation is 29.3 tons. In terms of payload the LACV rated at 30 tons of cargo is essentially without fuel. Fuel consumption varies with operational conditions. In the LOTS test the LACV-30 burned an average of 130 gallons or about a half ton per hour. Thus, with full fuel tanks, the total cargo that can be carried is about 23 $\frac{1}{2}$ tons; after about 6 hr of operations, the payload capacity could reach 26.5 s/tons. During the LOTS test the craft were frequently topped off, maintaining a capacity for transporting cargo of about 23 $\frac{1}{2}$ tons.

Figure 4.4 shows the weights carried ashore from the TCDF by the LACV-30 during the bare beach phases of the exercise, Phases I and I(R). There were an even hundred loads. Therefore, the ordinate of the chart indicates not only the absolute quantities of loads but also shows the percentages of the total loads⁵. The shaded bars indicate that two containers were carried. In the one hundred load-carrying trips, 148 containers were carried ashore, or just under 1.5 containers per trip⁶.

The figure illustrates that the heaviest loads taken ashore were single containers. In the two bars indicating heaviest weights there were 22 single containers that weighed between 22 and 23 short tons. There was also a peak centered at 12 tons composed of two-container loads. A method for identifying containers by weight and stow location was clearly needed.

As noted, preparing to load the LACV-30 with a second container requires information immediately at hand concerning the cargo capacity of the lighter and the weight and stow location of containers available to the crane. This is to avoid delaying the crane and overloading the lighter. Such a stowage plan was not available during the test nor can one be produced under

⁵ An additional 10 containers were loaded into LACV-30s from the COD.

⁶ During trial runs to the marshaling yard the LACV-30 carried two containers with a total load of 42,930 lb, consisting of an empty container weighing 4,920 lb and a container weighing 37,470 lb.

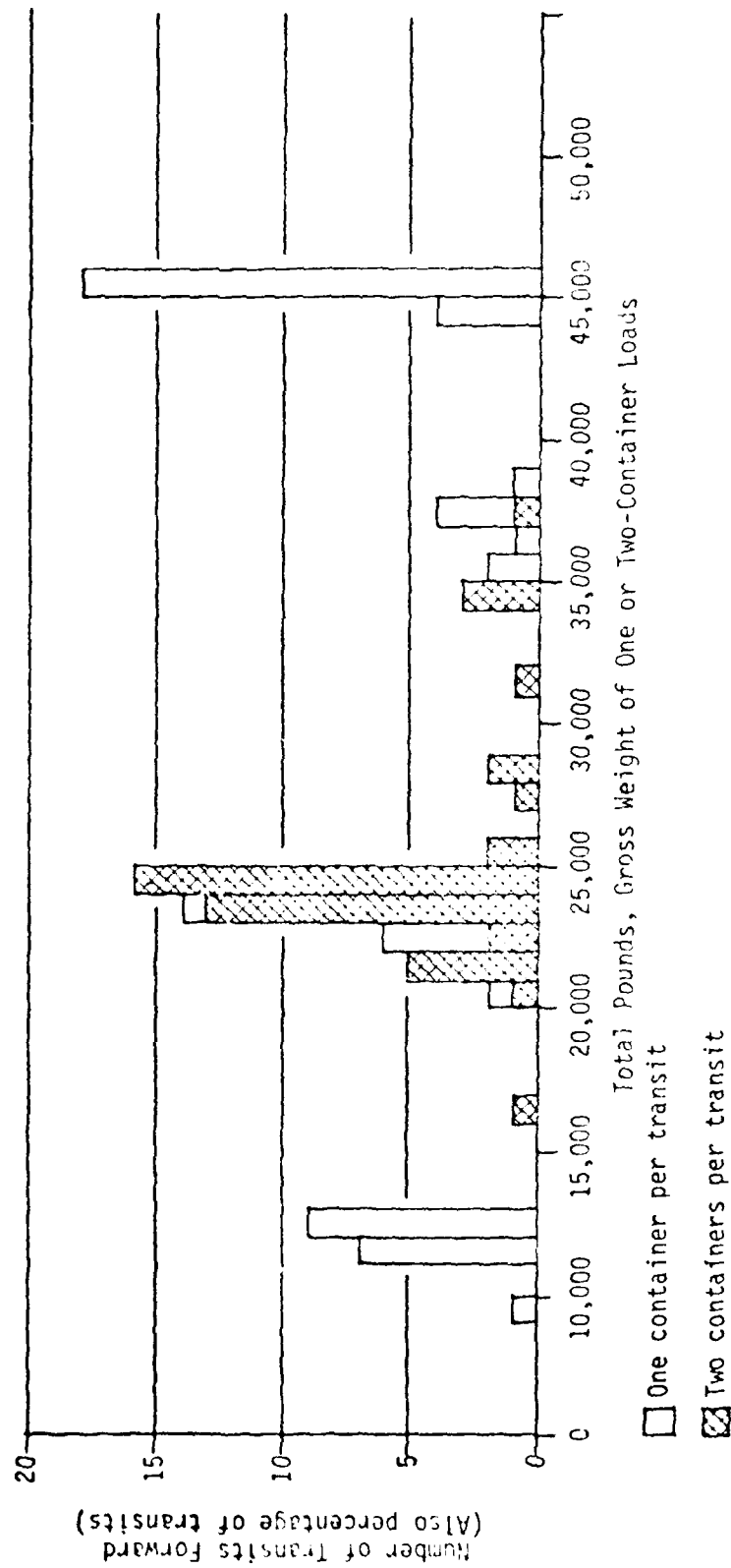


FIGURE 4.4. DISTRIBUTION OF WEIGHTS OF ONE HUNDRED LACV-30 LOADS IN LOTS TEST
Quantity of containers (one or two) per forward transit indicated.

current MILSTAMP documentation procedures. A quick fix system identifying containers as "heavy" or "light" was instituted. This arrangement helped but is inadequate for achieving maximum utilization of the crafts' carrying capacity.

Causeway Ferries

Causeway ferries are customarily made up of three or more 90-ft sections. The front one, which is not loaded and thus has a shallow draft, can be pushed up onto or close to the beach and forms a bridge to shore for unloading the containers. Each of the loaded sections have space for four containers if loaded with their long axes lengthwise on the ferry, or ten with the long axis athwartship. The lengthwise arrangement was used in the LOTS test and permitted unloading with the LACH vehicle. In the main LOTS test no results for operations in a seaway were available, but it was noted that the empty space between containers averaged only 2 ft with four containers aboard. In a seaway when there is relative motion between the causeway ferry and the container being loaded, it may prove desirable to limit the load to three 20-ft containers.

LIGHTER REQUIREMENTS FOR SUSTAINED SHIP OPERATIONS

This section discusses the determination of lighter requirements for LOTS operations. It was necessary to compute these quantities from observed times instead of finding them direct from the numbers used during the test. Such direct measures were not possible for several reasons, the major ones being:

- Overall, more lighters were available than could be used effectively. At the same time,
- There were not enough amphibians without LARC-XV's to continuously supply one ship crane with lighters, and
- During the test the different types of landing craft and amphibians were generally mixed together so that lighter cycles for each type on regular transits and accounting for elements of time was not practical.

The computation was based upon the number of lighters required to support maximum throughput rates. That is, no crane delays were allowed in the computation. In a real situation, time is used for removing hatch covers, moving the ship cranes, and the like. This means that the average requirement is smaller than the peak requirement. However, the computation must necessarily be based on the peak or else the ship cranes would have to stop occasionally to wait for lighters. In order to achieve any particular average crane productivity, there must be sufficient lighters available to permit the crane to operate at a higher-than-average rate in order to make up for lower-than-average periods.

Computation Methodology

Calculating the quantity needed is simple in principle. It can be visualized as in Figure 4.5. Consider a series of lighters loading at a ship crane. The number of lighters in the figure needed for serving the single ship crane is simply the quantity of separate lighters that are loaded during the time it takes the first one to make its trip to shore and return. The general formula, then, is to divide the total average lighter cycle time -- the time a lighter takes to load, move to shore, unload, and return ready to load again, including any necessary waits -- by the average time one lighter is at the shipside. This result is then multiplied by the number of ship cranes in use. For example, if the total round trip time is 32 min. and time at the shipside is 8 min., $32/8 \times 2$ or 8 lighters are needed to serve the two-crane system.

Data for Lighterage Computations

To make the computations some information is available directly from measurements of portions of the lighter cycle. For other portions, less direct data inputs had to be used. For example, in the LOTS data the transit times, acceleration and maneuver times, and waiting times were not separated. However, some minimum-time runs were recorded. Basically, most of the transit times are not directly usable because:

- With a surplus of lighters there were long waits that were not representative of normal circumstances, and
- The LOTS data base sometimes yields results that are not logical because watches were not synchronized between ship and shore.

Table 4.3 outlines the pertinent components of the cycle and the sources of information available.

The time at ship segment is considered to be in two parts, the lighter succession time discussed earlier in this section and the crane cycle time. For the computation, a lighter succession time of 1.5 min. was used for all lighters.

For the crane cycle time a rate of 5.4 min. per container was selected. This value agrees with the uninterrupted rates used in the computation of queue requirements. The value used can be put into perspective in the following way. The cranes at shipside incur two kinds of operational delays. One is time that no lighter is available to load into and this loss averages about 5 percent of crane time. The second loss is caused by the need to move bay covers and to move the cranes themselves. This is taken to be one hour per day for each crane. The two kinds of losses together reduce the effective working day from 20 hr to 18 hr. For the full day's work each crane, if it worked without additional interruption at the rate of 5.4 min. per container, would unload 200 containers per day. Since there are various

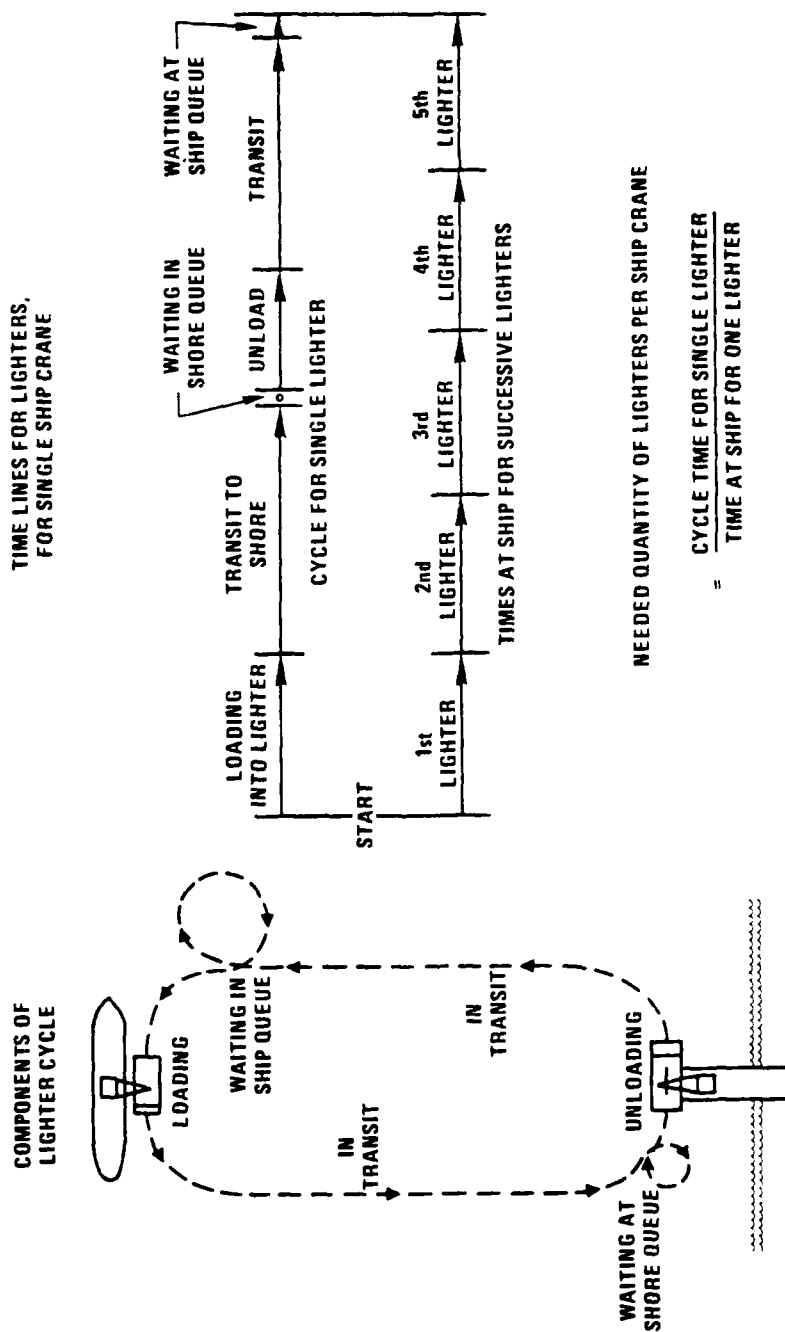


FIGURE 4.5. PRINCIPLE OF COMPUTING NUMBER OF LIGHTERS NEEDED

TABLE 4.3
TYPES OF INFORMATION FOR CALCULATING LIGHTER REQUIREMENTS

Time Components	Measurement Method	Sources of Numerical Values for Computation	Values Selected for Computation Minutes
Time at Ship			
Time lost (if any) by lighter successions.	Cannot be measured directly. Averages of watch readings in two categories (lighter succession times and crane cycles).	Combined records of (a) measured lighter successions times, and (b) average crane cycles for first container and lighter, combined averages for other unit containers, adjusted for net succession time.	1.5 min
Loading time per container.	Watch readings	LOTS data bank and CRI sample data, adjusted for crane delays.	5.4 min
Time Under way			
Running time at average speed	A few direct readings made by watch. Most reliance placed on published values of speed, with time calculated from measured ship-to-shore distance.	LOTS data bank minimum time values. Also LACV-30 D.I. test final report minimum time values. Reliance placed on published values of average speeds shown in Army Field Manual FM 30-15. Ship-to-shore distance calculated by triangulation. Readings from instruments on bridge of ship.	varies with lighter. LCM and 1600-class LCU: 9 kts 1400-class LCU and LARC-LX: 7 kts LARC-XV: 6 kts LACV-30: 21 kts and 27 kts.
Acceleration and Maneuvering	Estimations based on observations.	Estimations -- for LACV-30, manufacturer's engineering calculations supplemented the estimate.	1 min each direction.
Time at Shore			
Lighter Succession at Crane	Measurements similar to ship lighter succession.	Similar to ship data	Taken to be 75 percent of ship succession time.
Lighter unloading at shore cranes	Average of crane cycle times	LOTS data bank and CRI sample data, adjusted for delays.	Average of 4 shore cranes found to be 75 percent of ship crane times. This value used.
Waiting Queues at Ship and Shore			
Waiting for turn at ship crane.	Direct watch readings not usable.	From queuing simulation calculations. Inputs to queuing calculation include frequency distribution of crane times.	Allowance for queuing applied in form of 1.5 extra lighters/crane system. (Crane system operates 95% of time at times due to queuing).

additional minor interruptions and fluctuations, the 200 per day figure is a peak rate, not sustainable over a full day. Providing for this peak rate, though, permits an average figure, somewhat lower, to be achieved despite the minor fluctuations.

The time underway for the lighters is computed by dividing the distance to be travelled (in nautical miles) by the speed in knots. For most lighters the difference in speed loaded versus empty is not great and no attempt was made to show such a difference in the calculations. To the computed result is added a 1 min. allowance each way for maneuvering, avoiding other craft, and for acceleration.

The time at the shore cranes was necessarily averaged over some quite different conditions, since there were four different kinds of shore operations. In general, the shore cranes moved the containers less far than the ship cranes did. Further, the crane operators could see the containers during the whole cycle, instead of sometimes operating blind according to hand signals, as when the container was deep in the ship hold or when the side of the ship prevented the operator of the COD from seeing the lighter. The crane cycle times for the whole test, for all the shore cranes and for all types of lighters, were averaged without including delays. The unweighted overall average was found to be 74 percent of the average value for the ship cranes, and this was rounded to 75 percent for the computation of lighter quantities.

The lighter succession times at the shore cranes were not so clearly defined as at the ship. For two cranes, the beach crane on the jetty and the one on the DeLong pier, the net lighter succession time during a part of the test was zero. For the beach crane one lighter was able to move into a spot from which it could be unloaded when its turn came. This approach could be made during the time a previous lighter was having its turn at being unloaded. At the DeLong pier, a technique was developed of mooring one lighter outboard of the one being loaded, then moving in quickly when the inboard lighter moved away with no loss of crane productivity. On the other hand, lighter succession times at the elevated causeway tended to be relatively long, mainly due to the difficulties of mooring with an alongshore tidal current and a one at a time approach to successions versus the approach used at the DeLong pier. An overall average of $3/4$ of the ship succession time was selected for the computations. Finally, a basis for determining lighter queue requirements had to be developed.

Determining Lighter Queue Requirements

The need for additional lighters discussed here is to avoid losses in crane production during peak periods because of a lack of lighters. That is, how many lighters are needed for such a queue. To assist in answering the question, a computer simulation of queuing was used.

Figure 4.6 illustrates types of outputs used to determine the numbers of lighters needed to approach 100 percent of crane utilization. It is apparent in the Table 4.4 that the cost in numbers of lighters for each increment of improved crane utilization increases rather sharply.

TABLE 4.4
LIGHTER COST RELATED TO PERCENT CRANE UTILIZATION

Change in Percent Crane Utilization	Cost in Additional Lighters	
	Per Increment	Cumulative
85-90	.57	.57
90-95	.89	1.46
95-99	1.61	3.07

As a matter of judgement, 95 percent of full crane utilization during periods of peak performance was accepted as a reasonable cut off point. This results in a requirement of 1.5 lighters for a queue in addition to those needed in the lighter circuit.

An analysis of this queue requirement over varying distances was also made. Figure 4.7 shows the results. For ranges from 0.5 nautical miles to about 4 miles, the 95 percent value intersects the curve at about the point corresponding to 1.5 additional lighters. This value has been added to the number of lighters calculated to serve two ship cranes.

Results of Computation

Figure 4.8 displays the result of computing the quantities of lighters needed for the types of lighters used in the LOTS test. The figure can be used for the types of lighters used for establishing planning factors for watercraft units.

The curves for each lighter type are nearly straight. That is, along any one curve for each added mile that a particular lighter type travels, a very nearly equal increment of lighters must be added. For the ship to shore distance in the LOTS test of 1.4 nautical miles, the number of LCUs or LACV-30s needed is about the same (six or seven are needed). The larger capacity of the LCU makes up for its slower speed. The LARC-XV, slow and with a capacity of only one container, requires half again as many (11 versus 7) to keep its circuit filled continuously. For the other craft, the LARC-LX requires nine and the LCM8 about eight.

Figure 4.9 shows the sensitivity of lighter requirements to varying the speed, number of containers, and crane time. The center graph of the nine represents a two-container lighter that can move at 9 knots. The graphs

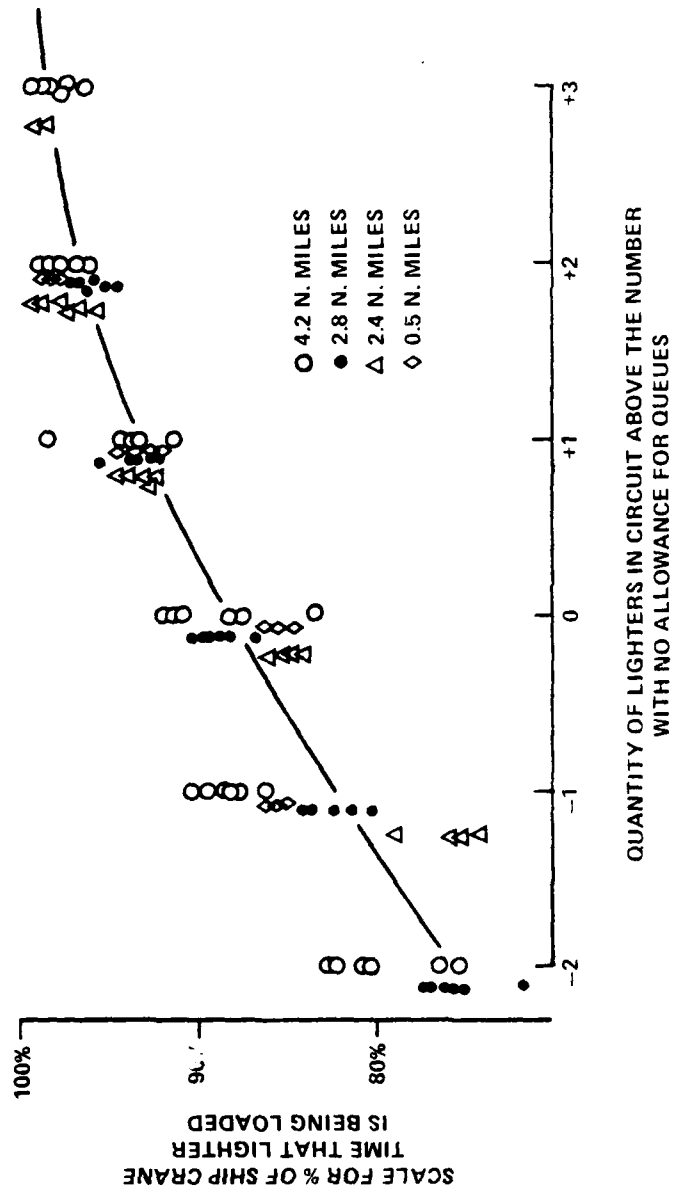


FIGURE 4.7. AFFECT OF SHIP TO SHORE DISTANCE ON LIGHTER QUEUE REQUIREMENTS

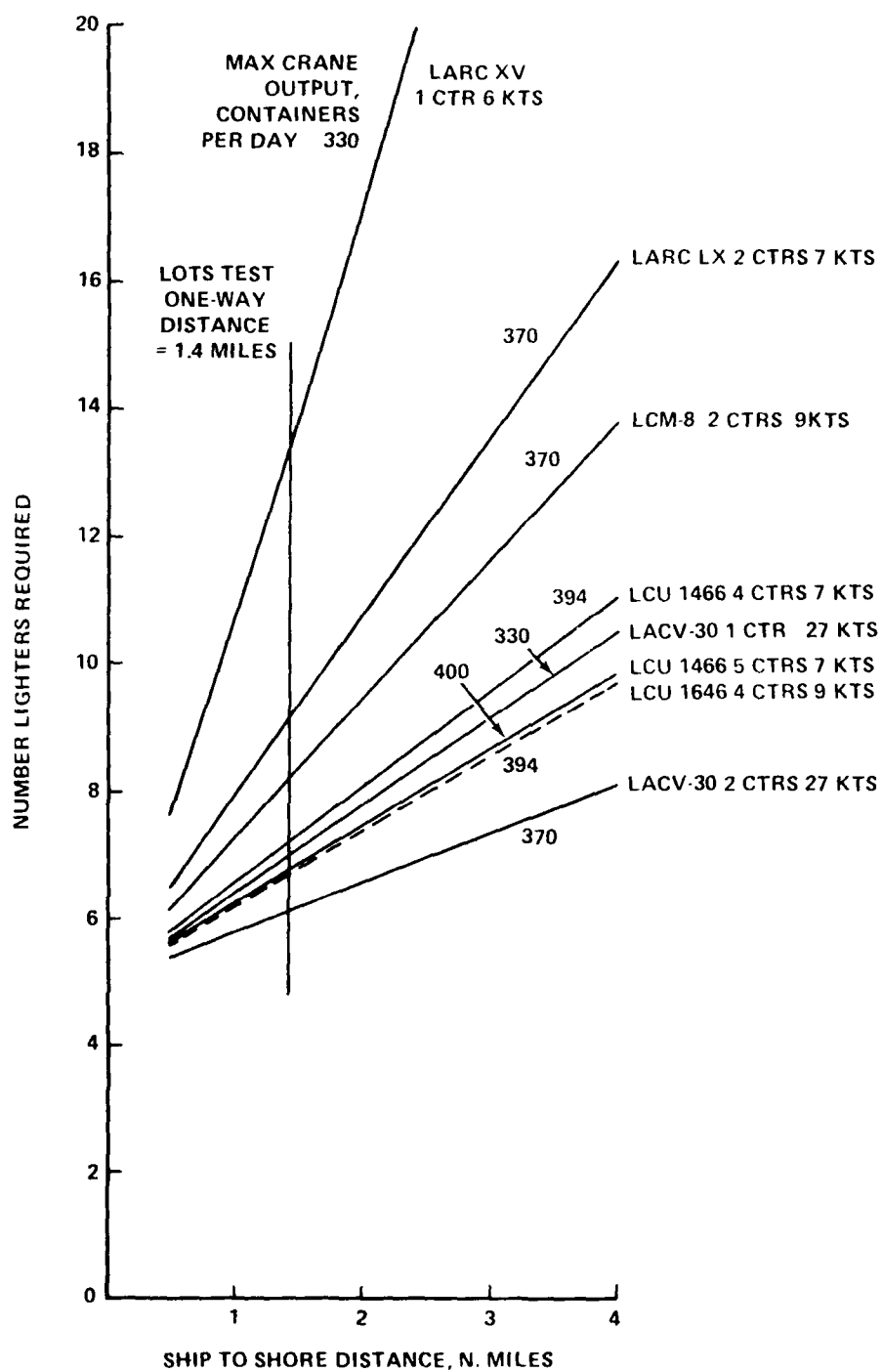


FIGURE 4.8. LIGHTER REQUIREMENTS AND PRODUCTIVITY OF TWO SHIP CRANES

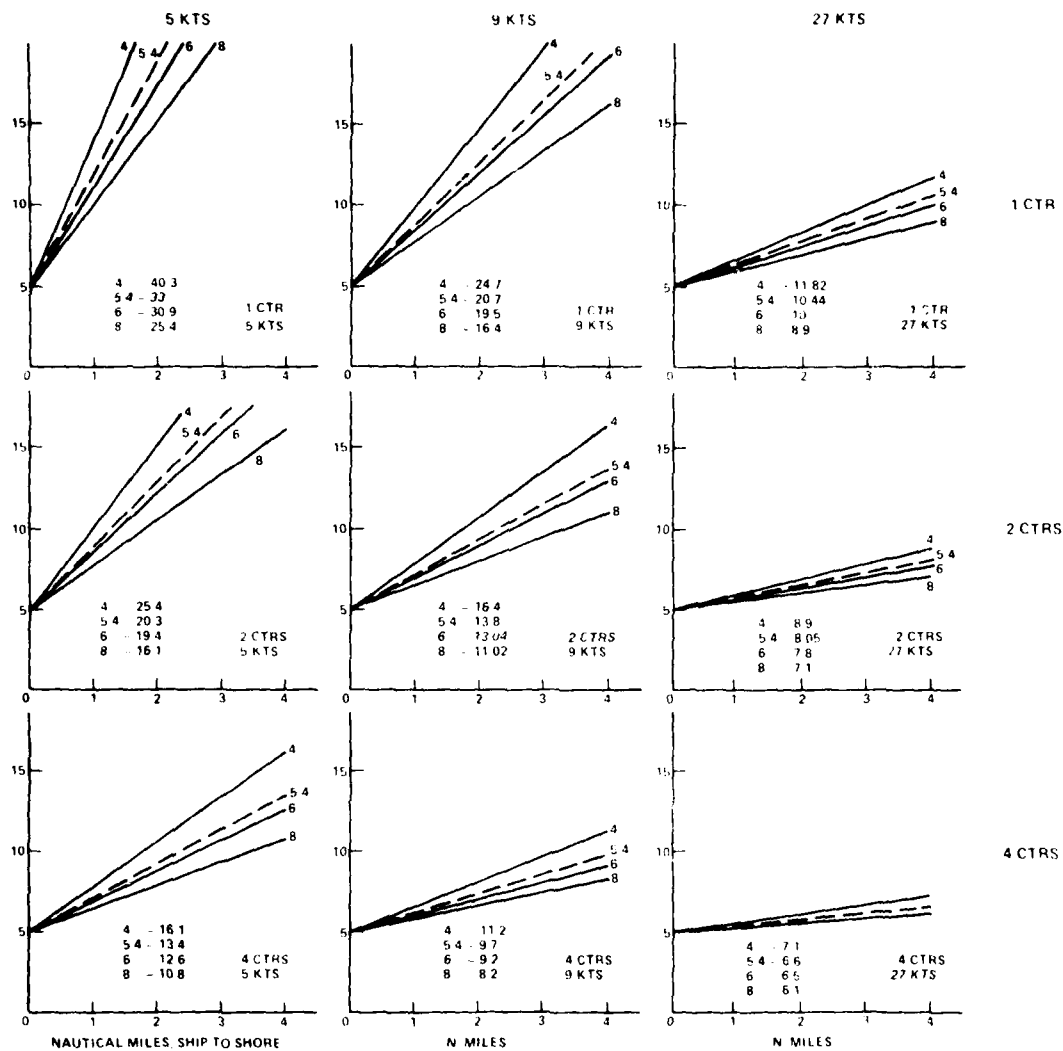


FIGURE 4.9. SENSITIVITY OF NEEDED QUANTITIES OF LIGHTERS TO SPEED, NUMBER OF CONTAINERS, AND CRANE CYCLE TIMES PER CONTAINER (Chart Includes 1.5 Lighters for Queuing Allowance)

above and below it are for similar lighters with one and four containers. The ones to each side are for 2-container lighters having substantially increased and decreased speeds.

The charts show that at distances less than $\frac{1}{2}$ mile, neither speed nor capacity has much effect. At distances of 1 to 2 miles:

- The within-graph variation that shows the effect of speeding up or slowing down the crane cycle is greater at slow speeds than at high speeds, and has more impact on one-container lighters than for four-container lighters. Basically, changes in crane cycle time need to be extreme in order to have much effect.
- Slow speeds (three charts at left) result in considerably greater quantities of lighters; high speeds substantially fewer.
- One-container lighters (top row across) are needed in substantially greater quantities than lighters with two or more containers.
- Medium speed lighters with four containers (middle of bottom row) are needed in the same numbers as high speed lighters with one to two containers (top and middle of third row).
- Finally, the extreme cases, (upper left and lower right corners), for the abnormally slow speed of 5 knots, very large quantities of one-container lighters would be needed. At the other extreme a hypothetical 27-knot, four-container lighter would be required in relatively small quantities which would increase quite slowly with distance.

In addition to the graphs shown, other computations were made. The results can be summarized as follows:

- Doubling the lighter succession time from the $1\frac{1}{2}$ min. used in the two figures made only small differences in the quantities needed. The real impact of lighter succession time is on crane cycles, as discussed earlier.
- Changes in the maneuver times from 2 min. to 0 or to 4 min. made very small differences in lighter requirements.

Lighter Fuel Consumption Estimates

No attempt was made to measure logistic support requirements of equipment used in the LOTS test. However, an operational test of one of the LACV-30 vehicles included fuel consumption measurements. Rates for the other lighters are available in military publications. Since fuel may well be in short supply for future operations, estimates of lighter fuel consumption was considered important. This section puts the information in the context of LOTS type operations.

Army Field Manual FM55-15 shows planning factors for use of landing craft and amphibians. These data are given as consumption in gallons per hr. The figures are shown in the first column of Table 4.5. These figures appear to apply to times the craft are operating at cruising speed⁷ and might be expected to be reduced for loading and unloading times. However, the figure is instead used as an overall planning factor by the US Army Transportation School according to JTD personnel, and with the exception of the LARC-XV is so used in this section. Timings of LARC-XV transits confirmed a slower rate than the factor of 8.6. The more realistic speed of 6 knots was used in these computations.

The fuel consumption figure for the LACV-30 was arrived at from test data as follows. The operation test report⁸ on one of the two LACV-30s showed that its fuel consumption during the period 6 August through 22 August, which included the LOTS test, averaged 136.9 gallons per engine hour, or 127.7 gallons per hour of auxiliary power unit operation. The figure is here rounded to 130 gallons per hour, which agrees almost exactly with a prediction made by the designers of the craft for a "stop and go" profile corresponding to the Ft. Story LOTS tests.

The column at the right of the table shows computed fuel consumption per container carried ashore from a ship 1.4 miles out. The figures in the last column have been rounded to the nearest gallon, so as not to imply an overall three significant figure accuracy as shown in the computation parts of the table.

⁷ This interpretation comes from the fact that figures are also shown for the fuel capacity and speed loaded, which, when combined with the consumption per hour, result in the figure shown for range.

⁸ U.S. Army Armor and Engineering Board, Capt. Richard A. Ritchie, Lighter, Air Cushion Vehicle, 30-Ton (LACV-30) Operational Test II Final Report, Ft. Knox, Kentucky, 14 February 1978.

TABLE 4.5
FUEL CONSUMPTION BY LIGHTER TYPE

	Fuel Consumption gal/hr	Water Speed knts	Containers per hour operations	Hrs enroute during round trip	Hrs at ship/shore and deuce **	Total RT time, hrs	Fuel Cons./ trip gal.	Fuel Cons./ ctr
LCU, 1406-Class (old)	34	7	4.5	1.40	1.18	1.58	53.7	12
LCU, 1610-Class (new)	27*	9	4	1.31	1.05	1.36	36.7	9
LCM-8	34	9	2	1.31	1.55	2.86	29.2	15
LACV-14	16	6.0	1	0.47	1.30	0.77	11.4	11
LARC-14	36	7.0	2	0.40	0.55	0.95	36.1	18
LACV-30	130	27	1.5	1.10	0.43	0.53	60.3	46

* Figure not in FM51-15 supplied by Joint Test Directorate

** Computed as 6 and 4.5 min per container at ship and shore respectively, plus 3 min for lighter succession, plus .75 x ship time for queuing. Total hrs = (15 min/ctr + 3.0 succession) x 60

In terms of fuel consumed per container landed on the beach, the LACV-30 does not compare well with other lighters in the efficient use of energy. The LACV-30 consumed fuel at a rate 2¹/₂ to 5 times more than the others. The cost for higher speed is in fuel consumption at a rate not offset by increased payload delivered. A similar craft with a capacity of 4 containers would achieve a better rate (17 gal/container), more on a par with conventional lighters.

V. SHORESIDE TRANSFER OPERATIONS

SECTION SUMMARIES

ADP Summary

In summary, the ADP facility and crew performed their mission adequately and were not overtaxed. The crane was not used to attempt the off-load or retrograde of any 40-ft containers during the test, although it does have the capability. Based upon its observed performance, the ADP crane can off-load containers at a rate of about 3.5 min. per 20-ft container or faster during surge periods with an experienced crane operator. To maintain such a rate, however, it requires the assistance of a frontloader and an area sufficient to work two amphibians at a time. The average operational rates reflected in the data base of 4.5 - 7 min. for day and night off-loading and retrograde do not accurately portray the capabilities of the ADP since there was little stress associated with performance. For retrograde operations the data indicate between 5 and 6 min. as being realistic times. Thus, 5.5 min. is selected as an expected value for crane retrograde cycles.

Based upon the above rates the ADP has the capability to off-load about 245 containers per day or retrograde about 210 containers per day. This rate is based upon continuous operations, an experienced military crane operator and crew, a capability to accommodate two amphibians concurrently at the ADP site, and the assistance of a frontloader. A mix of retrograde and off-load operations was not observed during the test, so no data are available to evaluate this type of operation.

Crane-On-Jetty Summary

The jetty crane off-loaded more containers in a 24-hr period (192) and had the highest hourly surge rate (18) of any crane in the test. This was possible because it was receiving containers from two shipside cranes and could accommodate two lighters simultaneously at its location. Its cycles were also expedited by the use of a frontloader to retrieve containers landed

on the beach and load them on trailers nearby. From the results obtained, this combination of crane, lighters, trucks and frontloaders was the most productive of any used during the test.

However, the jetty crane facility has some critical limitations. Tide, surf, and beach gradient determine the extent to which it can work landing craft. Because of this limitation confirmed in pretests it had been deemed necessary to shift beach locations for the test. It was noted that the jetty constructed for the OSDOC II test was unable to stand up to heavy surf conditions because of the erosion factor. The one in the LOTS test was constructed differently (steel plates and sand bags) but had to contend with very little surf. Thus, the durability of the jetty as a temporary facility could not be evaluated. If the Army revises its bare beach concept to include the use of LACH vehicles, then the problem is of little consequence insofar as the handling of 20-ft containers is concerned. The flexibility of a crane to accommodate containers of other sizes by simply changing spreader bars is an important consideration for long term operations which could find many ship types involved. This apparent gap between a 20-ft container LACH capability and the need to be able to handle other size containers needs to be resolved by the Services.

Based upon the results achieved in Phase I(R), a discharge rate of 4.4 min. per container was determined. However, the sustained productivity rate of the jetty crane is subject to weather, tide and beach gradient, which are highly variable. (Planning factors are discussed separately in Section IX.)

Elevated Causeway Summary

As a pier system the elevated causeway is more readily deployable than the jacked-up DeLong pier, being deployable by both amphibious and conventional breakbulk vessels. However, amphibious shipping is critically limited for other lift requirements and it would require a considerable number of breakbulk ships to accomplish an elevated causeway deployment. Also, LASH ships are available under the SRP or by requisitioning and could be used for deploying the system. During the test the elevated causeway provided a stable platform for off-loading lighters. It demonstrated a theoretical surge potential of 278 containers per day. The elevated causeway crane is rated at 5.7 min per container for off-loading and 6.0 min for retrograding. (Daily throughput capacity is discussed in a subsequent section on planning factors.) It is recommended that the Navy revise mooring procedures to minimize crane delays.

Jacked-Up DeLong Pier Summary

The jacked-up DeLong pier provided a stable platform and sufficient water depth alongside for around-the-clock crane operations at the beach. However, the pierhead section requires special modification to support the 140-ton crane lifting 20-ft containers. The handling of 40-ft containers weighted to capacity in LCUs was not demonstrated but a subsequent test with the crane repositioned on the DeLong section has confirmed this lift can be accomplished.

The DeLong pier has deployment deficiencies, noted earlier, that coupled with expected long term reliance upon amphibians and tide limitations of the 300-ton beach crane could result in a critical bottleneck at the beach. Thus, the Army requires a solution for the early deployment of its beach pier facility.

With respect to throughput capability of a jacked-up DeLong pier, if the crane could work both sides of the pier the lighter succession problem would be greatly eased. This would mean using a crane with greater lift capacity which the Army should at least consider since lighter succession, especially in moderate or high surf conditions, could preclude use of the nesting approach to mooring. In turn, this would eliminate delays as a result of lighters interfering with each other. To modify the shape of a DeLong for such an operation would require the addition of a truck turntable. Strengthening of the shore connector is required to some degree anyway, if the 140-ton crane is to be driven on and off the DeLong pier.

As used in the LGTS test, the DeLong pier was rated at 5.5 min. per container for off-loading and 5.9 min. per container for retrograde.

LACH Summary

In summary, the U.S. Marine Corps can support a 240-300-daily container throughput during the early phase of an amphibious operation with three operational LACH vehicles independent of elevated causeway operations. The Army, by adding two LACH vehicles to its terminal service company enhances its bare beach, all tide operational capability and provides additional equipment to unload landing craft in supporting a 240-300-per day container throughput rate.

AMPHIBIAN DISCHARGE POINT (ADP) CRANE

Optimum (Surge) Operations

The ADP crane was fully utilized only briefly during the test. That was the night of August 7-8 during Phase I when the crane-on-jetty dropped a container and all containers discharged at the ship were off-loaded at the ADP. The capability to bring LACV-30s in at one location and LARCs at another minimized crane delay times and helped turn amphibians around very quickly. During this period the ADP crane's average cycle time was about 3 1/3 min. per container with some complete cycles as fast as only 2 min. An amphibian was out of the water for only 8.5 min. on the average. In this period (from around 0200-0600 hr) 21 amphibians consisting of nine LACV-30s, five LARC-LXs and seven LARC-XVs were off-loaded carrying a total of 30 containers. Even then, the ADP crane had almost 2 hr of inactivity within this relatively heavy surge period. Table F.1 provides an average crane cycle divided into operational segments

TABLE 5.1
CRANE CYCLE SEGMENT AVERAGES (IN MIN.) DURING
ADP PHASE I SURGE PERIOD

Position spreader bar over container	Attach spreader bar	Lift-to- land	Detach spreader bar	Return spreader to position	TOTAL
1.34	1.13	1.38	1.17	1.11	6.14

Operations Methodology

The task of the ADP crane, a 140-ton P&H truck model 9125, was to rapidly return amphibians for additional loads since landing craft could not be discharged while the jetty crane was non-operational. In keeping up the pace, two other factors were important besides fast crane cycles. One was the ability of the ADP facility to have a second amphibian getting ready to be discharged while another was being unloaded. This included moving in close to the crane and lowering the ramp so tagline handlers could board. The second factor was the use of a frontloader to quickly transfer containers to trucks keeping the beach clear.

With respect to one amphibian getting ready while the second one was being discharged, one procedural change might have expedited amphibian turnaround. When the crane lifted a container off a LACV-30 it swung the container over the point where the LARCs were discharged, causing them to have to stand back until the last LACV-30 container was discharged. The crane then had a slight delay while the LARC eased its way the last few feet and lowered its ramp. There was no problem if a LARC was being off-loaded as a LACV-30 was moving into position and getting ready since it was past the crane's arc. If the crane had swung containers around to a position opposite the LARC discharge point, the cycle would have been increased slightly because of the longer arc but the longer delay awaiting the LARC would have been avoided.

The second factor, having the frontloader assist in the container transfers, saved the longer time required by the crane to load containers onto trailers. At the DeLong pier facility (discussed later) this step alone added about 1 1/3 min. to the crane cycle and during the surge period an added 1 1/3 min. loading trailers would have caused longer amphibian queues at the beach and crane delays at the ship.

For the most part the ADP was under-utilized in Phase I (except for the surge period described) because of the slow discharge rate shipside due to the early learning experience there. In Phase I(R) the ADP crane had a light workload because most of the containers were being loaded into landing craft by the two ship cranes and being off-loaded by the crane-on-jetty, which was able to keep pace during favorable tidal periods. Thus, the ADP crane did not

have the opportunity to live up to its real potential except during the one brief surge period in Phase I.

Data Base Averages

Table 5.2 shows the results obtained from the automated data base. A 12 min. cycle cutoff was used to calculate the averages. Distributions were generally in the 3 to 7 min. range for Phase I and 1 to 5 min. range for Phase I(R).

TABLE 5.2
ADP CRANE CYCLE AVERAGES (IN MIN.) TAKEN FROM AUTOMATED DATA BASE

OPERATIONAL PHASE	OFF-LOAD				RETR. PHASE			
	DAY		NIGHT		DAY		NIGHT	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
PHASE I	5.99	6	5.54	5	7.16	6	6.18	6
PHASE I(R)	4.43	4	4.99	4	-	-	-	-

Two types of spreader bars were used with the ADP crane, a manual one and a hydraulically operated one. Analysis of the data base indicates that during day off-load operations ADP crane cycles with the hydraulic one averaged 6.14 min. and 5.95 with the manual one. The difference of about 19 seconds is not considered significant for the following reasons. The hydraulic spreader bar was not used during the retrograde period during which crane cycles generally were slower because of the more careful loading needed in loading the amphibians as opposed to simply setting off-loaded containers anywhere on the ground. Also, during night off-loading operations, the manual spreader bar was not used enough to make a comparison (only three times).

CRANE-ON-JETTY

General

Details on the deployment of the crane, construction of the jetty, concept of employment, and summary of container transfers are contained in Volume I. The crane-on-jetty was tested to determine if a beach platform could be constructed within contingency time frames, extend the crane's reach sufficiently to extend operating periods around high tides, and withstand the effects of erosion from tidal wave action.

The first two questions were answered in that the crane was deployed and the crane-on-jetty erected within scenario time constraints. Some minor stabilization and sand erosion problems were encountered but promptly corrected by engineer and terminal service operating personnel.

The concept of employing a crane on a jetty may have been overtaken by events in light of the possibility of deploying a two TCDF and two section DeLong pier by a SEABEE ship. Subsequent to the conduct of the LOTS test this vessel has been committed to the Sealift Readiness Program (SRP) and the possibility of one of the three ships becoming available by call-up has improved. Secondly, the LACH and use of causeway ferries provide attractive alternatives for a more readily deployable system for all tides. Nonetheless, the crane-on-jetty is discussed here to demonstrate the advantage of operating a crane on any platform that can serve lighters beached or tied up on either side of the crane.

Surge Activity

The crane-on-jetty (also referred to as the bare beach crane) also performed well during surge periods. When the tide was roughly synchronized with crew change and crane maintenance periods so that little throughput time was lost, jetty crane productivity levels were high. During the day shift of Phase I(R) the jetty crane transferred 81 percent of 141 containers landed, the most productive period of container discharge at the ship. The jetty crane still had some periods of inactivity and a 2-hr late start due to low tidal conditions. Peaking at 18 containers per hour, the jetty crane achieved the highest surge rate of any crane in the test. During the night shift and after about a 2½-hr low tide delay, a few LARCs were shifted over from the ADP crane; after that the jetty crane began working landing craft again. During the night shift the jetty crane handled 54 percent of the containers. Figure 5.1 illustrates the level of activity at the jetty crane with respect to tides during Phase I(R).

Table 5.3 provides data on crane cycle segments taken from both bare beach phases of the test. The data provide average times to accomplish the four basic elements of a crane cycle and do not include all factors, such as brief halts to change operators, lighter delays, spreader bar changes, and other factors. Nevertheless, as will be noted later, these Phase I(R) times are comparable with those contained in the automated data base, indicating the pace of activity at the crane during that period. The cycles show a 30 percent improvement in time while productivity—largely a function of shipside discharge productivity and lighter type selection—increased 300 percent.

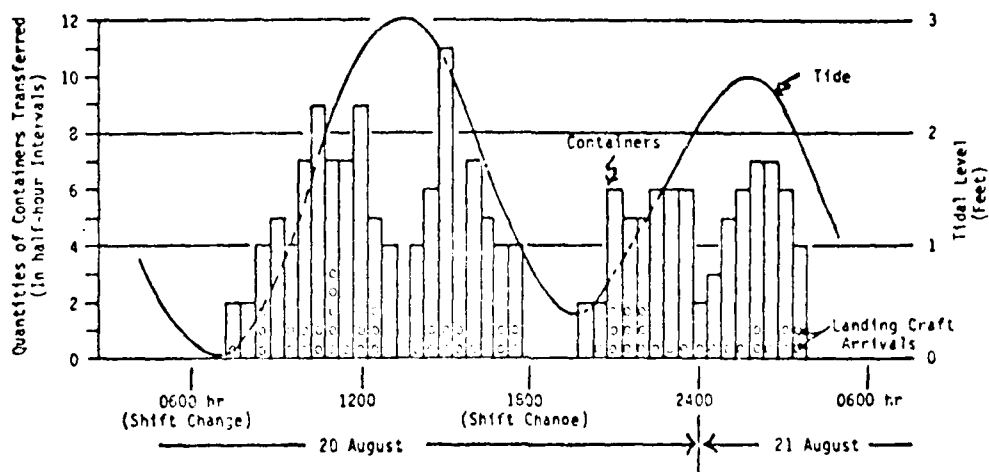


FIGURE 5.1. JETTY CRANE TRANSFERS IN HALF-HOUR INTERVALS, PHASE I(R) (Also shows landing craft arrivals (o) in half-hour intervals, and tide level.)

TABLE 5.3
AVERAGE CRANE-ON-JETTY CYCLE SEGMENTS
(In Min.)

Operational Phase	Attach Spreader Bar	Lift-to-Land	Detach Spreader Bar	Return to Start Position	TOTAL
PHASE I	1.60	1.64	.28	1.59	5.11
PHASE I(R)	.65	1.03	.18	1.72	3.59

Operational Methodology

The crane-on-jetty worked in a manner very similar to the ADP crane. While working a lighter on one side, another lighter could retract or beach on the opposite side. When the crane lifted a container from a lighter on the right side, the crane's rotation was to the right and vice versa for the port side. Once the spreader bar had been detached, a frontloader retrieved the container and loaded a trailer nearby. Using this system the crane was relatively independent of minor delays in lighters and truck operations and could keep its boom working almost continuously.

As a temporary measure the construction of a jetty would be helpful until a more durable facility could be installed. It is the only means readily available now to the Army for using the P&H 6250 crane on the beach to discharge landing craft. However, the durability of the jetty could not be evaluated during the test since there was no heavy surf to stress it by creating a serious erosion problem. If there had been a shallower beach gradient and a requirement to extend the jetty out farther, erosion of the sand fill could have been more of a problem, and likely also, the stability of the crane.

Previous experience in the 1972 OSDOC Test at Ft. Story showed that even moderately high waves caused serious erosion. The OSDOC jetty had been constructed using driven plate piles that interlocked in an attempt to minimize water penetration. The jetty used in the LOTS test had a different basic framework, constructed of salvaged steel plates which were backed by a large number of sand bags that helped retain the loose sand in the interior. Moisture penetrated and helped keep the sand packed but the sand bags did not allow much to wash away.

How far to seaward the jetty's location would be for the test was a compromise, arrived at in part by trial-and-error before the test. If the jetty extended relatively far into the water where erosion would be more of a problem, the crane could reach the lighters during a large fraction of the tidal cycle. Extending to a lesser distance would result in a structure less vulnerable to the waves but also with less crane reach and, consequently, useful for a lesser fraction of the tidal cycle. The position arrived at for the LOTS test was one in which landing craft could be served for more than half of the tidal cycle. Since no waves occurred that were more than about 2-ft high, there was no real test of the effects of wave erosion.

The jetty was assembled and installed within the 4-day time constraint (specific personnel and time data for the total fabrication period are not available). The jetty served adequately as a temporary beach crane platform for this test. It worked well in the calm conditions experienced. If further use of this type of facility is planned, additional testing under adverse sea conditions is needed.

Overall Cycle Averages

From Phase I to I(R) the jetty crane showed a 39 percent cycle time improvement for day operations and an 8 percent improvement in night operations. No retrograde was accomplished in Phase I(R) so there is no basis for comparison

Table 5.4 provides the crane cycle averages taken from the automated data base. As with other automated data base calculations, a cutoff of cycles greater than 12 min. was used.

TABLE 5.4
CRANE-ON-JETTY'S AVERAGE CONTAINER
CYCLES TAKEN FROM AUTOMATED DATA BASE

OPERATIONAL PHASE	OFF-LOADING				RETROGRADE			
	DAY		NIGHT		DAY		NIGHT	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
Phase I	5.86	5	5.68	5	7.28	7	8.00	8
Phase I(R)	2.60	3	5.21	5	-	-	-	-

In the above averages significant delays associated with lighter beachings (cycles greater than 12 min. were excluded) are not reflected. Basically they represent unloading or retrograde times as they existed once the lighter had arrived. The averages for Phase I(R) appear to be more representative of an experienced unit and an average of 4.4 min. per container is considered an expected discharge rate for the jetty crane for day and night operations.

40-Ft Containers

The jetty crane was the only crane on the beach used to transfer 40-ft containers, which were all off-loaded in Phase I (although during Phase III a test lift was made). The 40-ft containers were off-loaded from LCUs, LCM8s, and LARC-LXs. To change spreader bars the crew required 7.4 min. on average, with times varying from 3.4 to 12 min. The average 40-ft container lift required 8.76 min.¹ Segment intervals of the cycle were:

- Attach spreader bar and prepare to lift— 3.33 min.
- Lift-to-land of container— 3.21 min.
- Detach spreader bar from container— .58 min.
- Return to starting position— 1.64 min.

¹ The automated data base reflects an average time of 10 to 10.5 min. but has a sample size of only three of the 25 containers handled. The above averages were calculated from ORI data which covers 11 of the 25 containers and includes the data points necessary for calculating segment intervals of the cycle as shown.

ELEVATED CAUSEWAY

General

A significant feature of the elevated causeway is its deployability. Its components can be readily loaded on several types of amphibious ships as well as commercial U.S. flag carriers. The introduction of these components into a LOTS build-up within five days is a reasonable expectation, assuming the availability of compatible shipping. On breakbulk ships the elevated causeway's outsize components would require a considerable number of breakbulk ships for deployment. A LASH ship would be more suitable but like the SEABEE, LASH ship availability is not assured either.

The administrative introduction of the attached causeway sections equipped with spudwells implied certain assumptions that have not been tested. None of the causeway sections previously loaded during the LOTS test were equipped with spudwells. These may have to be added to the causeway sections at the objective site or modified procedures developed for their loading.

The deployment of the elevated causeway resulted in a number of lessons learned. One that was particularly important was to ensure that all attached pilings be raised above the bottom of the sections. This was not the case during the beaching process. Two of the pilings protruded below the bottom and became embedded in a sand bar. The resulting sudden jolt severely damaged the end connectors between two of the sections. Obviously, time was lost extracting the pilings from the sand bar and repairing the damaged elevated sections during the connecting process.

The elevated causeway provided a relatively good, stable platform after all pilings were driven to acceptable depths. Unfortunately, there is no simple way of predicting the depths required for the pilings in order to attain a stable mode. Hydrographic surveys are helpful, but core samplings are better in revealing the true depth requirements. Silt build-ups, normally at or near the entrance to large bays and inlets must be anticipated. A pile driver refusal rate of 60-90 blows per foot proved to be a sound factor as evidenced by the absence of any significant settling once the causeway was elevated.

The length of the elevated causeway placed the pierhead more than 600 ft from the high water mark. This distance might seem to be more than required for operating with landing craft. However, lighter discharge and loading cannot be done safely within the surf zone or on sand bars which are 200 to 300 ft off-shore. Off-loading beyond the surf zone is necessary since shallow water waves become steeper and more forceful. Thus, it is safer to be out of the surf zone.

The height of the pierhead is such that it must clear the floating fendering system by 6 ft at high tide. If such clearance is not provided, wave action would cause the fenders to collide with the pierhead sections at the spudwells.

The elevated causeway did not appear to be stressed severely at any time during the test when docking and undocking lighters and barges. Similarly stresses were not evident during the truck operations with the crane. Strong tidal currents provided good operational experience for the lighter crews and line handlers.

Some lighter damage was experienced along the exposed seaward end of the fenders and lighters nearly collided with the pilings supporting the turntable section. This was corrected by placing and anchoring an AMMI pontoon section at the seaward end of Section No. 3. (See Figure 5.2.)

Potential Modifications

With an alternative array, as suggested above, a six-section pierhead would have provided more working space, which was needed. Also, other transfer methods could be investigated. A crane, not necessarily the type used, could be centered on the seaward end of the pier in order to service lighters on both sides of the causeway. The turntable could be placed forward of the crane where trucks could be turned around and backed into a transfer position. (See Figure 5.3.) Loaded trucks could then be driven around the turntable.

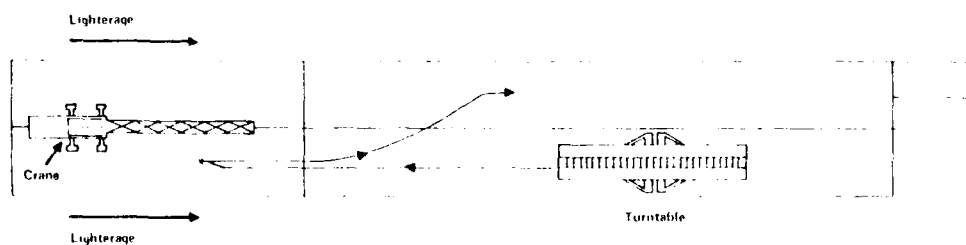


FIGURE 5.3 SIX SECTION PIERHEAD

Elevated Causeway Results

Table 5.5 illustrates daily crane productivity. Crane delays most frequently occurred during the succession of lighters or when no craft were available for unloading. Total times for each could not be accurately identified for the entire phase.

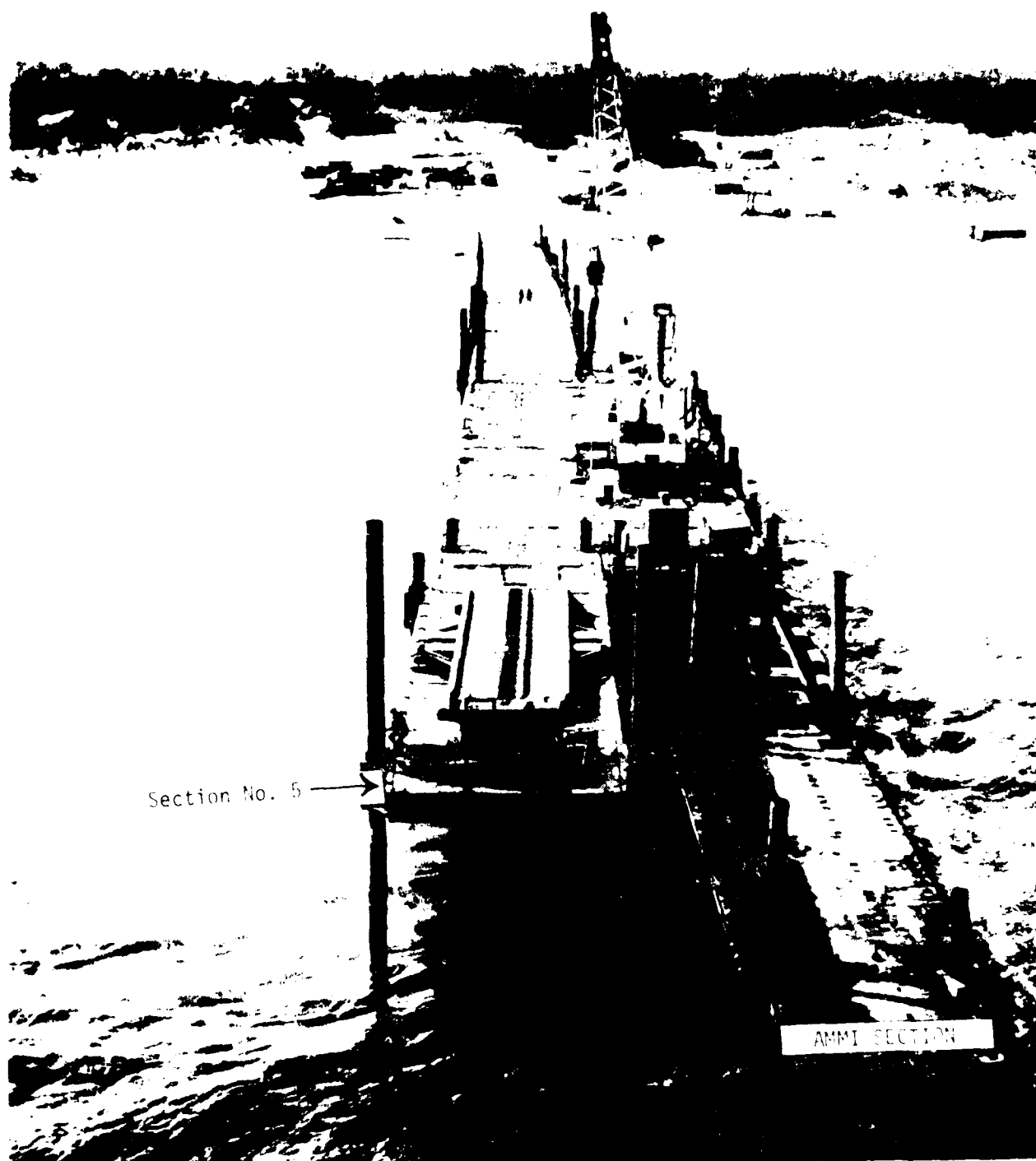


FIGURE B.2 POSITION OF AMMI SECTION

TABLE 5.5

CRANE PRODUCTIVE TIME

Date	Minutes Sampled	Crane in Motion		Awaiting Lighters		Awaiting Trucks		Awaiting Misc	
		Minutes	Percent	Minutes	Percent	Minutes	Percent	Minutes	Percent
11 Aug	314.51	145.12	46.1	167.81	53.4	-	-	1.56	.5
12 Aug	586.97	278.45	47.4	235.27	40.1	73.25	12.5	-	-
13 Aug	665.46	265.76	40.0	358.27	53.8	37.23	5.6	4.23	.6
TOTAL	1566.94	689.33	44.0	761.35	48.6	110.48	7.0	5.81	.4

During Phase II a series of detailed data collection efforts were made on causeway operations. The crane worked 689.33 min. and transferred 160 containers in this period, resulting in an average cycle time of one container per 4.31 min. Thus, during a 20-hr working day, 278 containers could theoretically be handled, if such ideal conditions existed. As shown in Figure 5.4, 12 August was the most productive day in terms of transfers. On that day, 134 containers were transferred or 48 percent of the estimated total crane operating potential. This averaged to about one container each 8.76 min. when all interfacing delay activities for that day were included with the crane's cycle times. It is significant that 45-52 percent of the time the crane on the elevated causeway was either awaiting lighters or trucks and did not reach its maximum potential.

In addition to the above information detailed data were taken on crane cycles and truck operations on the elevated causeway. The crane cycle data, provided in Table 5.6, traces crane activities only and does not include other interfacing activities. Nevertheless, the mean for off-loading is relatively close to the cycles extracted from the automated data base (discussed later) which considers all combinations of delays and cycles of 12 min. or less. For retrograding, the difference was 1 min between the two calculations.

TABLE 5.6

ELEVATED CAUSEWAY TRANSFER OPERATIONS

Crane Cycle Segment Times (In Minutes)

Phase II	Attach Slings	Lift to Land	Detach Slings	Boom Return	Average Total Cycle
Day #1	.76	1.56	1.53	1.34	5.19 *
Day #4	.90	1.85	.49	1.76	5.00 **

Truck Operations Phase II

Truck Operations	Day #1 *	Day #5 **
Number Trucks in Load Position	1 Truck	
Average Number Trucks in Queue	3 Trucks	
Average Time in Queue	13.31 Min.	12.87 Min.
Average Time to Move to Load/Unload Position	6.51 Min.	1.61 Min.
Average Time in Load/Unload Position	4.03 Min.	2.72 Min.
Average Time to Clear	3.36 Min.	4.71 Min.
Average Time on Causeway	27.21 Min.	21.91 Min.

* Off-load

** Retrograde

During Phase III the elevated causeway off-loaded 125 containers the first 24 hr and 52 during the next 12 hr. The procedures for transferring containers did not change from those used in Phase II. The elevated causeway started operations with a queue already developed from the back-up from the jacked-up DeLong pier. Between 1300 and 1700 hr the elevated causeway hit its best 4-hr surge discharge period, off-loading nine in the first hour, nine in the second, ten in the third, eight in the fourth. This provided a surge average of nine containers per hour with a peak one-hour period of 10. Only twice before did the elevated causeway sustain an off-load average of eight containers per hour for a 4-hr surge period. On four other occasions, which occurred during Phase II, the elevated causeway peaked at 10 containers per hour.

Conditions during this period were nearly ideal for operations. Once the initial queue had been reduced there were no other backlogs built up which were nearly as significant. For the remainder of Phase III the JUD and the elevated causeway continued to share the shoreside transfer responsibilities.

Lighter Successions

One significant and recurrent delay experienced at the elevated causeway was the problem of slow lighter succession times. During off-loading in Phase II, for example, on the average the time to approach and moor to the elevated causeway was about 3 min, the average time a lighter was alongside was 24.71 min, and the average time between lighters 20.14 min. The average load per lighter (which included one LCM8 and causeway ferry) was 3.81 containers.

Because the Phase II data were largely subject to the availability of containers and lighters, another comparison of lighter succession times was made using data from Phase III operations when there were loaded lighters in queue. The results (for LCU's, the predominant lighter used) were that about 3 min was required to approach and moor, and about 2 min to cast-off and clear the position so that the next lighter could come alongside the elevated causeway. Thus, lighter succession time at the elevated causeway with a queue of loaded lighters using a one-at-a-time moor and cast-off procedure required an average of about 5 min. This approximates the crane's cycle time and even in the periods analyzed (day shifts, 16 and 17 August), the crane was delayed in 42 percent of the lighter successions. During this period of improved performance, the lighter spent about 19 percent of its total turnaround time during the approach, moor, cast-off, and clear procedures. This suggests that a faster procedure could be employed. One possibility is to place the crane in the center of the causeway (as previously suggested) and use port and starboard side mooring. A second is to adopt the procedure used at the DeLong pier which is discussed in more detail later. The procedure at the DeLong pier was to moor a second lighter alongside the one already being off-loaded/loaded and pulling into position as soon as the first departs. This eliminated lighter succession delays.

Overall Crane Cycle Averages

Between Phases II and III crane cycle averages did not change significantly, except that during Phase III the cycles were about 3 percent slower. Unlike at all the other facilities, the Navy and Marine Corps had several days of activity prior to their test phase in which to work out some of the training and operational hitches a new facility experiences its first time in use. Table 5.7 provides the crane cycle averages extracted from the automated data base (with cutoff of cycles greater than 12 min).

TABLE 5.7
ELEVATED CAUSEWAY CRANE'S AVERAGE CONTAINER
CYCLES (IN MINS) TAKEN FROM AUTOMATED DATA BASE

OPERATIONAL PHASE	OFF-LOAD				RETROGRADE			
	DAY		NIGHT		DAY		NIGHT	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
Phase II	5.61	5	5.82	5	5.66	5	5.00	5
Phase III	5.66	5	5.98	5	5.75	5	5.44	5

Analysis of crane cycles in the data base shows the Phase II day and night shift distribution of cycles ranged primarily from 3-6 min for both off-loading and retrograding operations. The Phase III results were comparable to Phase II although the distributions were slightly more variable.

From the above for planning purposes it was determined that an average of 5.7 min would be an appropriate rate for off-load and 6.0 min for retrograde. Daily productivity, however, depends upon the flow of containers to the elevated causeway, lighter succession times, and other factors. These rates could be improved if the lighter succession problem could be eliminated, possibly by one of the methods suggested above.

Other Operational Factors

It was noted that during Phase II, 12 percent of the sampled time on 12 August found the crane idle while awaiting trucks. More trucks could have been employed but the primary reason for the large delay time was a vehicle accident that blocked the route. An alternative route or other traffic arrangements should have been made. Truck delays were also noted on the following day.

It was also noted that part of the delay time for lighters could have been reduced. The procedures of transferring line handlers between incoming and outgoing craft and mooring methods observed during the test, in general, left considerable room for improvement.

Weather affected causeway operations the same as other shoreside systems. All work was secured when electrical storms appeared in the vicinity.

The air cushion turntable was a significant aid in maintaining throughput rates at the elevated causeway. A random sampling during the afternoon of 15 August gave an average truck time on the turntable of 2.28 min. The table did have some minor breakdowns but no substantive delays were recorded.

JACKED-UP DELONG PIER

General

The jacked-up DeLong (JUD), an Army pier which converts a bare beach operation into a semi-fixed or improved beach system, offers some distinct operational advantages over the bare beach crane on a jetty. It permits the use of a smaller crane to discharge lighters; the crane has a firm foundation upon which to operate; LASH and SEABEE barges can be moored alongside; and it provides an operating platform that is less environmentally-sensitive than the 300-ton jetty crane. However, the JUD has some drawbacks too.

The JUD is affected by beach gradient (the more gentle the gradient, the farther seaward it has to be placed) and it needs a sturdy ramping system to connect it to shore. The pier sections are limited in number and the B sections are deployable only on three ships. DeLong A sections are not deployable on any ships and must be towed. Therefore, in terms of strategic mobility planning the DeLong pier has serious deployment deficiencies and cannot be considered for a non-mobilization, quick response contingency requirement.

In observing crane operations at the JUD, it was noted that a 20-ft container at capacity weight and situated well inside an LCU caused the crane outriggers to come up off the deck, although the crane was loosely chained down. It was also noted that no 40-ft containers were attempted at the JUD. Subsequent to the test the Army has shifted the reinforced decking on the DeLong which supports the crane so that the crane is close enough to lighters to lift a 40-ft container from the centerline of an LCU.

Analysis Methodology

The JUD crane at the beach did not keep pace with the two ship discharge cranes. An analysis was made to determine what the JUD crane's container cycle rate was: first, if crane operations were considered in isolation of all other factors; second, if there was a steady flow of lighters; and, third, the actual hourly rate achieved including all interruptions. These rates provided insights with respect to (1) an ideal maximum throughput rate, (2) a real but somewhat optimistic rate, and (3) the rate actually achieved.

The first case is important because it looks directly at the operational technique for crane employment on a JUD and the elements in a crane cycle where the most time is spent. The second case looks at the relationship between lighters and the loads they carry, and the JUD crane. The third case looks at all possible circumstances by which the throughput rate across the DeLong was influenced during the test.

Using these approaches it is possible to determine where a crane cycle could be reduced by modifying equipment (a spreader bar, for example) or by changing operational techniques for transferring containers (e.g., use of a turntable to rotate trucks). With respect to the B DeLong section and the fact that the crane operates from a position along the centerline of that section, it might be better to place DeLong sections end-to-end instead of in a juxtaposition so that a crane with more lifting capacity could serve lighters on both sides. These proposals are examples of JUDS equipment modifications and changes in operational techniques that could increase the throughput rate.

Analysis of Cycle Times and Equipment

In examining crane cycle segment times contained in Table 5.8, some slight changes were noted, possibly due to the effects of heat and fatigue on operating personnel. The crane cycle time was observed on a cool morning of a very hot day to be 4.46 min while the afternoon operations slowed to an average of 5.24 min. For evaluation purposes, based upon first shift sample data only,² the mean for the full shift was used, 4.94 min. This was slightly faster than the overall cycle averages (discussed later). However, the supply of containers and lighters was relatively continuous and the crane was able to work at a steady pace.

² The DeLong pier facility had only slightly more than one full day to off-load containers before the ship was nearly off-loaded and thunderstorms began moving in to cause operational halts. Subsequently the DeLong pier off-loaded barges and handled a small amount of retrograde containers.

TABLE 5.8
DELONG PIER CRANE CYCLE SEGMENT TIMES (IN MINUTES)

	Attach Spreader Bar Average	Lift-to-load Truck Average	Detach Spreader Bar Average	Return Average	Average Total Cycle
First 4 Hr	0.92	1.35	.18	1.01	4.46
Next 5.5 Hr	1.11	2.42	.15	1.10	5.14
Cumulative	1.03	2.39	.16	1.07	4.94

Table 5.9 summarizes the results of truck operations on the DeLong pier. No significant crane delays were experienced as a result of truck operations.

TABLE 5.9
TRUCK OPERATIONS ON THE DELONG PIER

Number Trucks In Load Position On JUD	1	Truck
Average Number Trucks In Queue On JUD	3	Trucks
Average Time In Queue On JUD	13.12	Minutes
Average Turn Around Time	2.71	Minutes
Average Time In Load Position	3.32	Minutes
Average Time For Truck To Clear JUD	1.08	Minutes
TOTAL TIME ON JUD	20.23	Minutes

Two elements of the crane's cycle which require strenuous physical effort from tag line handlers are especially worth considering. The first element involved pulling the spreader bar into alignment over the container for a pick up and the second involved pulling the container into alignment over the trailer to complete the transfer.

On the JUD the relative position of the centerline of the spreader bar to the centerline of containers in lighters and to trailers on the pier was always at an angle. This angle varied from 30-60 degrees. Since the crane used two hooks separated by a small spreader bar that attached to the container spreader bar, there was always some added resistance in attempting to make the alignment. In port operations such alignment problems do not generally exist because facilities were designed to keep a near parallel alignment between spreader bars, containers, and transport equipment.

Half of the time for every JUD crane cycle on the LOTS test was spent on the segment of the cycle involved with loading the trailer. Since the return segment of the cycle (spreader bar returns empty from the pier to

a position grossly over the next lift) is less than 25 percent of the cycle, it is probable that about 25 percent or 1 to 1.5 min. is spent on each cycle trying to exactly position the container on the trailer.

This time could be reduced by modifying the spreader bar. The modification should permit the spreader bar to rotate beneath the crane's two hooks. This would facilitate spreader bar alignment when either attaching to a load or when repositioning a load on a trailer. Besides decreasing the amount of pier crane cycle time, the modification could be employed on spreader bars at other crane operational sites where alignment is a problem.

Overall Crane Cycle Averages

Since there was only one phase in which the DeLong pier facility was used, there was no opportunity to observe learning effects other than the first four hours (discussed above). However, the averages contained in the automated data base indicate that for the period it was used, it was used effectively. Table 5.10 provides the averages obtained from the automated data base (cycles longer than 12 min. omitted).

TABLE 5.10
DELONG PIER CRANE AVERAGE CONTAINER
CYCLES (IN MINS) TAKEN FROM AUTOMATED DATA BASE

OPERATIONAL PHASE	OFF-LOAD				RETROGRADE			
	DAY		NIGHT		DAY		NIGHT	
	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN	MEAN	MEDIAN
Phase III	5.27	5	6.16	6	6.41	6	5.54	5

Retrograde operations were conducted for only one day and night, with most of the containers transferred at night. Distributions for the day retrograde crane cycles were more widely scattered than for the night shift which were mostly in the 2-8 min. range. This suggests that the retrograde operations may not have been as well organized on the day shift.

For day off-load operations, 75 percent of the crane cycle distributions were in the 2-6 min. range; for night off-load operations, 2-7 min. However, the distribution for night operations was less concentrated around the mean as would be expected.

Calculations concerning crane operations with respect to lighters suggests that one JUD crane over two 10-hr shifts would have off-loaded 228 containers assuming there had been a steady flow of lighters to the pier. Disregarding the first 4 hr in which considerable time was lost mooring (due to tidal current and the fact that the double mooring or "nesting" method

was not used), LCUs averaged 4.14 containers per trip. They had a JUD turnaround time (the sum of the time required for mooring, off-loading and casting-off/clearing the JUD) of 21.72 min. The average time alongside divided by the average LCU load equals 5.25 min. per container and includes all routine operations and minor delays. Minor delays, for example, include occasional 1-2 min. halts while mooring is completed and the tag line crew boards the new lighters. To the extent that more than four containers could be loaded in an LCU, the time per container was improved.

The best actual 20-hr rate was 162 containers with most of them (101) being off-loaded during the first shift of Phase III. During the second shift the ship discharge rate slowed, so there were fewer to handle. In addition, the elevated causeway system was also being used for lighterage off-loading. Thus, the highest number of containers the JUD system off-loaded was on the first shift of Phase III. From this analysis it is apparent that the JUD crane system as used in the LOTS test would require additional shoreside off-loading support to meet the 300 container per day objective of an Army throughput system.

To determine an appropriate throughput rate a combined day and night average based upon the test results of 5.5 min. per container was used for off-loading and a rate of 5.9 min. per container was determined applicable for retrograde.

Two alternatives are possible to improve Army beach throughput rates by modifying the pier. First, the DeLong zigzag arrangement with the crane/pierhead alongside an end section could be changed and a turntable added (since the DeLong B section has already been modified to serve as a container crane pier). Although truck operations did not cause major delays, the yard tractor and trailer had to do a near jack-knife turn in order to get into position for loading. A turntable would minimize the amount of space required by the tractor-trailer. It would also reduce the amount of turning space that had to be dedicated to tractor-trailer operations. However, it should be noted that no significant surf was present to hamper the resting approach to mooring.

Secondly, by using the DeLong sections as a straight fingerpier, lighters could approach and moor to both sides. While one side is being readied (moored/unmoored), a lighter on the other side could be worked to eliminate lighter delays and interference.

Another alternative to increasing beach container handling productivity for the Army is to install an elevated causeway, which is more easily deployed, and use the ADF crane on it. Not only would this ensure a good back-up for the container company in the event of an accident or equipment failure on the other pier, it would also permit a separation of cargo flow, a highly desirable feature for handling ammunition in a LOTS operation. Finally, lightweight amphibious container handlers (LACHs), which are discussed later, also could be used as beach transfer augmentation.

LIGHTWEIGHT AMPHIBIOUS CONTAINER HANDLER (LACH) OPERATIONS

Operational Methodology

The LACH as employed in the test was limited in demonstrating its full productivity potential. As an example, the distance from the LACH operating site to the truck trailer loading point was too far to permit a quick turn around of the experimental vehicle. Thus, to capitalize on its ability to unload grounded out landing craft rapidly, the containers were first stacked on the beach. If no other landing craft were waiting, the last container unloaded from the lighter was moved directly to and loaded on a trailer spotted on an apron of the tractor-trailer parking area. Then as the empty landing craft retracted from the beach, the LACH loaded the remaining containers on the beach onto trailers.

The procedure adopted was a sound one considering that there was only one LACH available. The double handling on the beach was justified by not delaying the unloading of the LCU which could be returned to the ship sooner for another load. If the tractor-trailer units could have been loaded on a prepared surface closer to the LACH operating site, turnaround times could have been reduced enough to permit direct container transfers from LCU's to trailers without unduly delaying the landing craft unloading process.

This can be demonstrated by examining the average times taken during Phase II in the transfer of containers from lighters to the beach for temporary storage, from beach to trucks, and finally, direct from lighter to truck. A summary of these times for LACH operations during Phase II ship discharge operations are given in Table 5.11.

TABLE 5.11
LACH CYCLE TIMES

TRANSFER OPERATION	AVERAGE LACH COMPLETE CYCLE TIMES (IN MINS.)
Lighter to Beach*	
LCU	8
Causeway Ferry	9
Beach to Truck	7
Lighter to Truck	
LCU	11
LCMB	10
Causeway Ferry	10

*There were no LCMB to beach transfers.

Timings of the LACH operations were analyzed to determine average time segments of LACH cycles in unloading LCUs to the beach and in transferring containers direct to the trailer. The great majority of the transfers were

made from LCU's to the beach and separately from the beach to trailers. To build a larger body of data the time segments for the LACH to enter and depart LCU's were taken from both LCU to beach and LCU to truck transfers. Likewise, the time segments for from "began to position" at the truck to unlock were taken from transfers from the beach to trailers and LCU to trailer. Similarly, the times for transit to trailer and from "clear trailer" to return to the LACH operating site were also compiled. The results are shown in Table 5.12.

TABLE 5.12
AVERAGE TIME SEGMENTS OF LACH CYCLES

	MIN.
Enter/Depart LCU	3.5
Transit to trailer	2.0
Began position at trailer to unlock	3.0
Clear trailer & return	2.5
Ramp to Ramp cycle:	11.0

Sample timings were also made during the test of the transit time from the LACH container stacking area on the beach to a point at which the vehicle began to position itself for loading trailers. These times averaged one minute. Thus, the LACH cycle for transfers direct from an LCU to trailers at a loading point near where the containers were stacked on the beach can be estimated at about 9 min. by subtracting two minutes from the total cycle time constructed above.

Productivity

Under the near ideal conditions at Ft. Story the potential daily productivity of the LACH could be increased by 22 percent (11/9) and the time advantage of unloading from lighter to beach versus direct to truck narrowed. It should be noted, however, that there is much more variability in the cycle times for loading trailers than in simply landing containers on the beach. The prompt return of lighters, which otherwise might interrupt ship crane operations, is more important than optimizing LACH utilization.

The foregoing has been based on a one LACH operation. A more representative case would be with two or three of these vehicles supporting an operating site. Given a ship discharge system producing an average rate of about 240 containers per day during a period prior to the installation of an elevated causeway or a DeLong pier, two cases are postulated. The first is with LACHs discharging directly from LCUs to trailers and the second, LACHs unloading to the beach assisted by frontloaders loading containers from the beach to trailers. For each case LCUs are arriving at an average rate of three per hour, or one every 20 minutes.³

³ $\frac{240 \text{ containers/day}}{20 \text{ hrs} \times 4 \text{ containers/LCU}} = 3 \text{ LCU's/hr.}$

Two LACH Container Operation. A time line was made of LCU arrivals and LACH's unloading containers directly to tractor-trailer units on a parallel beach road immediately adjacent to the off-loading site. The results are shown in Figure 5.5. In this case, except for the variability in LCU off-loading and trailer loading times, two LACHs can work one LCU at a time without interference and transfer containers directly to trucks without delaying the lighters. The total productivity of the system on average, would be 240 containers per day or 120 per LACH.

The question of variability of unloading LCUs and loading trailers, which could periodically delay the discharge of the LCUs, needs to be addressed. As stated earlier, if possible, delays in LCU discharge should not be allowed to result in delays in ship discharge. One alternative is a larger number of lighters for a beach queue. In most cases a surplus of lighters cannot be counted on and other alternatives need to be explored. One is to provide additional LACH units. This is the most practical consideration for the Marine Corps as it avoids the issue of introducing a new item of equipment such as a frontloader. The Army, on the other hand, has the opportunity of adding LACH vehicles to their terminal service units. With frontloaders already available in Army units for handling containers on the beach and in the marshaling yard, the utility of frontloaders used in conjunction with LACH vehicles is worth examination.

One LACH Backup Unit. In the first alternative, the advantage of adding one vehicle for a three LACH operation was looked at. As would be expected the LACH cycles can be delayed considerably without major disruption to an average LCU cycle of 20 minutes.

Additionally, a backup LACH unit provides flexibility in that LCUs vary in their arrivals around the 20 min average. Also, LACH units incur random breakdowns of varying frequency and time duration at which times the third LACH can fill the void. For the sake of illustration a three LACH operation is depicted in Figure 5.6 in which major delays occur of the magnitude experienced in the Joint LOTS test. The first LACH unloads the first container from the LCU in an average time of 3½ min but is delayed at the truck by having difficulty in positioning the container on the trailer (10½ min. vs an average of 3 min). This was an unusually long delay."

The second LACH is delayed in extracting the next container from the LCU, 8 min compared to the 3.5 min average. Again on 11 August, the shortest time recorded was 1½ min and the longest 9¼ min. While the second LACH loads the container on a trailer, the third LACH clears the ramp and unloads the last container in a total elapsed time of 20 min. The example can be varied widely, for example, with consecutive delays in extracting containers from the LCU so that the 20 min unloading time is exceeded. In such a case that delay cannot be avoided, but the third LACH can commence unloading the next arriving LCU and avoid additional delays.

* Positioning containers was the most common case of delay during the test. average time from position to unlock was 3 min, with times as low as 1½ to one high of 11½ min which occurred during the first shift 11 August.

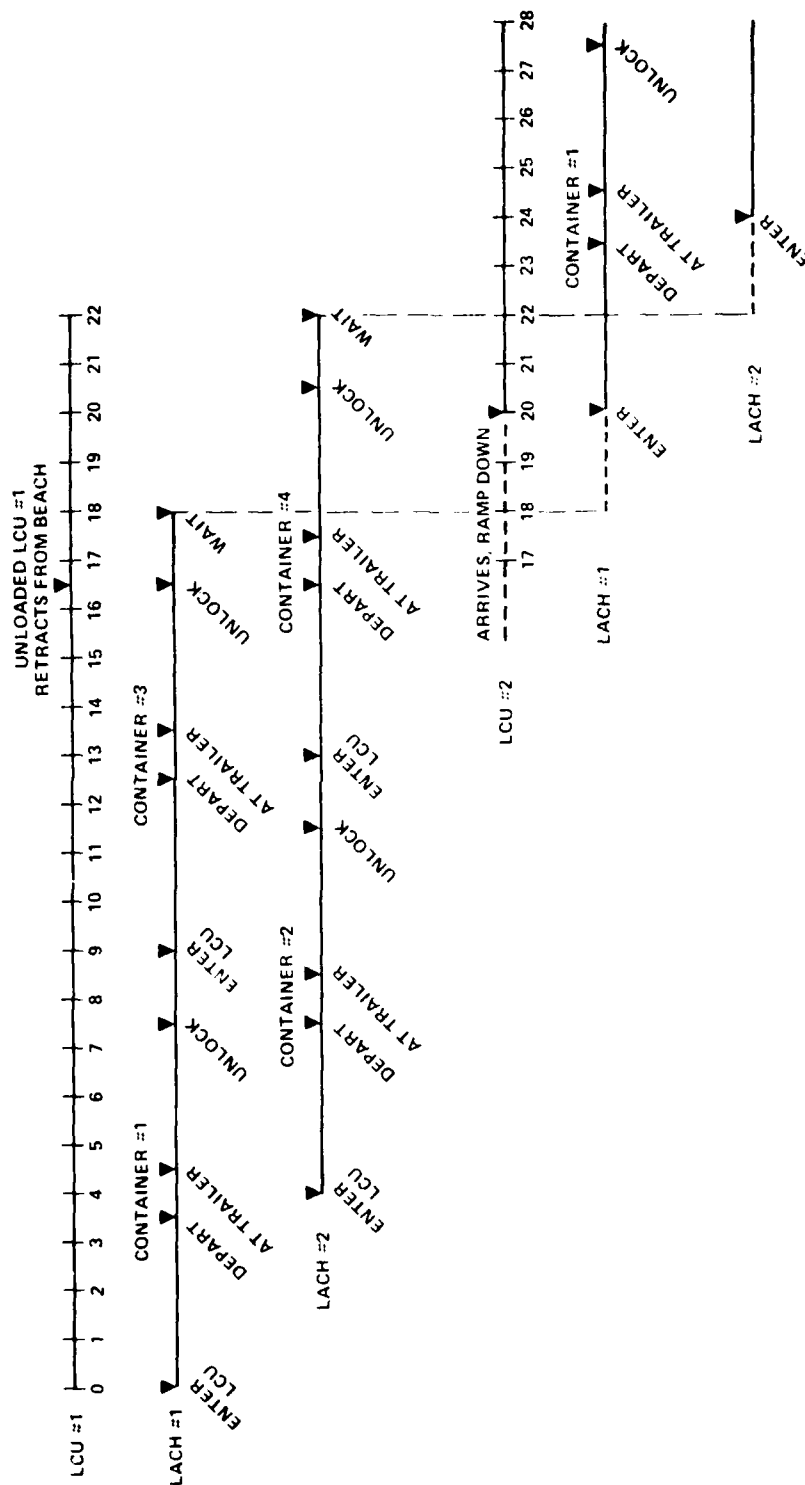


FIGURE 5.5. TWO LACH UNITS IN LCU UNLOADING OPERATIONS
Time increments in Minutes

Frontloader Assisted LACH Operations

As noted earlier the Army has the option of employing frontloaders on the beach to assist LACH container transfers from landing craft to trailers. The advantage is in the ability of the frontloader to load a trailer from the side more quickly than the LACH straddling the trailer from the rear. More importantly, the Army's new dual purpose 34-ton trailers are loaded with a single 20 ft container at a center position to balance and distribute the load between the triaxle wheels of the trailer and drive wheels of the tractor. The LACH could not position a milvan far enough forward from the rear of the trailer to balance the load properly since the guides and locking pins were located for stowage in the rear.

In the previous example, it was noted that the LACH trailer loading time took as long as 11½ min with an overall average time of 3 min. Adding transit time to the trailer of one min. and 1½ min to retract from the trailer and return to the LACH operating site would average 5½ min. The frontloaders demonstrated faster cycle times (average 4 min) including waiting time while standing clear of containers being landed by the ADP crane from amphibians. With two LACH vehicles each landing containers at the rate of one per 8 min, one frontloader could support the transfers to trailers with an average 4 min cycle time.

For the early phase of a bare beach operation, LACH units working in conjunction with the ADP crane offers an important alternative to the crane-on-jetty, particularly if the second 300-ton crane is committed to barge-TCDF operations. After a DeLong pier has been deployed and a 140-ton crane installed, the LACH units could provide a backup capability for the crane system.

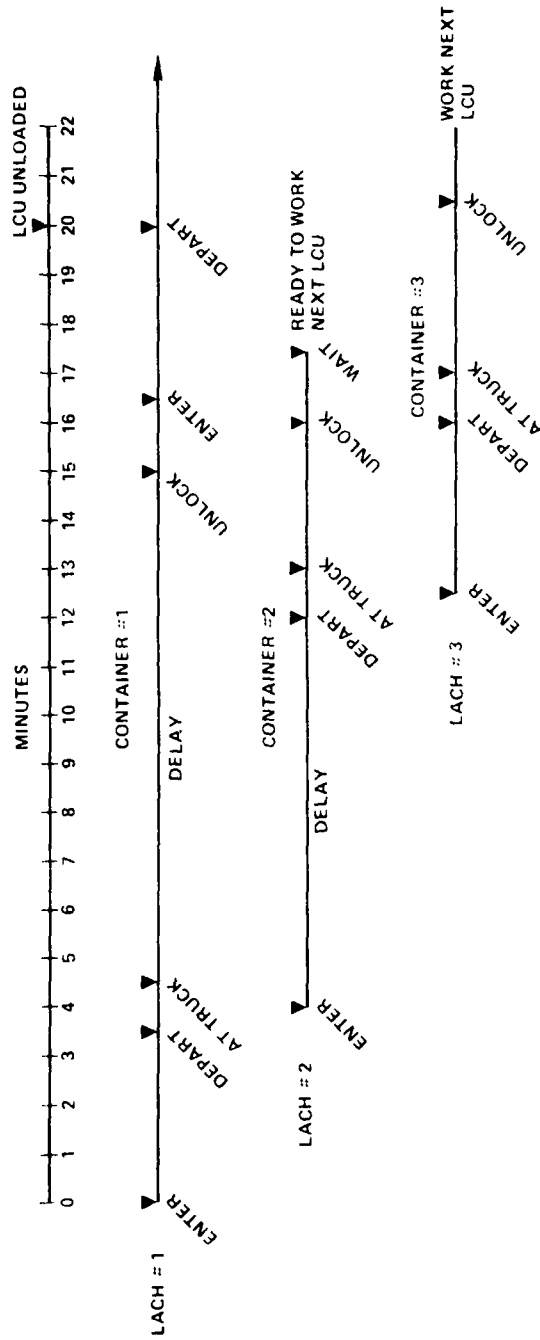


FIGURE 5.6. THREE LACH CONTAINER OPERATION, LCU TO TRUCK-TRAILER

VI. CONTAINER TRANSPORTERS AND HANDLING EQUIPMENT

SECTION SUMMARIES

Army Yard Tractor-Trailer Summary

The Ottawa Model 50 yard tractor was designed for use in modern container terminals, e.g., with unsprung chassis, two-wheel versus four-wheel drive, etc. The XM872 semi-trailer was designed for handling containers or breakbulk cargo in general highway use. The vehicles demonstrated excellent roadability on the hard surfaces, but excessive bouncing was experienced on the irregular, lightly surfaced beach roads. Nevertheless, the equipment operated surprisingly well.

A cycle from the beach to the marshaling yard averaged about 50 minutes, with much of the time (65 percent) spent in queue at the beach. The queue period suggests that there were excessive vehicles for transport. The container handling terminal service company has authorized 28 of these vehicles. The conclusion reached after additional analysis was that the number should be reduced to 22.

M-52/M-127 Tractor-Trailer Summary

The M-52/M-127 tractor-trailer combination was found to be marginally suitable as a container transporter for use until a vehicle designed for container handling is obtained by the U.S. Marine Corps. Ten tractor-trailer units plus back-up for maintenance could support a one LACH and elevated causeway operation at sustained rates; 13 plus maintenance back-ups for two LACH units and an elevated causeway.

Frontloader Beach Operations Summary

The frontloader was used as both an item of container handling equipment (on the beach and in the marshaling yard, discussed later) and a forklift. It proved to be a highly versatile and reliable piece of equipment. (Maintenance data were not available for analysis, however, no observable problems were noted.) Additional frontloaders will be added to the terminal service company's TOE as replacements for the sideloader. (Further analyses on the frontloader is contained in Section VII, which follows.)

ARMY YARD TRACTOR-TRAILER TRANSPORTER OPERATIONS

General

The yard tractor selected by the Army for the container handling terminal service company is an Ottawa Model 50 shown pulling the XM872 34-ton transporter in Figure 6.1. The general technical characteristics are given in Table 6.1.

TABLE 6.1
ARMY YARD TRACTOR-TRAILER TECHNICAL CHARACTERISTICS

Truck Tractor, Yard Type, 4 x 2.	
Curb Weight	16,440 lb
Overall Length	184.25 in.
Overall Width	97.25 in.
Overall Height	120 in.
Wheel Base	114 in.
Fifth Wheel Height	45.9 to 61.9 in.
Semitrailer, Platform Breakbulk/Container, Transporter, 34-ton, XM872	
Weight	14,000 lb
Width	96 in.
Overall Length	41 ft
Triaxle, 6 dual wheels	



U.S. ARMY
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The yard tractor is primarily intended to be used with the XM872 semitrailer with corner guides for moving loaded and retrograde containers within a fixed port terminal area. The units typically would move containers between ship and a marshaling yard up to a 5 mile radius.

The yard tractor incorporates an automatic locking, hydraulic lift fifth wheel. This feature allows a driver to couple onto a semitrailer; raise it until sufficient clearance is obtained between the semitrailer's landing legs and the ground; move the semitrailer to a new location; and then drop the semitrailer and repeat the cycle. The ability to move a semitrailer without manually retracting and extending its landing legs permits a single operator to move far more trailers within a given period of time than would be possible utilizing conventional tractors.

Operational Suitability

The yard tractor was designed for use in modern container terminals, e.g., with unitized chassis, two-wheel versus four-wheel drive, etc. The XM872 semi-trailer was designed for hauling containers or breakbulk cargo in general highway use. Throughout the exercise the roadability of the tractor-trailer combination on the hard surfaced roads was excellent but excessive bouncing was experienced on the irregular, lightly surfaced beach roads.

Even on the rough beach roads the equipment operated surprisingly well. The yard tractor had ample power for negotiating the exit road under load. As long as the drivers kept their speed down to about 5 mph or less, the vibration was not excessive. As will be shown in the analysis that follows the average speed for trucks in a port and beach environment is generally 10 mph. This allows for very slow speeds in the vicinity of a ship loading or discharge operation in a port or at a beach site combined with the local road speeds to and from a nearby marshaling area (15 to 20 mph). Computations indicate lower speeds--required to preserve the equipment and the lightly surfaced roads--would not have over committed the number of tractor units assigned to the company for the beach clearance mission.

The corner guides served their function of helping position containers in place. However, two difficulties were encountered during the test. First, when landing containers with the frontloader, the guides interfered with and were damaged by the mast of the frontloader. Repositioning the guides eliminated this problem. Secondly, the twist lock pins, which secure the container on the twist locks on the trailer bed, had a tendency to vibrate loose. A better means of securing the pins is required.

The corner guides served their function of helping position containers in place. Also, as with the locking pins on the milvan trailer chassis, some extended loading times were incurred when containers were loaded by the crane on the DeLong pier. Here again line handlers had difficulty in getting all four corners of the milvan positioned exactly over the locking pins.

From the standpoint of general suitability for LOTS operations, it is concluded that the yard tractor and XM872 transporter performed very well. The units are superior to the 5-ton tractor and M-127 trailer combinations in moving heavy loads and in general maneuverability. If the vehicles are operated at speeds appropriate to the existing road conditions, the equipment can sustain the demanding use made of it in beach clearance operations. At these lower speeds, 5 mph or less, the beach road surface can also be maintained on a daily basis with less engineering effort.

Tractor-Trailer Requirements

The second major area of evaluation concerning the yard tractor and container transporter is in terms of productivity and numbers required to support a LOTS operation.

The daily shift report provided totals on the number of vehicles committed, number of transits (one-way under load), average transit times and numbers of containers forwarded and/or retrograded. These data, however, do not provide an adequate basis for answering how many units are needed to support a given daily average throughput.

Data samples were taken from data collection sheets and reduced for analysis. Times were analyzed in Phases I and III to determine average times for each segment of a truck-trailer operating cycle: queue time awaiting turn to unload, unload time, and finally the transit time to the beach to rejoin the queue there.

Attempts to monitor trucks with containers and returning empties and isolating queue times during Phase I were abandoned due to a number of difficulties.

- The trucks passed through a number of data collector points where watches were not synchronized. Thus, in some instances, vehicles arrived in zero elapsed time or before they had departed.
- During ship discharge in Phase I there was considerable confusion among the data collectors on what vehicle number or trailer number should be recorded.
- Errors in recording container numbers compounded the difficulty of tracking vehicles by ID number through the round trip cycle.
- Also during this first phase, the beach documentation control point logged outgoing loaded tractor-trailer units but did not log the returning empty vehicles. This omission eliminated the possibility of isolating return transit time from beach queue time.

By Phase III the above problem areas were corrected to the extent that large samples of reasonably accurate time segments could be analyzed.

In the first analysis of total transit time the data from day one, shift one of Phase I(R) were used. This period was taken since it represented a peak throughput period during which time maximum truck transport requirements were generated.

The results of the analysis are set forth in Table 6.2.

TABLE 6.2
AVERAGE ARMY TRACTOR-TRAILER OPERATING CYCLE

Shift 1, Day 1, Phase I(R)	
Cycle Segment	Time (Minutes)
Beach Queue	32.8
Loading Time	1.4
Documentation Time	2.4
Transit Time (round trip)	8.5
Marshaling Yard Queue Time	1.9
Unload Time	2.8
TOTAL	49.8
Less Beach Queue Time	17.0

Some interesting observations can be made from these preliminary test results. First, the short queue time in the marshaling yard indicates the ability of the frontloader operators to off-load the trailers almost as rapidly as the trucks arrived from the beach. At the same time the lack of some delay for checking vehicles in, handling some form of documentation for control and cargo accounting may indicate that such controls were not fully exercised. (See discussion on documentation and related matters in the next section.)

The loading and unloading times should be approximately equal and it is suspected that the unload time includes some time which should be charged to marshaling yard queue. That is, it was the time beginning with the arrival at the unloading site rather than the time indicated as "ready to unload," a difference of about a minute on average.

The time interval between vehicle arrival at and departure from the Beach Documentation Control Point (BDGP) was charged to documentation time (about 2½ min.). Again, considering normal port cargo security and accounting practices, this is a minimum check out time.

The average waiting time at the beach of 32.8 min. suggests more transport units were committed than were required to support the operation. Even during peak surges there were vehicles available in the queue. The queue time is an indicator of some excess in vehicles but does not answer the question of how much is enough.

A review of the unit TOE does not provide a good answer. The rationale for the 28 tractor-trailer units in the TOE was based on supporting four container cranes in a fixed terminal operation with a daily average throughput rate of 720 containers per day. In a LOTS operation only two cranes at the ship and two at the shore provide for the total container throughput. The truck requirement is not halved, however, due to other operating differences between fixed port and LOTS operations. In general, the more than twice the container throughput capability of four cranes in a fixed port situation is offset by the distance to a marshaling yard and container rehandlings. Thus, the rationale for the TOE of the company cannot be directly applied to the LOTS situation.

In seeking an answer to the question of how many trucks is enough, a basis for an adequate queue is required. Having a few trucks more than is required for an average throughput is a small cost compared to not having enough trucks to avoid delaying the cranes. Whenever crane time is lost, it directly reduces the container flow through the LOTS system -- it is time that is lost and cannot be made up. Thus, in the computations that follow, an allowance for a queue to cover variations in crane operating cycles is added to the total vehicle requirement.¹

Another important consideration in the computation of vehicle requirements is to examine typical operating conditions as compared to the test situation at Ft. Story. Time for documentation and security checks at the beach exit and marshaling yard entrance points have been noted as being less than normally required. More importantly, the average round trip times are too fast to represent a typical case in an area of mixed local traffic.

In Phase I(R) test samples the average round trip time from Table 6.2 for the 2.5 mile distance equates to about 18 mph. Since this result was well above the expected average of 10 to 15 mph, a second sample was taken for analysis. With only a few extreme times eliminated, an average of 68 round trip times was found to be 11½ min. These data were taken only at the BDCP so that watch synchronization deficiencies would not be involved. However, this round trip time includes the unloading time. The latter taken as 2½ min. results in an average transit time to and from the beach of 9 min. This result compares so closely with the Phase I(R) (8½ min.) as to be considered the same. In the calculations used below, road speeds more typical of average port and beach clearance operations were used.

¹ For the basis of adding 15 percent to vehicle requirements see ORC Technical Memorandum ORC-T-361, Analysis of Means for Moving Logistic Cargo from Ship-to-Shore (U), November 1957.

Vehicle requirements are especially sensitive to distance and average road speed when, as in the case of container operations, the loading and unloading times are so short. Three round trip distances were selected which demonstrate this sensitivity: 3, 6, and 10 miles respectively.

For computing truck-trailer requirements for LOTS operations on a more universal basis, the following factors were used:

For all distances, 20-hr working day:

Documentation/Security-Safety Checks	5 min.
Average Loading Time ²	5 min.
Average Unloading Time ²	5 min.
Average Vehicle Availability	75 percent
Queue Allowance	15 percent

For various round trip distances from the beach to the marshaling yard average speeds were used as follows: 3 miles - 10 mph; 6 miles - 12.5 mph, 10 miles - 15 mph.

Using the above factors, Table 6.3 shows the number of truck-trailer units required to support an average workload of 300 containers per day.

TABLE 6.3
TRACTOR-TRAILER REQUIREMENTS²

Round Trip Distance (Miles)	3	6	10
Number of Vehicles for 300 Containers	8	11	14
15 Percent for Queue	1	2	2
75 Percent of Vehicle Availability	3	4	6
Total Transport Required	12	17	22

Since the LOTS test the primary mission of the terminal service company has been changed to performing LOTS operations versus fixed port operations, the latter now being secondary. With this in mind, a review of total tractor-trailer requirements for the TOE is in order.

² All values rounded to nearest whole unit.

From the foregoing analysis it is seen that the present unit authorization of 28 for fixed terminal operations exceeds what could be considered maximum requirements (5 miles being an outside limit from the beach to a suitable site for a temporary container holding area). Since a LOTS operation is temporary in nature, that is, a transition to improved beach/fixed type terminal operations is made as rapidly as possible, consideration should be given to providing for truck augmentation as the mission situation changes. In the past this has been done with teams which can be used as building blocks to tailor the basic unit to a particular mission requirement.

The conclusion reached in this analysis is that the Army, in reposturing the container handling company for LOTS operations, should reduce the authorization for truck tractors, yard type and trailer transporters by 6 to a total of 22.

M-52/M-127 TRACTOR-TRAILER OPERATIONS

Suitability for Container Operations

The load location of the milvan well to the rear of the M-127 trailer aggravated the high center of gravity but more importantly tended to unload the fifth wheel. This condition induced a tending of the tractor-trailer combination to jackknife and one overturned while rounding a curve.

Some of the fully loaded containers placed an excessive load on the trailers. The M-127 trailer is normally rated for 12 tons with an overload of 50 percent (total 18 tons) for highway use. A milvan with dense cargo such as ammunition can weight 22.5 tons. By shifting the load further forward, with careful handling and operating at low speeds, the M-52/M-127 units can be safely operated.

The M-52 tractor and modified M-127 trailer negotiated the elevated causeway and its turntable without difficulty. As an interim vehicle, with the limitations noted, the M-127 is marginally satisfactory as a container transporter in an expeditionary environment.

Determining Tractor-Trailer Requirements

The elements for beach queue and loading were difficult to determine due to poor synchronization of watches among some of the data collectors. However, by establishing an arbitrary minimum desirable queue time with actual load, unload, and transit times for the two beach off-load systems, truck cycles can be computed to serve as a basis for estimating transport requirements. Tables 6.4 and 6.5 provide the inputs for calculating the requirements.

TABLE 6.4
M-52/M-127 CYCLE TIME - LACH TO LSA AND RETURN

Element	Queue*	Loading Time	Beach to LSA	LSA Queue	LSA Unloading	LSA to Beach	Total (Min.)
Time (Min.)	3.8	5	4.0	3.0	3.0	6.5	25.30
* Minimum Queue of 15%							

TABLE 6.5
M-52/M-127 CYCLE TIME - ELEVATED CAUSEWAY TO LSA AND RETURN

Element	Beach Queue*	Causeway Transit/Load	Beach to LSA	LSA Queue	LSA Unloading	LSA to Beach	Total (Min.)
Time (Min.)	5.4	13.9	4.0	3.0	3.0	6.5	35.8
* 15% of Total Time							

An analysis of actual cycles in the test indicates that beach queues averaged 21 to 31 minutes for the LACH and elevated causeway respectively. Nevertheless, there were some infrequent delays. The LACH spent only 2.3 percent of its time awaiting trucks. The elevated causeway experienced no truck delay during the first day of Phase II, but did have a 12.5 percent truck delay (primarily due to road closure following a truck accident) during the day shift of the second day of Phase II and a 5.6 percent delay during the day shift of the third day.

The above cycles were constructed to estimate the number of M-52/M-127s required to support simultaneous LACH and elevated causeway sustained operations. For the LACH the average loading times taken were the sum of the average times to position over the trailer, LACH to move clear, and the truck to depart (5 min.). A 15 percent minimum queue is added. The number of vehicles to support the LACH operation with its average cycle of 11 min. is 2.30 in a 20-hour work day. Similarly, for the elevated causeway, to support average peak crane cycle rate of 5 to 6 min. (220 containers per day), 6.6 tractor-trailer units would be required. The combined requirement is 10 tractor-trailers plus an appropriate maintenance afloat. For a 2-LACH site, an additional three tractor-trailer units would be required.

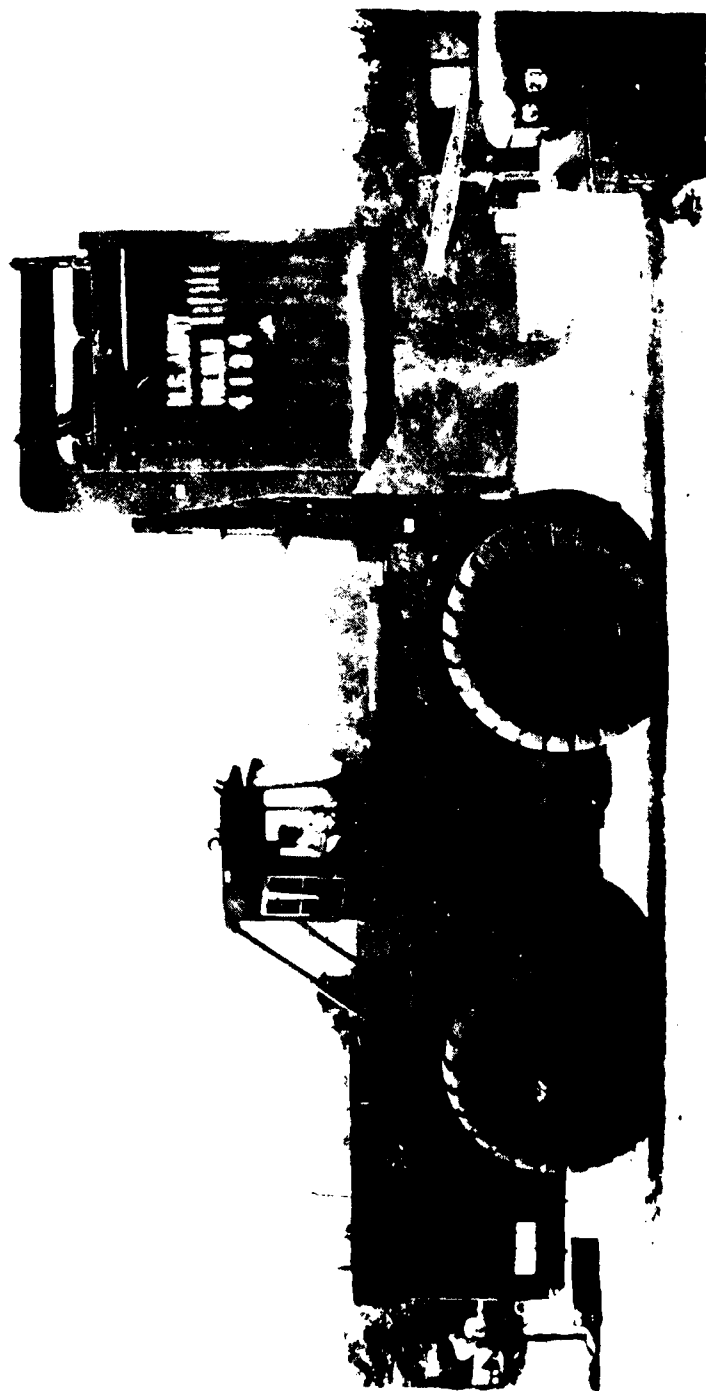


FIGURE 6.2 CLARK 475B 50K FRONTLOADER

CONTAINER MHE

Frontloader

Suitability for LOTS Operations. For the most part the Clark 475B 50K frontloader (see Figure 6.2) proved to be an exceptional vehicle. Its 37 inches wide tires and articulated steering clearly demonstrated excellent maneuverability in a LOTS environment while under load. The vehicle did require that containers be on a reasonably level surface for pickup and on occasion when the 300-ton crane failed to accomplish this, then a failure to engage the tophandler would be experienced. The crane would then re-position the container and the frontloader could clear it. However, this situation was infrequent.

Shortfalls of the frontloader used in the LOTS test are that it is not rated to lift containers weighing more than 25 tons and is not readily suited to off-load containers from landing craft, although this was accomplished during the test. Some 40-ft containers were handled on the beach but required more time than the 20-ft containers. A manufacturer's representative has stated that the frontloader's lifting capacity can be upgraded but would increase its overall weight.

The frontloader has a tophandler clearance of 216 in (18 ft) at maximum lift from the bottom of its container locking lugs but in lifting a container this clearance is reduced to 10 ft. Because containers must be stowed athwartship, the frontloader is not suitable for off-loading newer class LCUs. In any event, the frontloader is relatively unstable when lifting loaded containers at the height necessary to clear the bow of a 1466-class LCU.

The frontloader has a capability to ford 60 in of water. During the test fording was required only once. A container was dropped in the surf near the 300-ton crane. In order to retrieve it a frontloader was used, retrieving the container from about 2 ft of water.

To support the LOTS test six frontloaders were used, three on the beach and three in the marshaling yard. The marshaling yard also used side-loaders (in hard surface areas) but except for that there were no back-ups. A 25 percent back-up capability, two additional frontloaders, are needed by the terminal service (container) company. (Additional analysis on the frontloader's use there is contained in the section which follows. The analysis concludes that nine frontloaders are required per company.)

The frontloader was also used with forklift tines early in the operation to assist in the assembly of the beach cranes. In that capacity it helped with the assembly of crane counterweights and positioning of the timber mats used as temporary roadways for the cranes.

(Employment with the cranes transferring containers has been discussed in Section V. For discussion of frontloaders use in the marshaling yard, see Section VII which follows.)

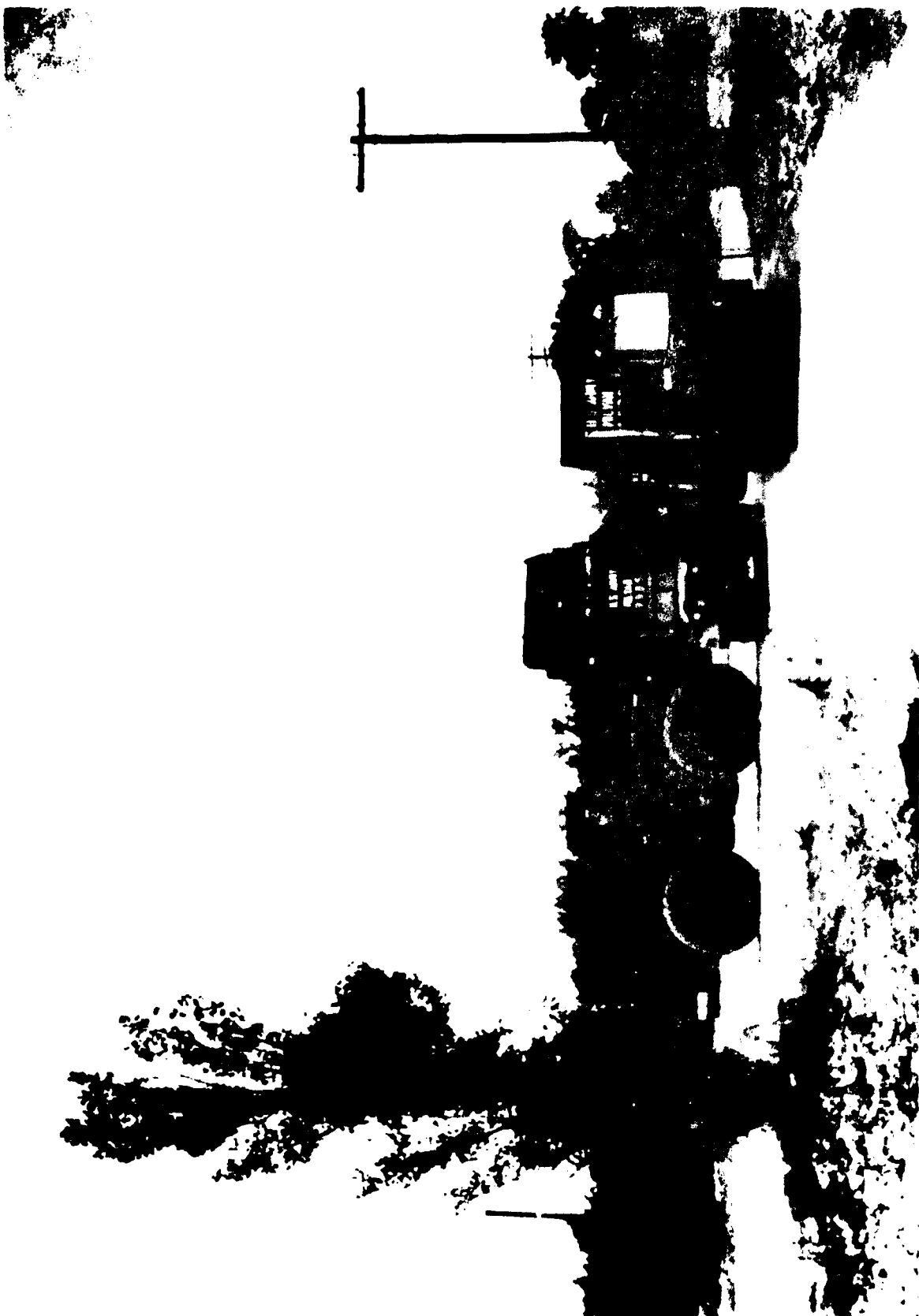


FIGURE 6.2 CLARK 475P 50K FRONTLOADER

VII. MARSHALING YARD/LSA OPERATIONS

SECTION SUMMARIES

Frontloader Summary

Frontloader cycles averaged from 5.8 to 9.3 min, depending upon whether day or night operations were being conducted. In a 20-hr day, each frontloader averaged about 158 transfers. Based upon a requirement of about 1,200 transfers per day (2-company operation, 300 containers inbound and 300 export plus transshipment requirements) and frontloader maintenance requirements, nine frontloaders per company are needed to support both beach and marshaling yard activities.

Documentation, Cargo Management Summary

A capability for producing timely documentation and management information assisted by automated procedures should be provided the LOTS terminal unit. In a container oriented logistic system either in a fixed port or bare beach situation the sheer volume of cargo handled in a day will overwhelm a manual system.

The RPF upgraded to a "stand alone terminal" is needed to support a quick reaction force and should have:

- An adequate communications link
- A small computer and software package to include quick reaction status reporting
- Adequately trained personnel to operate and maintain the system.

The mobile RPF as equipped and operated during the test had a number of serious limitations. It was, however, an important demonstration of data processing needs and potential support capabilities. The Army should continue to support the development and early acquisition of the improved mobile system.

LSA Summary

The following actions are considered necessary for the Marine Corps to acquire a capability for handling containers in LSA operations:

- R&D and acquisition of container MHE and transport appropriate for USMC amphibious operational requirements
- Completion of USMC doctrine and SOPs for container operations in the amphibious environment
- Exercise testing of candidate items of equipment and procedures when available for this purpose.

MARSHALING YARD OPERATIONS

General

The description of marshaling yard operations, area layout and workload experienced during the test are given in Volume I. In this section, an analysis is made of MHE requirements for marshaling yard operations in a general situation. It is recognized that the workload data generated during the LOTS test do not reflect full scale marshaling yard operations. This is because not all functions of a normal marshaling yard operation were fully exercised as outlined below.

The marshaling yard permits the use of time and space to process shipments for movement to destination consignees. Although selected shipments can be expedited for movement directly from the beach to consignee, the majority of shipments are processed in the marshaling yard freeing the beach area from possible congestion and resultant slowing of ship discharge. The normal functions of a marshaling yard are set forth in FM 55-70.¹ A partial listing is as follows:

- Forward Movement:
 - Segregation of containers by
 - Size,
 - Type,

¹ U.S. Army, Army Transportation Container Operations, with Change 2.
2 May 1977.

- Destination, and
- Special handling requirements (mail, security cargo, etc.).
- Retrograde:
 - Segregation of containers (filled containers stacked separately from empties) by:
 - Size, and
 - Type

Additionally, provision must be made for inventorying containers by location, accomplishing cargo documentation, and movement control, cleaning of containers prior to backloading, inspection of containers and chassis, and minor repair of damaged containers.

Basis for Frontloader Requirements

The layout of the marshaling yard used in the LOTS test provided areas for the functions enumerated above. However, not all of the functions were fully accomplished. For example:

- Detailed security and vehicle/container/chassis inspections were not continuously performed. Damaged containers and equipment were set aside for detailed survey after the test was completed.
- Only minimum segregation of cargo (light vs. heavy containers) was required.
- Only about 75 containers, as planned, were selected for daily movement to and from consignees as opposed to a total balanced import-retrograde operation.

Although the test conditions do not permit the direct translation of test results for the determination of equipment requirements, the data generated can be used (e.g., frontloader and truck transport operating data) to construct a work flow schematic of a general LOTS situation. This, in turn, provides a basis for estimating container MHE requirements.

Since the LOTS test the sideloader has been dropped from the Army Terminal Service Company TOE. The frontloader will be used to handle the total workload in both a LOTS situation or operations in a fixed terminal.

As described in Volume I, Phase I marshaling yard operations, cargo management, documentation and movement control functions were performed under particularly difficult circumstances. By Phase III many of the difficulties had been overcome and the frontloader data during the import part of that

phase approximates normal container transfer rates. These data plus allowances for frontloader support of all tasks normal to marshaling yard operations were used in the analysis that follows. The results obtained, of course, apply to the general situation depicted. The availability of suitable space, adequacy of supporting transport and road net among other factors directly impact upon equipment and personnel requirements. For example, separation of operations into a number of small, non-contiguous areas due to terrain limitations would increase supervisory, equipment operator, documentation personnel and container MHE requirements.

The schematic used for the analysis was modeled on the basis of the organization and area layout used in the test. The workload is stated in terms of the number of container handlings per day associated with a given total average throughput rate. For the case analyzed, it was assumed that:

- The marshaling yard under battalion control is supporting a two (2) container handling terminal service company operation.
- Operations have been underway long enough that retrograde containers are being returned at a rate equal to imported containers (an "average" peak workload condition).
- The daily container handling rate of the two terminal service companies periodically totals 600 containers per day (in and out).
- Breakbulk operations are being conducted by a third terminal service company and breakbulk cargo is being marshaled in an area separate from the container yard.

The 600 containers per day rate was chosen as the peak workload that must be handled in order for an average of 530 containers per day for two companies to be achieved on a sustained basis.

The layout of a representative marshaling yard is depicted in Figure 7.1. For each processing function an estimate of the total daily forward and retrograde movement is as indicated.

The total input to the marshaling yard is 300 containers per day (150 per company) matched by the retrograde of 300 containers to the beach. At the vehicle control point cargo is checked in, a storage location assigned and the driver directed to an unloading point. Of the 300 inbound containers a small percentage of them (5 percent assumed) are segregated for unstuffing for movement to an airfield for intra-theater air movement and another 5 percent for movement to a breakbulk point for local consumption. An additional 5 percent are assumed for movement to the security yard for holding until moved by line haul transport. The balance (255) are segregated by consignee and processor for movement by line haul transport. The reverse flow of 270 from line haul (255 + 15) and 30 containers from local transport are checked in, inspected

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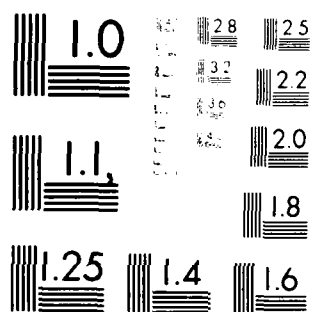
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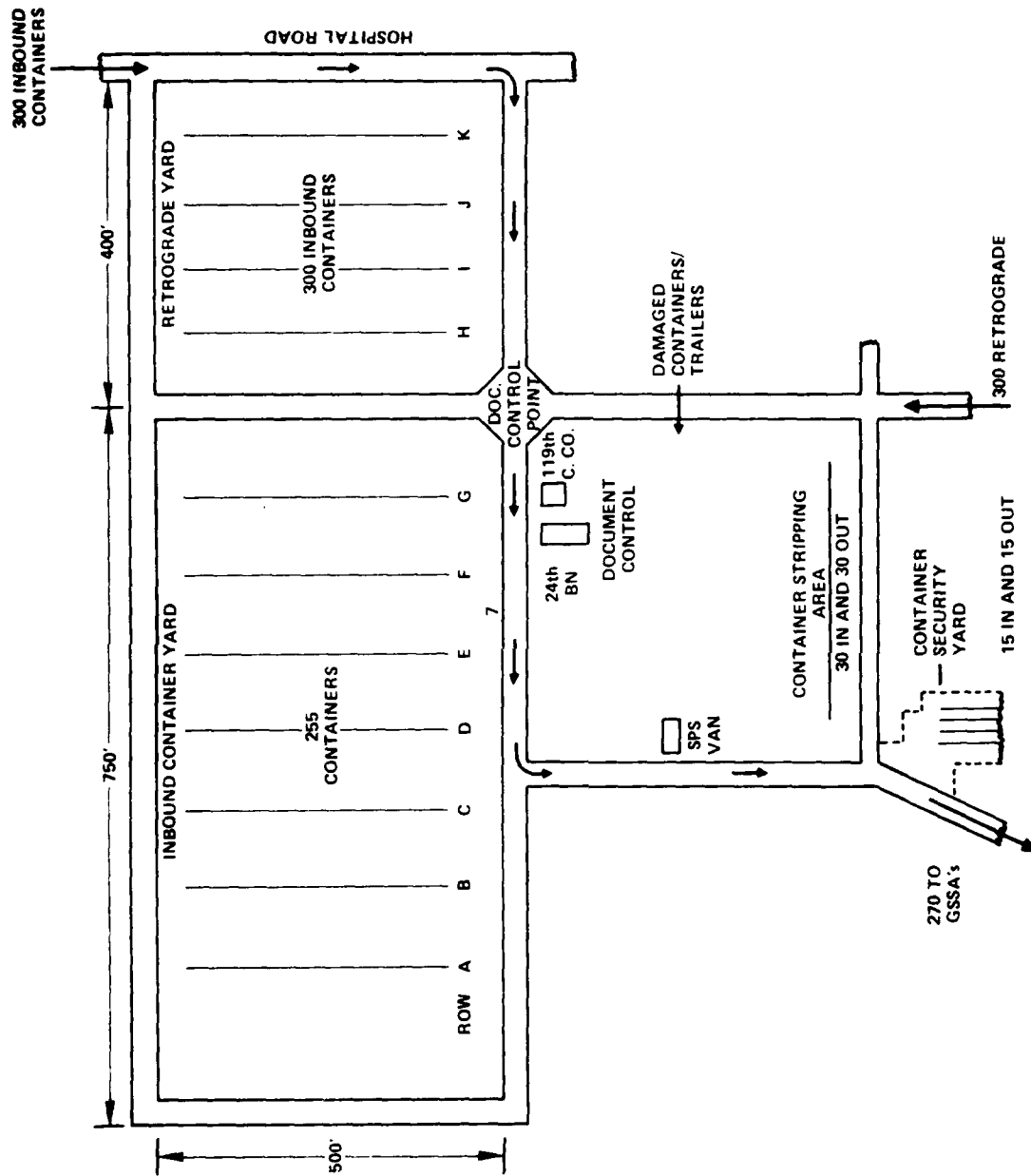


FIGURE 7.1. ARMY MARSHALING YARD OPERATIONS

for damage and stacked in the retrograde area. Based upon this workload flow, an analysis of frontloader operations was made in order to estimate the number of units required to support the throughput operations.

First, the day shift off-loading operations of Phase III were examined for average frontloader operating cycles (Figure 7.2). The data collection sheets were used to note any unusual delays. The most common delays associated with off-loading trucks and stacking containers were in positioning and locking onto containers. For backloading by trucks there were some additional delays associated with searching for the correct container which had been selected for shipment to the GSSA. These normal delays were included. Some longer delays were due to reduced throughput activity, awaiting trucks. Not all long delays attributable to waiting for trucks, however, were noted on data collection sheets. Thus, a cut-off point had to be selected. An examination of the raw data sheets revealed that the longest time in unloading a truck to landing a milvan in the stacking area was 11 min. The delay indicated was "Don't know where to put the milvan." The average transit time (load clear to begin position) was just under a minute. Thus, the cut-off at 12 min. for cycles including normal operational delays appears reasonable. With a cut-off at 12 min., there are 235 cycle times in the sample with an average of 5.83 min., a median time of 5.93, and a sigma of 2.63 min. Note that the average of $5.83 + 3\sigma$ equals 11.46, very close to the selected cut-off value as would be expected in a near normal distribution.²

A similar analysis was made of the 16 August night shift frontloader data. The frequency distribution shown (Figure 7.3) reflects the longer times due to operating under conditions of reduced lighting. The most frequent time was eight minutes versus 4 min. during shift 1. Again, a cut-off time was selected based on an examination of the data. The data becomes discontinuous after a zero frequency at 22 min. With this cut-off point the average cycle time is 9.34 min.

In arriving at total frontloader requirements, a composite factor was needed to apply to the total daily workload. As noted in the container operations at shipside, the average for the night shifts was slower (by about 35 percent) than the day shift. The average frontloader cycles in Phase III night shift was 9.34 min.; 38 percent slower than the average of 5.83 min. for the day shift. Thus, the same result would be obtained for numbers of frontloaders required if the heavier day workload was divided by the faster frontloader cycle and the slower night shift container workload was divided by the slower average cycle. For the total workload combined factor, the average for the two rates of 7.6 min. was used.

With operations conducted during a 20-hr day (1200 min.), each frontloader handles an average of 158 containers per day ($1200/7.6$). The marshaling yard container transfer operations can be summarized as follows:

² It can also be demonstrated that the average includes about 2 min. delay (queue) for trucks ($5.83 - 3.67$ unload trucks to stack and return).

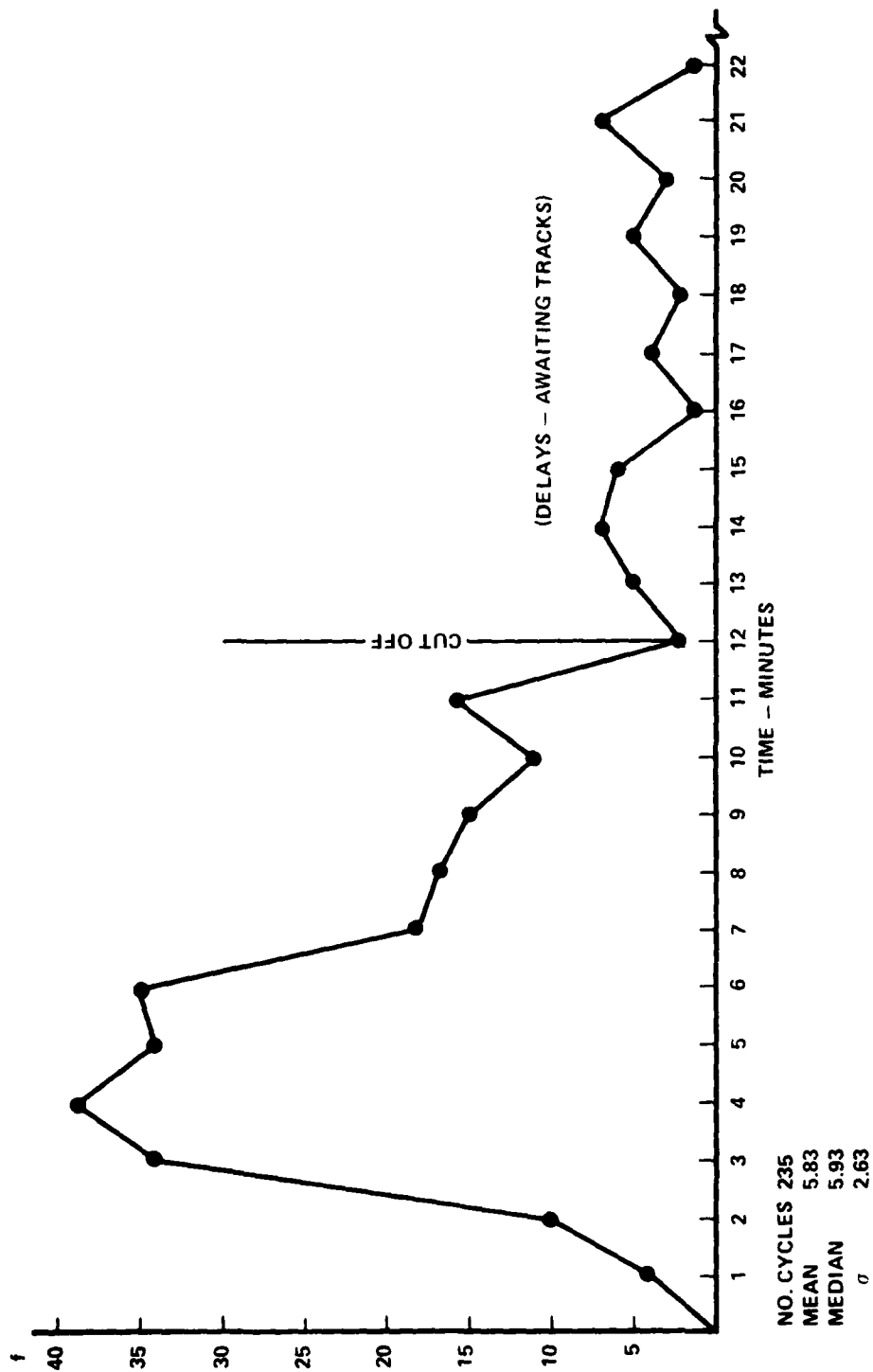
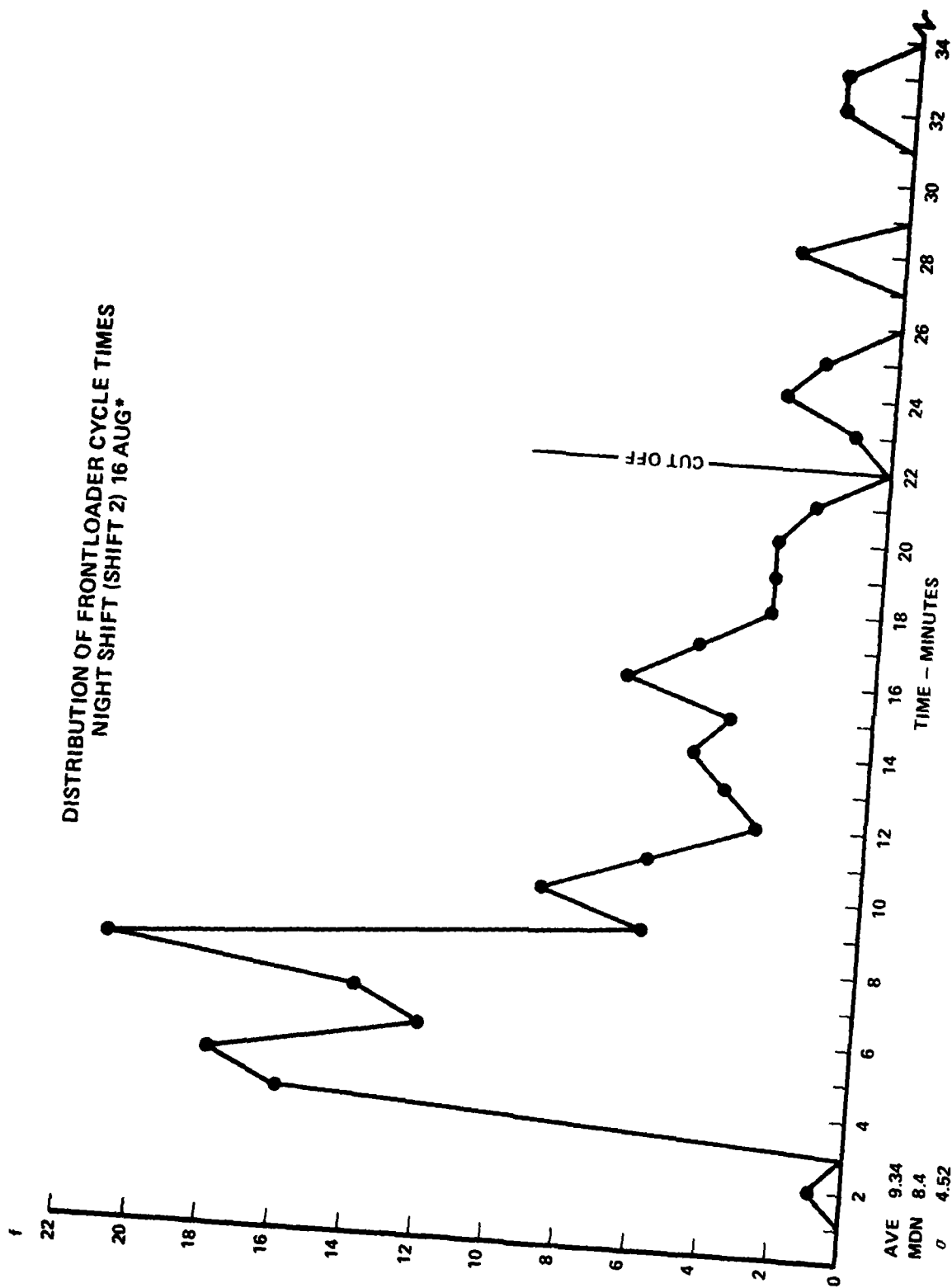


FIGURE 7.2. DISTRIBUTION OF FRONTLOADER CYCLE TIMES DAY SHIFTS, 16 and 17 AUGUST



*SHIFT 2, 17 AUG. WAS ONLY A PARTIAL SHIFT OF MARSHALING YARD OPERATIONS

Figure 7.3. DISTRIBUTION OF FRONTLOADER CYCLE TIMES
NIGHT SHIFT (SHIFT 2) 16 AUG*

FORWARD CONTAINERS

<u>NO. HANDLINGS</u>	<u>TRANSFER OPERATION</u>
285	Unload trucks from the beach
30 (15 in, 15 out)	Movements to/from security area
30	Load on trucks to breakbulk points (intra-theater air and local consumption)
270	Load to line haul trucks to consignee.
<u>615</u>	

RETROGRADE

<u>NO. HANDLINGS</u>	<u>OPERATION</u>
300	Unload empties and containers with retrograde cargo from local and line haul transport
300	Backload to terminal trucks (to beach).
<u>600</u>	

TOTALS: $1215 \div 158 = 8$ frontloaders

+ 1 for misc. movements, restacking, and
operational backup

9

Maintenance require-
ment 3 ($9 \div 75$)

TOTAL 12

For determination of total frontloader requirements, three are needed for each company on the beach to assist in container transfer operations: one at each crane site and one sorting containers to expedite backloading of containers in the right sequence and to serve as backup for the two frontloaders. Total recommended for the two companies is 18 (12 plus 6) or 9 per company TOE.

The results of the foregoing analysis is not absolute. Data from longer experience performing all necessary operations would be required. The results are a best estimate based on the data available. They are considered reasonable, assuming good organization and development of effective operating procedures. The averages used provide for wide fluctuations normal to such an operation including an overlap in cycles with truck arrivals.

DOCUMENTATION, CARGO MANAGEMENT

General

In Volume I the basic concept of employing a Digital Subscriber Terminal Equipment (DSTE) communication center network for transmission of mechanized reports printed at a Remote Process Facility (RPF), was described. The RPF will prepare formatted transportation reports generated from the Corp Support Command or any other supporting computer base. The following major areas are covered in this preliminary evaluation.

- Deployability and suitability in a LOTS environment.
- Responsiveness and adequacy of the system to documentation requirements.

Deployment

The mobile DSTE normally used to support a LOTS contingency was committed to another mission and, therefore, a fixed DSTE was installed at Ft. Story. All of the equipment required for the remote processing facility (RPF) is contained in an ISO standard milvan, refrigeration model. The van may remain mounted on a milvan trailer chassis or placed on the ground for normal operations. The van can be loaded on any conventional breakbulk ship or handled as a 20-ft container in a containership. For transport to the beach it can be brought to the shore by any of the lighters used in this test. On the beach the van can be moved by frontend loader to a position where it can be used to best support terminal documentation and reporting requirements. This is normally in the immediate vicinity of the container temporary holding area (marshaling yard) or on the beach adjacent to command and control elements.

In the test the RPF was moved by highway from Ft. Eustis to the marshaling yard at Ft. Story to allow for maximum training time in preparing documentation. The ability of the unit to withstand movement and emplacement in a beach environment had been tested in the heavy-lift breakbulk ship preliminary field test conducted in November 1976. It was not embarked, however.

Responsiveness and Adequacy of the System

The RPF as presently equipped completed its longest runs in about 2 hr. With timely receipt of manifest data, the RPF can easily meet the requirements for advance preparation of tallies, cargo disposition instructions and transportation control movement documents (TCMD) for port clearance. With the longest processing cycle time taking about 2 hr the RPF can handle a multi-

ple ship discharge workload of a terminal battalion. If manifest data is delayed, lost, or garbled in transmission as happened in the beginning of this test, delay in documentation preparation must be expected. Some cargo will have to be held at the marshaling yard until the TCMDs can be completed. In the test in spite of the incomplete data, containers were moved without delay to the marshaling area. Thus, the beach area was kept fluid and unchoked while the documentation problems were being sorted out.

In an actual situation overseas the terminal would have worked with the estimated 60 percent complete manifest data to clear as many containers as possible through to destination without delay. In the test only 75 containers were required, as per test plan, to be moved to the GSSAs. To that extent the TCMD workload was less than normal.

To reconstitute the missing manifest data the terminal would normally use the ocean manifest arriving with the ship. In a worst case of no manifest aboard ship the terminal would have had the slow job of preparing TCMDs from the packing lists taken from each of the remainder, in this case about 240 containers. This action would also require the recording of seal changes on the shipping documents.

As noted in Volume I, the manifest data arrived late due to the short one-day sail time of the ship. This denied the terminal time normally available to request and receive a corrected manifest from Eastern Area Military Traffic Management Command (EAMTMC). Additionally, the late receipt of the incomplete manifest gave the documentation team minimum time to prepare documents manually and not delay container operations.

During Phase I and II the incomplete manifest was reconstituted from information available from preplanning the test shipments with EAMTMC. This documentation simulated the data that would have been available in a manifest from the vessel.

When the RFP was fully operational at the beginning of Phase III, it was meeting all advance documentation preparation requirements and status reports were being up-dated about 1 hr behind container movement cyclic cut-offs. These reports provided end of shift status on:

- Number of containers remaining aboard ship.
- Number of containers on hand in the marshaling yard.
- Number of containers shipped to consignees.

In each case the ID number of the containers was given. The status reports were not used by the battalion staff since they were not adequate for detailed monitoring of the progress of container operations. Status reports manually prepared during the test consisted of periodic reports based on discharge tally information. This field expedient was employed to provide additional management information not programmed nor a part of the planned RFP mission for the test.

These manual reports provided data on:

- Vessel discharge operations
 - Number of containers discharged by each crane type (TCDF and COD)
- Lighterage and beach discharge operations
 - Containers landed by type lighter
 - Containers unloaded by crane type (jetty, amphibian discharge, DeLong pier)
- Marshaling yard operations
 - Containers received
 - Containers offered for movement to GSSA's
 - Containers shipped to GSSA's
 - Containers received from GSSA's
 - Containers retrograded to beach.

This data combined with other information on equipment assets gave the battalion operations personnel a better picture of utilization and productivity of cranes and lighters, the key to improving container throughput. However, some of the data collected for measurement of crane, lighterage, etc., operations is not normally collected by the cargo accounting teams. This additional workload at times took precedence over the normal duties of the cargo accounting teams.

A second factor was timeliness of the reports. As the test progressed, reliance on the manual reporting system grew. Spot reports by radio and telephone provided progress information the historical reports could not. Since the two status reports did not always agree -- for example, the number of containers remaining on board ship -- the battalion staff was reluctant to use the RPF produced status reports.

New RPF system hardware and software are planned to include a mini computer providing a stand alone data processing capability. The experience

gained in container operations in the LOTS test has helped to promote the development of the improved system.

Visibility of Intransit Cargo

During the test the question was raised concerning the capability of the mobile RPF to provide visibility of all items in a given container. The response was properly made that such detailed information was not needed at the terminal.

The basic things a terminal operator must know are:

- Weight and cube of cargo (in the LOTS test correct weights were urgently needed for planning the back load of the containership and for LACV-30 operations.)
- Commodities requiring special handling, e.g., heavy lifts.
- Presence of hazardous, dangerous, sensitive, and/or classified cargo.
- Priorities and required delivery dates (RDD).
- Consignee.
- Transportation control number (TCN) associated with the shipping unit (one per container).
- Status reports (containers awaiting discharge, discharged, shipped, on hand, in transit, etc.).

With this data the terminal commander can plan for the discharge and safe handling of the cargo, provide for all necessary safeguards, comply with host nation customs and other safety and special handling requirements, arrange with movement control personnel for port clearance by appropriate mode and account for the cargo received, on hand, and shipped as reconciled with each ocean manifest. Note that this does not imply that he has a detailed listing of cargo in each container as it would be itemized by federal stock number. The commodity codes as listed in MILSTAMP satisfy his needs.

To match requisition numbers with TCNs requires an extensive logistics intelligence file in a theater of operations. At the present time, shipments can be traced by query to CONUS to track shipments from origin through each node in the transportation system. The objection to this process is that it is frequently too slow to provide for timely theater action to cancel, divert, or hold shipments enroute.

Current plans are to provide the Corps Support Command Material Management Center with the capability of maintaining current status of supplies on order and being shipped. Even though the capability may not be in hand for

some time, it doesn't appear sound to expand the terminal documentation processing capability to such a point that it becomes, in effect, a large in-transit supply depot rather than a transfer point for supplies from one mode to another. The concentration of effort to develop that capability should remain focused on the Corps Support Command (COSCOM).

The data reproduced for cargo accounting and movement control at the marshaling yard was adequate for the limited information needed. The additional management information for operational decisions may be produced with some enhancement of the current system now under development. Caution should be exercised in expanding the level of detail in the present RPF MILSTAMP output. An entire manifest can be expended from a few pages--a single line per container--to a document several inches thick in order to identify all items in each container.

Post Exercise Documentation

At the conclusion of the exercise the cargo accounting team was given the mission of producing the required documentation to return the containerized cargo to the proper consignees. TCMD's for military line haul were prepared for containers consigned to Ft. Eustis and the Richmond Depot. Also, a manifest was prepared by the team for the installation transportation officer who then prepared commercial government bills of lading (GBL's). All containers were properly identified with no loss of any cargo used during the test.

LOGISTIC SUPPORT AREA (LSA) OPERATIONS

General

Control procedures, an adequate number of tractor-trailers, and Army MHE augmentation enabled the handling of throughput rates of containers to the LSA with minimal delays. The maximum throughput rate occurred on day two, Phase II, when 202 containers were received at the LSA. The highest hourly rate of 15 containers occurred between 1400 and 1800 hr on that day, with an overall average of 13.5 containers per hour for the period. Queuing at documentation control averaged only 3.1 min. per tractor-trailer during the same peak period.

The above LSA workload, however, could not have been sustained using only USMC equipment, as discussed below.

Container MHE

An examination of the Drott crane operating unassisted by other MHE is somewhat hypothetical in that it handled only a limited number of containers in only one of five stowage rows in the LSA. However, insights to certain problem areas are possible through such an examination.

Since the Drott crane is unable to transport loaded containers across the LSA to stowage positions, the original concept of using Momat covered interior roads for tractor-trailers with containers to reach each stowage row was sound. However, since containers were stowed by weight as commodity groups, it would have been necessary for two Drott cranes to shuttle back and forth between the five rows with a third acting as a spare. This would have lengthened the average operating cycle to seven or more minutes resulting in off-loading delays and longer truck queues in the LSA. The net result would have been a much lower daily throughput. It is concluded that with the limited assets assigned to the main test, the Marine Corps could not have supported the desired daily throughput rates without equipment and personnel augmentation provided by the U.S. Army.

As noted in Volume I, the Drott crane was seriously limited in handling containers weighing over 21 short tons under sustained operating conditions. An alternative is the LACH when production models become available. However, the Terex tractor that pushed and towed the LACH in the test would be destructive to Momat roads in the LSA. The USMC MRS-100 wheeled tractor might prove to be a suitable prime mover for this purpose.

Of all the container MHE used in the test, the Army frontloader was the most effective in rapid movement, fast loading/unloading of vehicles and handling containers in the LSA. Additional advantages were its space saving two-high stacking capability. It is understood the Army is seeking a lighter, less expensive model which the USMC may wish to consider for use in the LSA and on the beach.

Management

Accuracy of recorded stowage locations of containers in the LSA was tested during day two, Phase II. The actual location of 86 containers in the LSA was compared to locations listed by documentation control. The following discrepancies were noted:

- Two containers actually in the LSA were not listed by documentation control.
- One container listed by documentation control was not present.
- Two containers intended for transshipment to the Army were inadvertently stored in the USMC LSA.
- One container destined for the USMC LSA was inadvertently shipped to the Army.
- One 23-ton container was stored in the 10-13 ton row "C" instead of the 18-23 ton row "A."

Overall the above check disclosed a 9 percent error rate in stowage locations. All documentation was manually performed and appeared to be set up in response to known requirements. Container movements, not usually associated with amphibious operations, such as transshipments to Army control, were documented with minimal information. This information was in expectation of potential future audit trails and not in response to any operational procedure. Container SOPs for LSA operations have not been fully developed and published. Some containers were moved without complete movement documentation.

Night Operations

The two field lighting sets initially available during Phase II were insufficient for purposes of security, safety, and maintaining accuracy in documentation and stowage locations. The situation was improved later in Phase II by augmentation with Army lighting equipment.

VIII. PROPOSED OPERATING TECHNIQUES AND EQUIPMENT CHANGES

GENERAL

This section sets forth proposed changes to the operational procedures used by the Services when conducting LOTS throughput operations. The changes are offered for consideration based upon the data and observations resulting from the LOTS test and evaluation program. In the preceeding analyses the following proposals have been discussed already and no further elaboration is given here:

- Port and starboard mooring at all shoreside transfer facilities;
- Turntable for use on the DeLong pierhead section;
- Engineering augmentation for beach site development;
- Pairing operations of a frontloader with at least two LACHs on the beach;
- A better means for transferring tagline handlers;
- Elimination of lighter priority systems involving weight limited lighters;
- Use of multi-lighter mooring (nesting) techniques to eliminate crane delays;
- Development of alternative route(s) to and from the marshaling yard/LSA;
- Use of night, directional devices for crane signalmen; and,

- Addition of personnel to hatch crews to repair handling gear, act as supernumeraries, prepare the hatch for working ship activities, set up for night/day operations, and other deck activities.

In the analysis that follows, the suggested techniques and equipment are grouped by system element, i.e., containership cranes, lighters, etc. The LOTS difficulties encountered were common among test participants and, therefore, are not addressed separately by Service. The changes in operating techniques and equipments discussed are offered for consideration as possible means of expediting and simplifying future LOTS operations.

CONTAINERSHIP OPERATIONS

Extra Lifting Device

Each crane should be equipped with an extra lifting device, preferably a container sling as opposed to a spreader bar since an extra spreader bar costs room on deck and time to shift it around. Additionally, a sling is preferred because of the flexibility it offers as detailed below.

Damaged containers can be latched and lifted or, at least, jury rigged for lift in such cases as containers with a bad corner fitting. With a less experienced crane operator, or in operations in which considerable crane hook pendulation is being experienced, a sling can be latched to a container faster and easier than a spreader bar with its four fixed corner fittings swinging about. Finally, heavy use of spreader bars during the test periodically required adjustments to the guides. While this was being accomplished, an immediately available replacement was needed since the crane had to wait until the spreader bar was repaired.

Swivel for Lifting Device

Time was frequently lost and considerable human energy expended because the alignment of the spreader bar suspended from one boom was at an angle from the intended position over the container. A heavy effort by tag line handlers was required to align the spreader bar for attaching it to the container. A swivel attachment to the crane hook or spreader bar--allowing the lifting device to rotate so that any angle could be accommodated--would greatly expedite container/lifting device positioning. As much as 1/3 - 1/2 of most crane cycles were spent latching the spreader bar to a container or in loading a container onto a chassis.

LIGHTERS

LARC-LX Deployment

The LARC-LX helps fill an important amphibian role in that it can carry two 20-ft or one 40-ft container and during the test its reliability was observed to be good. Thus, it can make a valuable contribution at a LOTS container discharge site. However, because it weighs 88 long tons there

are not many ships that can deploy it (only the SEABEE, and the heavy-lift breakbulk ships of the MSC controlled fleet and US flag fleet). It can be deployed by more ships than an LCU, since a number of ships have 80- and 160-long ton boom capabilities.

The Army should consider ways to reduce the weight of the LARC-LX to minimize the weight difference. At present the LARC-LX fully fueled and operational exceeds the 70-ton boom rating by 25.7 percent and the ship's heavy-lift boom test criteria by 14.3 percent. It may be possible to exceed the 77-ton test criteria sufficiently to at least off-load a lightened (less fuel and operational equipment) LARC-LX on an emergency basis. If this is possible, contingency deployment of the LARC-LX can be greatly simplified. First, however, an engineering review of the boom's construction would be necessary and the minimal condition of the boom and its wire specified if such an approach under emergency conditions is possible.

Management and Control

The most apparent problem during the LOTS test which affected system productivity was lighter succession time at each crane. The need to ensure that cranes do not have to halt for unnecessary reasons should be a major, guiding precept. During the test lighter delays, for the most part, were unnecessary delays and improvements were noted when greater management attention was given to lighter control. Suggested control procedures are outlined below.

As a standard procedure, one lighter should always be standing close aboard each crane so that the approach can begin as the loaded lighter is casting off. Timing should be such that mooring is completed before the crane has begun its rotation toward the lighter. Clearing the mooring point should be accomplished with equal dispatch to be succeeded by the next lighter which should already have been stationed close aboard.

Directional aids could be used to help control lighter operations such as colored panels during daylight operations and colored lights at night. Their use could reduce communications requirements. They could provide a continuous signal to lighters on the operational status at a particular crane site. For this purpose, a simple red, green, and yellow color scheme with predesignated meanings prescribed for lighter positioning and approaches would suffice.

Not only could this type of arrangement be employed at the ship, but also at key shoreside transfer stations, such as the DeLong pier and elevated causeway. Once an operating procedure has been established, control will be simplified for all concerned.

SHORESIDE TRANSFER

Along with the proposed acquisition of the USMC LACH for improving its all tidal "bare beach" capability, the Army should also consider the use of the Navy's elevated causeway system as a method for accomplishing shoreside transfers. The elevated causeway does not have the critical deployment limitations of DeLong piers, sections can be extended beyond the surf zone, and could be subsequently used as a causeway connection to a DeLong section installed as a pier head for off-loading vessels alongside.

Both the elevated causeway and (when deployment is possible and tidal conditions permit) the DeLong pier are cost effective systems in that they support in-being lighterage systems. However, unlike the elevated causeway, DeLong sections are fewer in number; can only be deployed four to a SEABEE or by slow ocean tow; and, since two of the DeLongs on the SEABEE are likely to be barge-TCDFs in the early phases, only two sections would be available for pier operations. Thus, in an area where there is a lengthy tidal flat, the DeLong pier would be only slightly less hampered than a sand jetty, while an elevated causeway could be extended out to sufficient water depth. Also, the causeway would provide a means for handling SEABEE/LASH barge cargo during the early phase of a LOTS operation.

IX. PLANNING FACTORS

GENERAL

This section consolidates the results of the analyses of LOTS sub-systems to provide a basis for determining throughput capabilities as planning factors for LOTS units and equipment. The factors presented here are intended to represent the results that can be expected with experienced LOTS units and equipment in a high state of readiness. Moreover, these capabilities are also based upon near ideal weather and sea state conditions and nearshore beach conditions similar to those at Ft. Story, Virginia.

It should be noted that as currently equipped the Services do not have any back-up capability built into their container handling systems. Although shoreside cranes have the capability to provide surge efforts which can at least partially take up the added burden while one crane is down, ship cranes cannot. When one of these two latter cranes is out of action, 50 percent of the total throughput is lost until the crane is back on line.

CONTAINERSHIP DISCHARGE CRANES

Table 9.1 provides the rationale and data used for developing LOTS system planning factors. As with the containership cranes, a composite number was selected to represent an operation in which both off-loading and retrograde are conducted. For example, two cranes-on-deck could off-load 278 containers per day or retrograde 222 containers per day, for an overall average of 250 per day. The two barge-TCDF system can off-load 282 containers or retrograde 250 for an average of 265 per day. Both cranes can attain economies of time and operate more efficiently as a result of working with another crane of the same type system; e.g., two CODs or 2 TCDFs vs one of each. The averages used in the computations were based on the minutes per container factors developed in Section III of this volume. These averages were multiplied by the number of net operating hours per day per crane. The net operating hours were derived by deducting all necessary, non-container-transfer type activities that had to be accomplished over the course of a day.

TABLE 9.1
CONSIDERATIONS FOR DETERMINING CONTAINERSHIP
DISCHARGE/RETROGRADE PLANNING FACTORS

DETERMINANTS	CONTAINERSHIP DISCHARGE SYSTEMS	
	CRANE-COD-DECK	BARGE-TCDF
No. cranes per shift	2 cranes	2 cranes
No. shifts per day	2 shifts	2 shifts
Operational hours per shift	10 hr	10 hr
Operational time per day not associated with container transfers		
- Random delays	1.67 hr	1.67 hr
- Weather delays	.75 hr	1.15 hr
- Working ship activity	2.00 hr	3.50 hr
(TOTALS)	(4.42)	(6.32)
Net hours to transfer containers per day	15.6	13.7
Avg. crane cycle time/container		
for off-loading	6.73 min	5.83 min
for retrograding	8.40 min	6.60 min
DAILY OFF-LOAD CAPABILITY	278 cntnrs/day	282 cntnrs/day
DAILY RETROGRADE CAPABILITY	222 cntnrs/day	250 cntnrs/day
COMPOSITE CAPABILITY (Planning factor)	250 cntnrs/day	265 cntnrs/day

Based upon test observations a period of 2 hr per shift was necessary for crew changes, crane refueling and scheduled maintenance, and mid-shift crew breaks. The limited foul weather delays experienced were summed and averaged over the test period. For weather delays the barge-TCDF experienced more lost time than the COD and this difference is also reflected in the factors used.

The working-ship time allotted is based upon the expected result if two of each type crane system were to off-load a C-573 containership. The barge-TCDF requires more working-ship time than the COD because it has more moves to make, even though each move requires only 1/3 the time of a COD relocation. Each COD moves only once while a barge-TCDF must move four or five times (subject to which TCDF crane must off-load the hold aft of the superstructure).

The times used for determining working-ship activities were based upon the expected times an experienced crew would take to open/close a hatch or relocate a crane. All working-ship times were summed and averaged out for a daily average.

Because retrograde operations are slower but a necessary part of sustained container operations a mid-point for off-load and retrograde capabilities was selected as the system planning factor. In Table 9.1 this is referred to as a composite factor. Since the ship cranes were the bottleneck in all phases of the LOTS test, the upper capabilities for Service units in a LOTS operation were based on the type of crane system used.

LIGHTERS

The basis for recommended planning factors for lighterage is discussed in some detail in Section IV on analysis of lighter operations. Previous statements of Army terminal and watercraft unit capabilities were primarily stated in terms of breakbulk cargo. Container handling capabilities were included in the H Series TOE's of the medium and heavy boat companies only. The test objective, then, was to verify those previously developed for TOE's and to recommend new planning factors for units for which such a capability had not yet been established.

Five Army units are of interest here. The data, however, can be used for Navy assault craft detachments. The five Army units are the medium boat company (LCMBs), heavy boat company (LCUs), medium amphibian company (LARC-XVs), amphibious barge team (LARC-LX), and a detachment of LACV-30s.

In the analysis of lighter requirements, a determination was made of the number of each type of lighter needed to sustain container discharge/backloading operations. As a basis for computations a 95 percent probability of not delaying the two ship cranes while they operated at peak performance levels, was used. These requirements included allowances for all elements of a lighter cycle including a minimum queue. The number of lighters indicated in the calculations, therefore, would normally be sufficient to support peak crane off-loading and backloading rates. Of interest to the planner, however, is the number of lighter units needed to support a sustained effort of one or more terminal service companies.

The broad capabilities for the lighterage units stated below are directly related to a one ship, one terminal service company operation. This is in keeping with prior statements of lighterage company capabilities stated in breakbulk terms, e.g., a terminal service company and a medium boat company are both rated at 1,000 short tons/day. Although lighters could transport more cargo per day given an immediate load at the ship, it is recognized that the stated capability is limited to the cargo handling capability of the terminal service company.

An important aspect of planning factors is that they should be broad enough for general use, year in and year out. In this regard caution must be exercised in the use of these factors for situations and conditions markedly different from the "norm;" in this case the Virginia Beach, Chesapeake Bay area under near ideal weather/sea state conditions.

The number of lighters by type required to match peak crane activity and the calculation of unit capabilities are listed in Table 9.2. The computations are based on the expected average productivity of the terminal service company. For the Army, a 2-TCDF sustained rate of 265 containers/day was used. As noted in the lighterage analysis section, 7.2 LCUs are required to keep the cranes of the one ship system busy. Thus, the capability of the heavy boat company with an average availability (75 percent) of nine LCUs is calculated to be 330 ($9/7.2 \times 265$).

For completed statements of unit capabilities, the average number of trips and containers per trip are also shown in the table. The average containers carried per trip are based on the numbers normally transported during the LOTS test.

TABLE 9.2
LIGHTERAGE PLANNING FACTORS

UNIT	NO. LTRS REQUIRED FOR ONE SHIP SYSTEM	NO. OF CRAFT AUTH. AVAIL.		UNIT DAILY CAPABILITY (CONTS./DAY)*	APPROX. TRIPS/DAY	AVERAGE NO. OF CONTS./TRIP
Medium Boat Company (LCMB)	8.3	16	10	315	16	2
Heavy Boat Company (LCB-1400)	7.2	10	9	337	9-10	4
Company (LCB-1646)	4.8	11	9	251	10	4
Medium Amphib. Company (LAPC-XV)	12.7	14	14	351	19-20	1
Amphib. Barge Team (LAPC-LX)	4.2	4	3	95	14-15	1
Medium Amphib. Det. (ACV)**	6.6	**	2	80	27	1.5

* All values rounded to nearest 5 containers/day.
 ** The average availability of the ACV is not known.

As noted in the lighter analysis section the number of craft required materially increases and likewise the daily capability of the lighterage unit decreases as the distance from ship to shore increases. The test case capabilities given are for 1.4 nautical miles from shore, a generally representative distance for LOTS operations. For distances closer in or more distant from the shore, Table 9.3 can be used for planning purposes. The factors are derived from the lighter cycle data in Section IV. As an example, for a heavy boat company with 1646-class LCUs at a ship to shore distance of two miles, the unit capability is estimated to be 315 containers per day (350×0.9).

TABLE 9.3
FACTORS FOR DETERMINING UNIT CAPABILITIES AT VARYING DISTANCES (n.mi)

UNIT	TEST CASE Contrs./day	FACTORS FOR OTHER DISTANCES				
		1/2 nm	1 nm	2 nm	3 nm	4 nm
Med. Boat Co.	385	1.30	1.12	0.87	0.71	0.63
Heavy Boat Co. 1400	330	1.22	1.08	0.89	0.75	0.65
1646	350	1.18	1.07	0.90	0.78	0.65
Med. Amphib. Co.	350	1.48	1.10	0.73	0.55	0.44
Amphib. Barge Tm (LAPC LX)	95	1.34	1.11	0.83	0.66	0.55
Med. Amphib (ACV) LACV-30*	80	1.36	1.03	0.90	0.80	0.71

* Unit structure not assumed. Calculations based on 2 craft available/day

SHORESIDE TRANSFER SYSTEMS

Table 9.4 provides the inputs used as a basis for calculating shoreside transfer system capabilities. As with the containership cranes, average shore-side crane cycle times, determined from analysis of LOTS test data, were multiplied by the net time available to transfer containers to estimate daily capabilities. The planning factor is the average of the off-load and retrograde daily rates. These factors are summarized in Table 9.5

TABLE 9.4
PLANNING FACTOR CONSIDERATIONS FOR DETERMINING
SHORESIDE DISCHARGE/RETROGRADE CAPABILITIES

DETERMINANTS	SHORESIDE DISCHARGE SYSTEMS			
	ADP Crane	Crane-on-shelf	DeLong Pier	Elevated Causeway
No. cranes per shift	1	1	1	1
No. shifts per day	2	2	2	2
Operational hours per shift	10 hr	10 hr	10 hr	10 hr
Operational time per day not associated with cntnr transfers	-	-	-	-
- Random delays	1 hr	1 hr	1 hr	1 hr
- tidal delays	-	5 hr	-	-
Net hours to transfer	19 hr	14 hr	19 hr	19 hr
containers per day				
Avg crane cycle time/cntnr				
- off-loading	4.7 min	4.4 min	5.6 min	5.7 min
- Retrograding	5.5 min	7.0 min	1.9 min	6.0 min
DAILY OFF-LOAD CAPABILITY	243 cntnr/day	191/259 cntnr/day	237 cntnr/day	200 cntnr/day
DAILY RETROGRADE CAPABILITY	207 cntnr/day	122/163 cntnr/day	193 cntnr/day	190 cntnr/day
COMPOSITE CAPABILITY* (Planning factor)	230 cntnr/day	156/211 cntnr/day	220 cntnr/day	195 cntnr/day

* Rounded to nearest 5 Containers

TABLE 9.5
SUMMARY OF SHORESIDE
PLANNING FACTORS

FACILITY*	CONTAINER PER DAY		PLANNING FACTOR
	OFF-LOAD	RETROGRADE	
Applique Discharge Point Crane	140	210	
Crane-on-shelf	191/259	122/163	
DeLong Pier	110	193	
Elevated Causeway Crane	200	190	
LACH (2 120/220 and one front loader)	140	140	

* Except for the LACH site, each facility has one crane

In developing the above factors the crane-on-jetty was rated on the basis of both a 2.5 hr per shift tidal delay (as at Ft. Story) and in a location where tide would not be a limiting factor. For the LACH, two were determined as being necessary for developing the 240 container per day capability. However, when assisted by a frontloader to load trailers, this capability can be increased to 300.

TOTAL SYSTEM THROUGHPUT PLANNING FACTORS

Since ship cranes are normally the slowest element of a LOTS throughput system, unit capabilities are governed by the productivity of the discharge system employed. The shoreside systems, consisting of the cranes or of a crane and LACH combination previously discussed, demonstrated the capability to keep pace or exceed surge capacities of ship cranes. Assuming there is a balanced lighter system employed, the planning factors for both Services are considered the same if they use the same ship discharge systems. Finally, since retrograde is considered an integral part of containership operations a single daily transfer rate was determined. Although some economies can be realized by combining off-load and retrograde operations, there also are more complex management and organizational problems to be dealt with which can result in delays. Accordingly, these factors are considered self-cancelling.

For an operation supported by two barge-TCDFs a rate of 265 container transfers per day is considered a suitable planning factor, provided fair weather predominates.

For an operation supported by two cranes-on-deck a rate of 250 container transfers per day is considered appropriate for planning purposes under the same near ideal conditions. In view of the COD's apparent ability to operate in rougher sea states (limit yet to be determined), the COD system may be the more productive system in areas where rougher sea states prevail.

BREKBUK CAPABILITY

The currently established planning factor for handling conventional breakbulk cargo is 1,000 short tons per day per Army terminal service company. The results support this capability. During the LOTS test a two-hatch breakbulk operation was conducted in Phase I. A total of 600 short tons of cargo was discharged in less than two shifts, including time to open and close hatches. Thus, by extrapolation of these results to five hatch gangs, the capability of 1,000 short tons per day was actually exceeded.

COMMAND AND CONTROL

A transportation terminal battalion headquarters was tasked to manage both the breakbulk and container operations, site development, and the limited amount of equipment deployment the test required. This was accomplished without exceeding the capability of the battalion. However, with the completion of breakbulk ship operations, the unusual situation of the battalion directing a one ship, one terminal service company operation resulted to a degree in over-management of the terminal company functions. From an exercise standpoint the arrangement provided training and experience for battalion operations personnel.

However, because of the scope of cargo operations, the capability of the unit to command and control a number of terminal service companies with supporting units at more than one operational site could not be evaluated.

INSTALLATION OF ELEVATED CAUSEWAY

The elevated causeway was installed for the first time by an East Coast Navy unit. The causeway was still undergoing developmental testing during the LOTS test. A subsequent installation on a different beach by the same organization and using the same experimental equipment required approximately 65 hr or about 2/3 the time required on the first attempt. Until further tests establish better planning data, an allowance of 65 hr is considered appropriate.

BREAKBULK VERSUS CONTAINER OPERATIONS

A productivity comparison was made of a container terminal service company as demonstrated in the LOTS test with a breakbulk type terminal service company. Unit personnel strengths of the two units and their daily tonnage handling capabilities were considered. Table 9.6 sets forth the principle criteria used.

TABLE 9.6
PERSONNEL STRENGTHS AND CARGO HANDLING CAPABILITIES

Terminal Service Company	Personnel	Tonnage Per Day
Container	193*	3,445 STONS**
Breakbulk	320	1,000 STONS

* Excludes TOE truck element for which there is no like transport capability in the breakbulk company.

** Based upon barge-TOE planning factor. For off-load only (to support initial resupply operations) 3,666 STONS could be expected. Tonnage is based upon an average of 13 short tons per container.

Based upon the above calculations, in terms of productivity a container terminal service company can handle about 3.5 times the amount of cargo of a breakbulk company with about one-third fewer personnel. At the present time, the Army is considering personnel and equipment revisions to the container company TOE which would increase the total number of personnel to 291 (including 46 for truck operations). Again backing out the truck element in making the same comparison between the two units, the container company would still have about 25 percent fewer personnel. These personnel changes may improve the productivity and efficiency of the unit but the net effect cannot yet be quantified for this report.

An additional factor to be considered is that eventually empty containers must be retrograded. This would mean that instead of the productivity differential being 3,5 times that of a breakbulk company, with balanced off-load and retrograde operations would be more nearly twice the breakbulk productivity. This estimate is based on the fact that a breakbulk company would also be required to accomplish a certain amount of retrograde as well, although not to the extent of a container company.

X. CONCLUSIONS AND RECOMMENDATIONS

JOINT LOTS MAIN TEST

CONCLUSIONS

The following are conclusions based upon analyses of data and observations made during the planning and execution of the Joint Logistics-Over-The-Shore Test and Evaluation program. Conclusions are grouped by subject matter.

- POL RESUPPLY

- An Army capability (greater than the Navy's amphibious Assault Bulk Fuel System) is required for discharging bulk POL from tankers to storage facilities ashore and distributing products to meet corps sized force requirements in a LOTS operation.

- SYSTEM VULNERABILITY

- LOTS type operations may be exposed to the open sea and are vulnerable to sea and weather conditions. Because of this and the lack of redundancy in system elements, LOTS type operations still involve a high degree of uncertainty in continuity of operations. Nevertheless, they remain an essential means of providing logistic support to a contingency force.

- DEPLOYMENT

- DOD does not have an assured and responsive means for obtaining specialized merchant shipping to meet the Department's deployment requirements of LOTS heavy, outsized equipment in a non-mobilization contingency situation.

- The National Defense Reserve Fleet (NDRF) cannot support quick response contingency requirements.
- The Ready Reserve Force (RRF) should be constituted to include sufficient heavy-lift vessels to support the deployment of the Army's heavy boat company (12-LCUs) and the terminal service (container) company's cranes.
- The Sealift Readiness Program should be tested to determine problem areas, communications channels, and procedural response times for acquiring needed sealift assets.
- A SEABEE ship cannot be assumed to be available to deploy the Army barge-TCDF in a quick reaction (5 to 10 day notice) situation although it is now subject to call-up under the SRP.
- If no SEABEEs are available for deployment of the barge-TCDFs, the Services would be limited to operations involving self-sustaining containerships or crane-on-deck (COD) operations on NSS containerships. A decreasing number of self-sustaining containerships (less than 20) are in service.
- The minimum number of specialized ships required to deploy an Army container company and supporting lighterage is extensive, on the order of four: one SEABEE, two heavy-lift breakbulk and one heavy lift RO/RO ship with an additional two conventional breakbulk ships also required.
- To insure the deployment of large, out-sized LOTS equipment within required response time, priority in the allocation of scarce heavy-lift ships is required.
- To confirm the LCU deployment capabilities of the GTS ADM. WM CALLAGHAN MSC should sponsor a test lift of both 1466- and 1646-class LCUs.
- In consideration of LARC LX deployment limitations, an engineering analysis is needed to determine the maximum weight under emergency conditions that could be off-loaded from a CHALLENGER-class vessel.

- BEACH PREPARATION

- The Advanced Multi-purpose Surfacing System (AMSS) was a relatively fast means of improving beach road nets and was particularly effective for corners and turn-around points when used with Morat.
- The mission of the Army's engineer port construction company does not include beach and marshaling yard preparations in addition to its port construction efforts. Augmentation by other engineer units would be required for major projects such as construction of a beach ingress/egress network and marshaling yard preparations.

- CRANE-ON-DECK (COD)

- The COD was an effective method for discharging a C5-S-73b non-self-sustaining containership in a LOTS environment. A single COD was rated as having a discharge capability of 139 containers per day and a retrograde capability of 111 containers per day, under near ideal conditions. For planning purposes, a rate of 250 containers per day was determined for a two crane system.
- During the test the COD was found to be less weather-sensitive than the barge-TCDF; the COD's weather limitations have yet to be determined.
- The 200-ton crane was of sufficient size to off-load on both sides of the containership, which provided operational flexibility in discharging the ship. The hatch bridging kit served its function well in supporting the crane in the conditions experienced during the test. Moving the crane to various locations proved to be practical and reasonably fast after the first few relocations.
- The throughput rate of the COD, like the barge-TCDF, improved during the test. Much of the improvement was due to increased skills acquired during operations, especially in organization and deck operations, and in scheduling lighter arrivals.
- Of the 95 U.S. flag fleet NSS containerships (nearly all) analyzed by the Navy only 31 percent have been determined to be acceptable or desirable for discharging by the COD.

- Full implementation of the COD concept in a major contingency would require deploying a COD two or three crane system on each containership to be off-loaded in an objective area. A large number of cranes on relatively short notice. The Services currently own only one crane suitable for a COD system. Purchasing that many large single-purpose cranes would be expensive. Leasing or requisitioning in the event of mobilization may be viable alternatives.
 - The hatch bridging kits to convert NSS containerships to self-sustaining ones are not on hand or being procured. They would have to be procured rapidly to respond to a major contingency situation.
- ARMY BARGE-TCDF
- The Army barge-TCDF performed well in this test and was rated as having an off-load capability of 142 containers per day and a retrograde capability of 125 per day. For planning purposes, a rate of 265 containers per day was determined for a two-barge-TCDF system.
 - The TCDF crane operators had a better field of view and the crews were more familiar with the TCDF than the COD operators and their crews, which resulted in the higher productivity of the TCDF.
 - Although weather conditions were highly favorable for most of the test, gusty winds and choppy waves slowed TCDF operations until they were finally stopped due to excessive boom motion. The barge-TCDF did not demonstrate a capability to operate in sea state 3 conditions and was slowed during some periods of sea state 2 conditions.
 - The barge-TCDF is deployable only by the SEABEE ship of which three have been built in the U.S. This vessel is, for the time being, committed to the Sealift Readiness Program, but the TCDF cannot be assumed available to meet quick reaction, non-mobilization contingency time frames (5 to 10 day notice).

• LIGHTERS

- The management of lighters is more intensive for container operations than for breakbulk because of shorter loading times. Initially lighters were poorly utilized in this test. As operating and lighter control procedures were improved, container throughput was greatly increased.
- During the early phases in calm sea states, lighters were not fully utilized, e.g., loading four containers per LCU instead of five or more, even during favorable tides.
- At the test distance of about 1.4 nmi from ship to shore, the LACV-30 and LCU were about equal in container delivery rates. This ratio remains the same independent of the off-shore distance because speed of the LACV-30 is offset by its cargo carrying capacity.
- Under conditions similar to Fort Story with no allowance for maintenance back-up to support a one containership (two-crane) operation approximately: nine LCM8s, or seven LCUs, or 14 LARC-XVs (if all containers weighed 15 STONS or less), 10 LARC LXs, or seven LACV-30s, or a combination of these lighters is required.
- The main advantages of the LACV-30 are its deployability by conventional breakbulk ship (although like the LCM8, it is limited to one or two per ship) and its ability to cross beaches landing craft cannot reach.
- Major deficiencies of the LACV-30 are the effects of blowing sand, dust and salt water on personnel and sensitive areas of equipment; poor directional control on land; and carrying capacity.
- The LACV-30's carrying capacity should be stated in terms of cargo payload. The cargo capacity should reflect the deduction of the normal operating fuel allowance. With full tanks this is only 23.7 S tons.
- The LACV-30 consumes fuel at a rate 2.5 to 5 times greater than other Army lighters in gallons per container delivered. The LACV-30 consumed about 46 gallons per container delivered versus 9 gallons for the 1646-class LCU.

- 300-TON CRANE-ON-JETTY

- The crane-on-jetty was discharged from the ship, moved to shore, the jetty constructed, and the site made operational within the 4-day scenario time limit (less than 48 hrs). The jetty was constructed from readily available materials using only equipment and skills available to the attached engineer port construction company.
- At the test site the crane could reach grounded landing craft except for 1-1/4 hr on each side of low tide. This was one of the most productive cranes in the test, demonstrating an off-load capability of 191 containers per day and a retrograde capability of 120 containers per day. The crane could off-load as many as 260 per day or retrograde 165 if there were no tidal constraints. A planning rate of 155/210 containers per day was determined with and without tidal influence.
- The jetty provided a satisfactory working platform for the crane throughout the test period with minimal daily maintenance support. Working two lighters concurrently and assisting the crane with a front loader were the key features contributing to the rapid crane cycles and high productivity of the facility.
- Although suitable for the conditions at Ft. Story, flatter beaches would require extending the jetty seaward and its survivability in heavy surf is questionable. Consequently, the Ft. Story results should be considered as applicable only to beaches of similar slopes and the jetty planned for only as a temporary expedient.

- AMPHIBIAN DISCHARGE POINT (ADP) CRANE

- When paired with a frontloader and with the capability to receive and work two amphibians concurrently, the ADP crane developed very high container transfer rates.
- The ADP crane was idle for a major portion of the time due to the limited number of amphibians available and scenario requirements. However, for off-loading the crane was rated at 245 containers per day and for retrograde at 210 per day from data averages taken during the test. For planning purposes a rate of 225 containers per day was determined.

- The sand berm was partially effective in protecting the crane from sand blown by the LACV-30. Wetting down the turning area also aided sand and dust suppression.

- ELEVATED CAUSEWAY

- The elevated causeway provided a stable platform and lighter working area outside the surf zone for continuous operations. The elevated causeway can sustain a rate of 200 containers per day for off-loading and 190 per day for retrograding. For planning purposes a rate of 195 containers per day was determined.
- Elevated causeway components are deployable by amphibious ships and commercial vessels. The cost in deck space on the latter would be quite high (only 1 to 2 3x15 sections can be loaded on a conventional breakbulk ship) unless a LASH ship can be made available.
- For the test, deployment of the elevated causeway system by amphibious shipping was assumed. Total lift requirements for piling and support equipment are extensive and operational commanders may have to assess mission requirements with space availability if all components of the elevated causeway are to be embarked by amphibious ships.
- The erection of the elevated causeway was slow (over 100 hr) due to the inexperience of military personnel accomplishing the task and the presence of deep silt at the seaward end. A subsequent post-LOTS test exercise reduced this time by one-third.
- The turntable was very effective in accomplishing tractor-trailer turn-around without delaying container transfer operations.
- In comparison with other shoreside facilities the elevated causeway was more adversely affected by slower lighter succession times which resulted in lower container throughput rates. Other causeway configurations and procedures could facilitate lighter docking and undocking operations and improve the throughput rate.

● DELONG PIER FACILITY

- The DeLong pier was erected in a net period of about 24 hr and provided a stable discharge facility with adequate water alongside for continuous container transfer operations. The facility can support a discharge rate of 210 containers per day during off-loading and 195 per day during retrograding. For planning purposes a rate of 200 containers per day was determined.
- A pier arrangement of DeLong sections end-to-end would permit lighter operations from each side of the facility, increasing overall productivity. The incorporation of a turntable for tractor-trailer turn-around would also improve container transfer operations.
- 8 DeLong sections can only be deployed by SEABEE vessels. The alternative of towing would not be responsive to quick reaction contingency requirements.

● LIGHTWEIGHT AMPHIBIOUS CONTAINER HANDLER (LACH)

- The Lightweight Amphibious Container Handler (LACH) exceeded developmental test expectations. This prototype vehicle is relatively inexpensive, rugged and uncomplicated in design and construction. Some deficiencies were uncovered, but these are being corrected.
- In this test the LACH successfully reached and discharged containers from grounded out landing craft during all tides.
- After only five days of on-the-job training with operational personnel of grade E-3 the LACH can support an average rate of 120 containers per day. No allowance for maintenance down time is included in this rate since such data have not been generated.
- The only major limitation of this vehicle for other Service use is its inability to handle containers larger than 20-ft.
- The LACH was not extensively tested as container MHE in the Logistic Support Area. Although slower than a frontloader it appears to be a possible candidate in this role.

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- The LACH was not extensively tested as container MHE in the Logistic Support Area. Although slower than a frontloader it appears to be a possible candidate in this role.

- LACH operations can be expedited when the vehicle is paired with a frontloader to load tractor-trailers. One frontloader could support at least two LACHs.

- BEACH CLEARANCE TRANSPORT

- The Army yard tractor, designed for fixed terminal operations and the 34-ton dual-purpose container transporter, designed for fixed port and highway use, were both successfully operated in the prepared beach environment.
- Analysis indicates that 22 of the currently authorized 28 vehicles can satisfy daily throughput requirements of up to 300 containers per day from the beach to a marshaling yard up to five miles away.
- The USMC modified M-127 trailers were found to be marginally suitable for container transport operations due to the location of the container on the trailer bed.
- Only eleven M-127 trailers were modified with container corner guides and locking pins for guiding and securing 20-ft containers. Ten trailers plus three for a maintenance float would normally be required for sustained operations.

- MARSHALING YARD

- The area, layout, and traffic circulation routes of the marshaling yard were adequate for the level of container operations generated in this test, but an alternative route should be planned for in the event of vehicle accidents or other road congestion problems.
- Accuracy of recorded container stowage locations was generally poor due to a lack of procedures and an inability of ground controllers to communicate with MHE operators. Inadequate lighting in some areas aggravated the problem during night operations.

- LOGISTIC SUPPORT AREA (LSA)

- Procedures developed for documentation and control of containers from the beach to stowage locations in the LSA were satisfactory for the most part.
- LSA container operational procedures overall could not be satisfactorily tested because of a lack of required numbers of USMC MHE.
- Further definition of USMC beach and LSA operational procedures are required.

- CONTAINER MHE

- The Army frontloader performed well on both the beach and in the marshaling yard. The vehicle is rated at 25 short tons but managed to handle 40-ft containers with some difficulty. A total of nine units, including maintenance requirements, can handle the average throughput requirements of one container company on the beach and in the marshaling yard.
- The USMC 30-ton Drott crane could handle containers up to 21 short tons in sustained operations in a stationary position on its outriggers. Weights heavier than 21 short tons overly taxed the crane. Consequently, the crane is considered marginal for general container handling operations until more appropriate MHE are obtained.

- MANPOWER

- The Army required additional crane maintenance and stevedore support personnel aboard the container-ship. Subsequent to the test, the Army has recommended changes to the terminal service company (container) TOE which appear adequate to the requirements.
- An executive officer and operations officer are also needed in the terminal service company container headquarters to provide back-up and planning support for the commanding officer for round-the-clock off-load and retrograde operations.

- DOCUMENTATION, CARGO MANAGEMENT
 - An automatic system for deleting late shipments of Eastern Area, Military Traffic Management Command (MTMC) resulted in the loss of a large portion of test manifest data.
 - The Remote Process Facility (RPF) can be upgraded to provide a "stand alone" terminal capability. An adequate communications link and computer and software package are required.
 - Documentation control and management of breakbulk cargo and containers were successfully accomplished using manual procedures.
- SYSTEM MANAGEMENT
 - The management of Service LOTS operations on all levels understandably reflected inexperience with container operations and throughput operations involving large quantities of cargo. Improvements were particularly noticeable in the final phases of the test.
- CONTAINER SYSTEM PRODUCTIVITY
 - The productivity of a container supported distribution system in a LOTS environment can be 3.5 times that of a breakbulk system with one-fourth fewer personnel under surge discharge conditions and about twice the productivity of a breakbulk system when retrograde must be initiated.

RECOMMENDATIONS

It is recommended that:

- As a priority matter the Army acquire all necessary equipment for discharging, storing, and distributing bulk POL from tankers in a LOTS operation.
- The Department of Defense carefully examine the vulnerability of the LOTS and amphibious follow-on echelon container handling subsystems to environmental factors and mechanical breakdowns; and considering the lack of system redundancy, assess the need for system maintenance requirements and the impact of probable losses of key components on sustained logistic support.

- The Department of Defense review the arrangements (legislative and contractual) under which essential shipping can be made available to the Department when required for military operations.
- OSD MRA&L provide positive direction in the coordination of LOTS/COTS program requirements to insure balanced system support at the earliest practicable date.
- OSD MRA&L support the assignment of an appropriate priority for the early acquisition of a deployable temporary container discharge facility by the Navy in order to meet planned development/operational testing in the FY 81-83 time frame.
- Until self-deployable container discharge facilities are available, OSD MRA&L consider the determination of requirements and acquisition of COD hatch bridging kits to support most likely contingency operations; and that the kits be positioned at locations to permit the rapid conversion of NSS containerships into self-sustaining ones.
- MSC sponsor a deployment test loading of 1466- and 1646-class LCUs aboard the GTS ADM WM CALLAGHAN.
- The Army examine trade-offs in the deployment, operating effectiveness, and support costs of alternative mixes of lighters to support most likely contingency situations.
- In conjunction with a review of lighterage requirements the Army examine the relative merit of the LACH, the elevated causeway, sand jetty, and the DeLong pier in meeting contingency requirements.
- The Navy conduct additional training and testing of the deployment, erection, and operation of the elevated causeway to include unfavorable weather conditions.
- The Marine Corps examine container MHE and transporter options and develop LSA operating procedures to acquire an adequate capability to handle containers in amphibious follow-on and resupply operations.

- The Army improve procedures and management of the marshaling yard, particularly in maintaining accuracy of stowage location and control.
- The Army improve the capability of the Remote Processing Facility to include a stand alone communication capability in receiving, processing, and producing terminal documentation, operational status, source data collection, and cargo accounting reports. The Army should also continue training and testing in the use of mechanized documentation for break-bulk and container cargo in planned annual exercises.

