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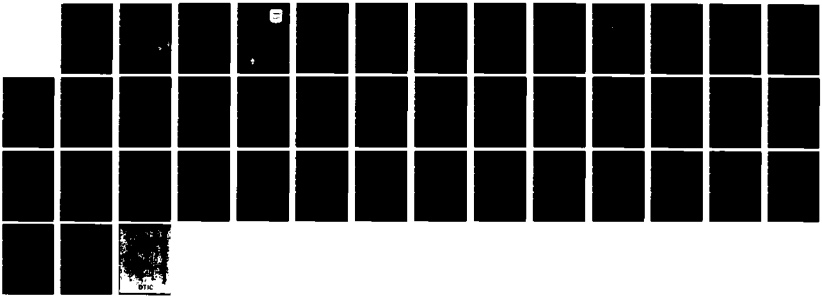

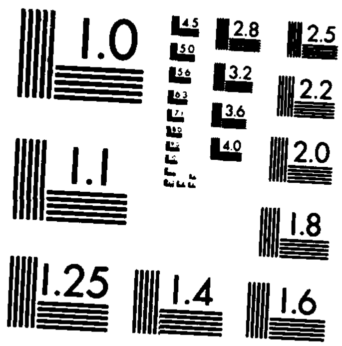

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Forty years ago planning was commenced for the greatest invasion force in human history. Almost all of the participants have left military service and the institutional memory has gone with them. This essay reviews the planning and execution phases of Operation Overlord, to see what problems were confronted, if and how they were overcome, and what lessons learned are still applicable today. The conclusion is that although some of the technology employed in 1944-45 is still useful and in some cases the same equipment is now available in improved form, the assets in terms of people, equipment and funds needed to

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STUDENT ESSAY

ENTERING A CONTINENT: AN HISTORICAL ANALYSIS OF PORT AND BEACH OPERATIONS IN THE EUROPEAN THEATER OF OPERATIONS, WORLD WAR II

BY

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12 APRIL 1983

US ARMY WAR COLLEGE, CARLISLE BARRACKS, PENNSYLVANIA

USAWC MILITARY STUDIES PROGRAM

ENTERING A CONTINENT: AN HISTORICAL ~~ANALYSIS~~ Review OF PORT AND BEACH OPERATIONS IN THE EUROPEAN THEATER OF OPERATIONS, WORLD WAR II

INDIVIDUAL ESSAY

by

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12 April 1983

ABSTRACT

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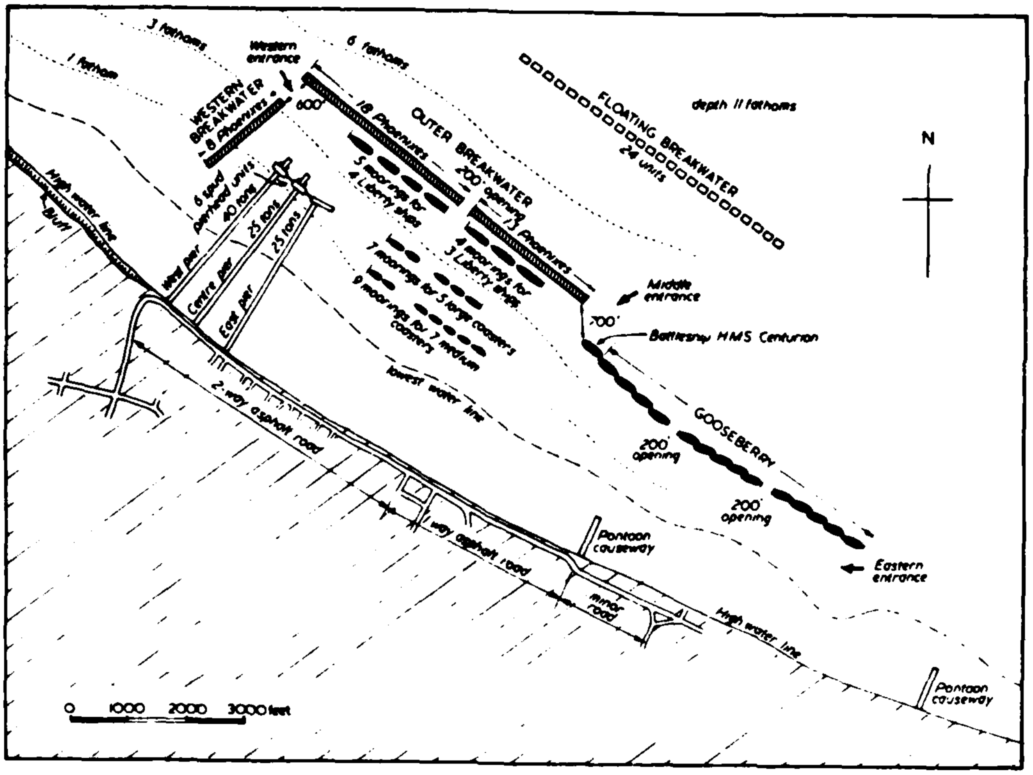
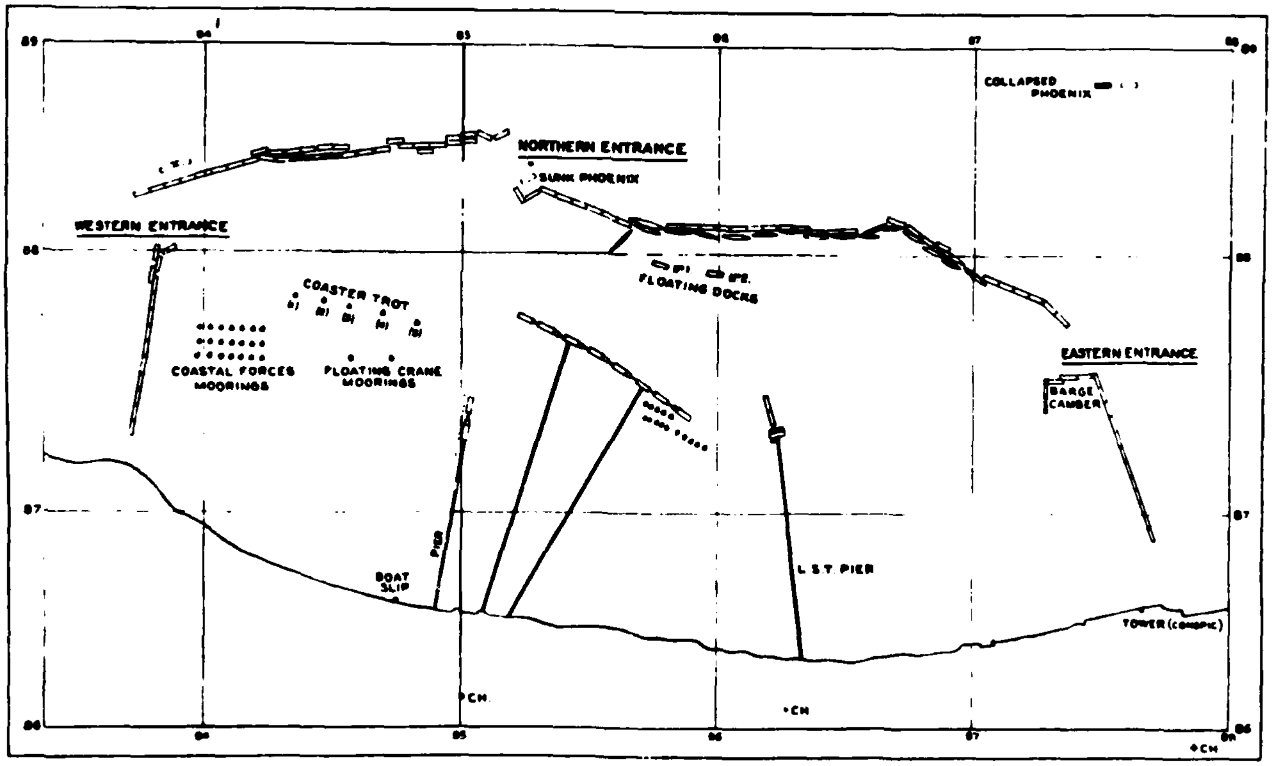
GLOSSARY OF TERMS

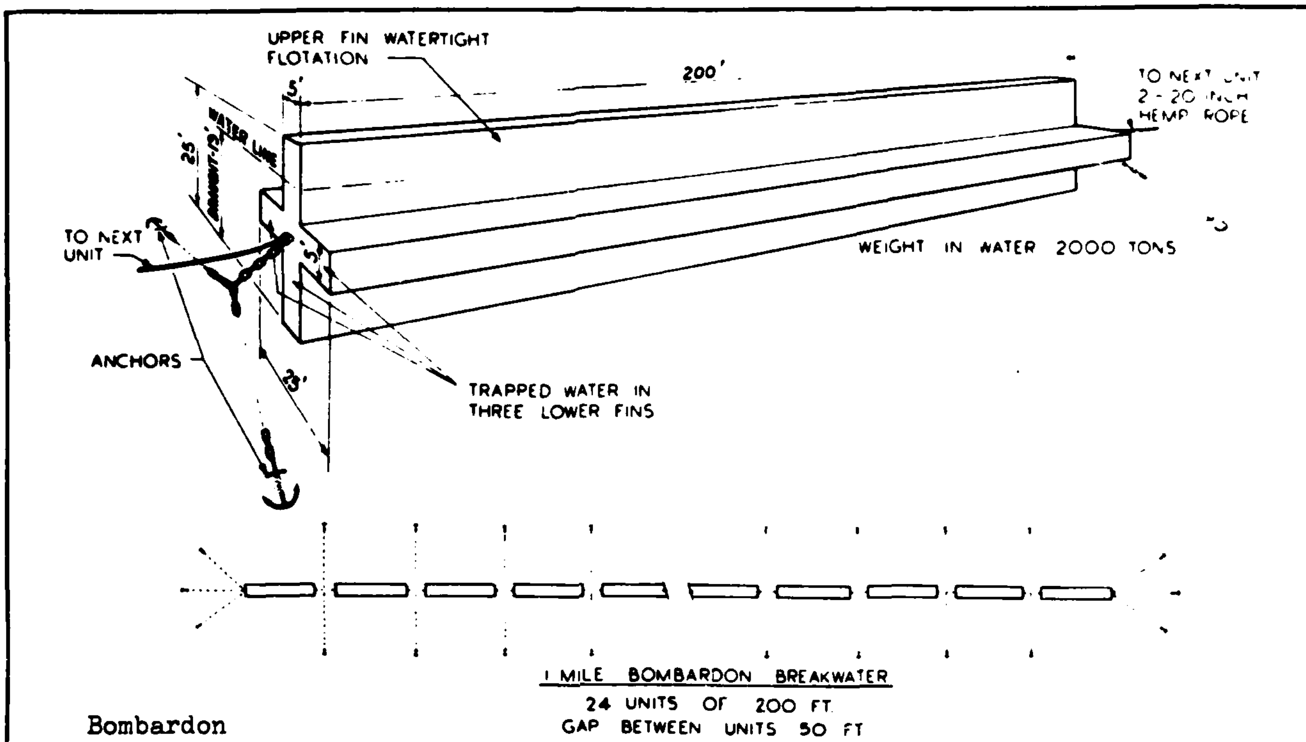
BOMBARDON	Floating steel breakwater anchored to seaward of blockships and Phoenixes.
COSSAC	Chief of Staff to Supreme Allied Commander.
D-DAY	Invasion day; D+1 is the second day of the operation, etc.
DUKW	2 1/2 ton, amphibious truck.
GOOSEBERRY	Shallow water sheltered by a line of sunken ships.
LCI	Landing Craft, Infantry--250 troops.
LCM	Landing Craft, Mechanized--30 tons.
LCT	Landing Craft, Tank--Depending on design varied from 30 to 300 ton capacity.
LST	Landing Ship, Tank--2,150 tons (beached); 2,500 tons (berthed); held up to a mix of 50 vechicles.
LILO	Earlier canvas variation of BOMBARDON.
MULBERRY	Artificial harbors for American "A" and British "B" beaches in Normandy landings.
OVERLORD	Code name for the Normandy invasion approved at Quebec, August 1943 and executed June 1944.
PHOENIX	Concrete caissons of six different sizes capable of being sunk to form a deep water harbor.
WHALE	Code name given to floating pierheads (LOBNITZ piers) and roadways used to bridge cargo and personnel from vessels to shore.



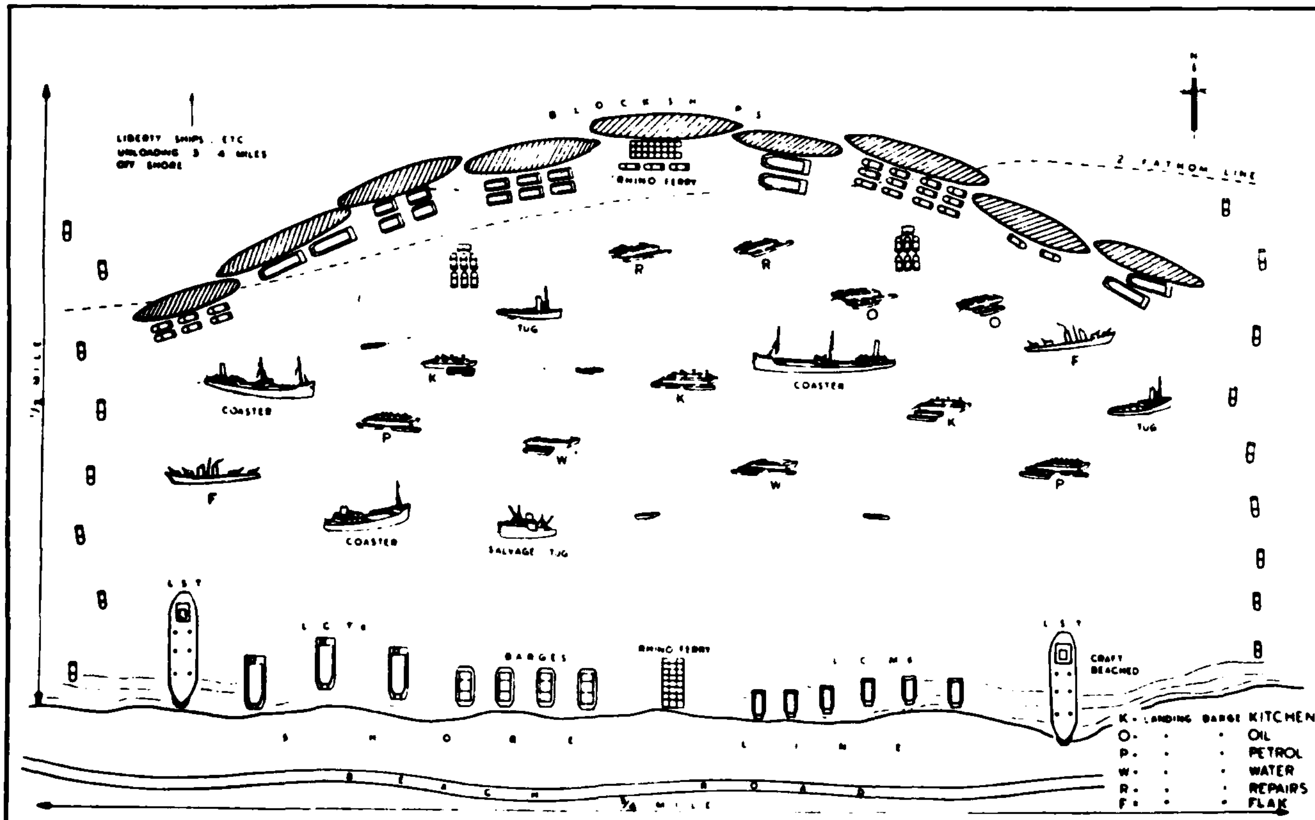
Mulberry A OMAHA Beach



Mulberry B Arromanches

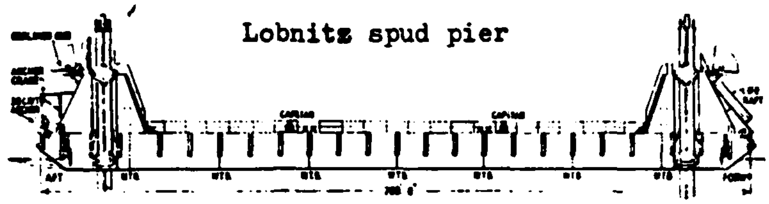


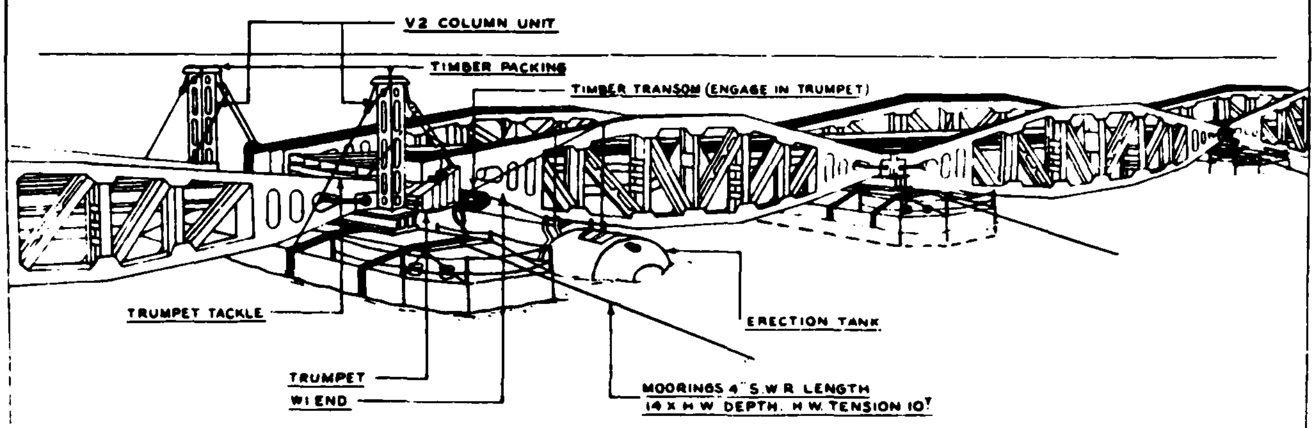
Bombardon



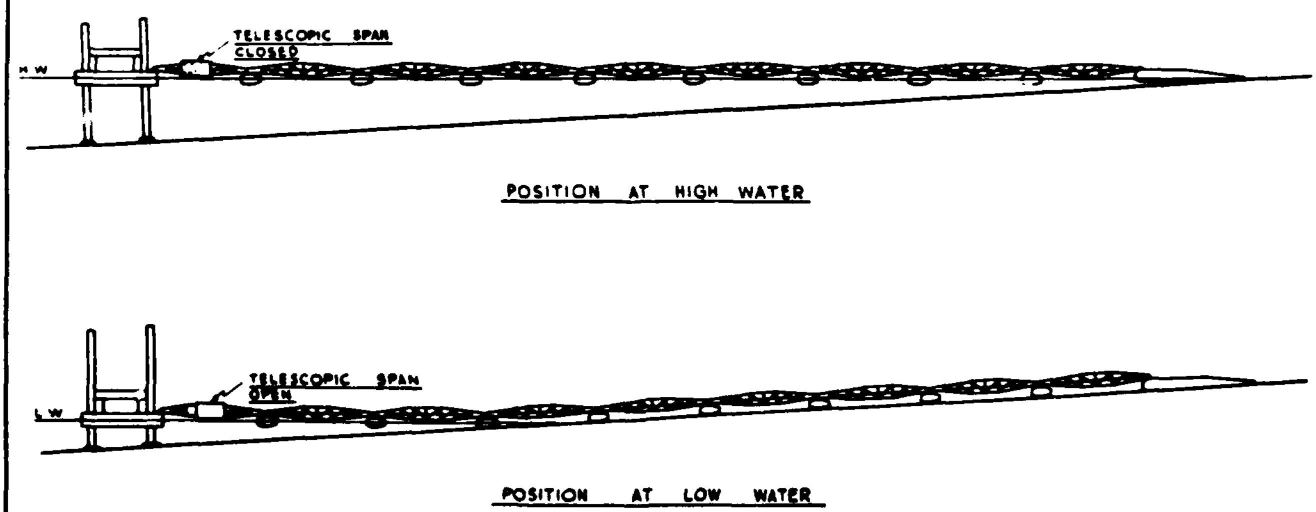
Conceptual Gooseberry

Lobnitz spud pier

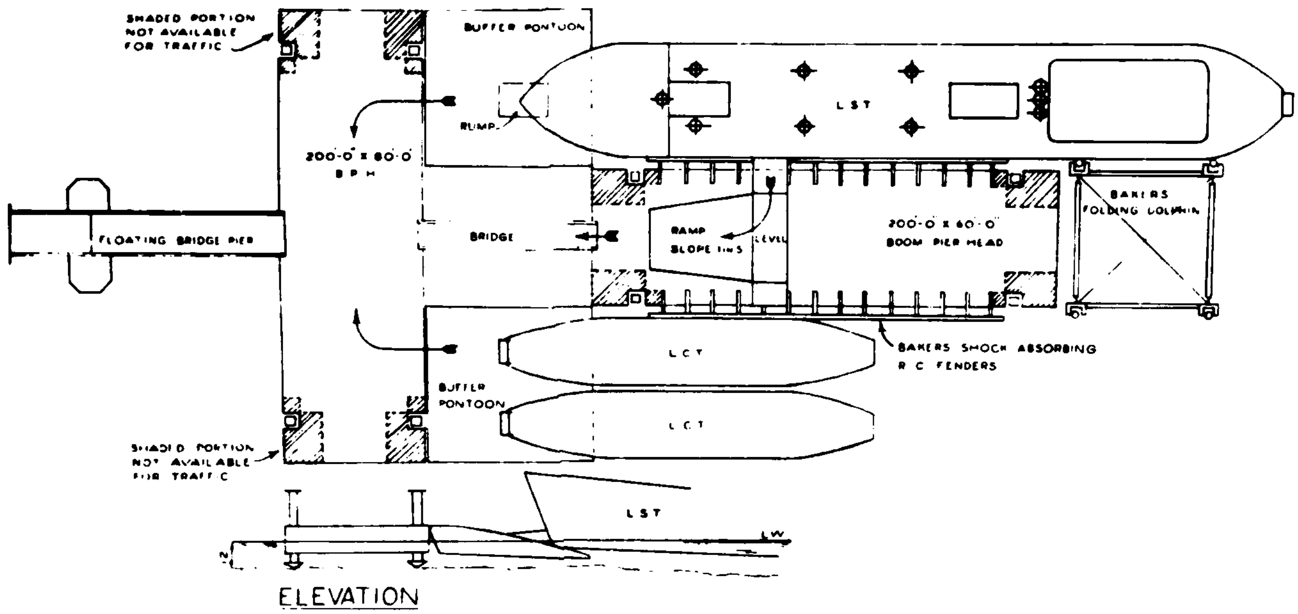




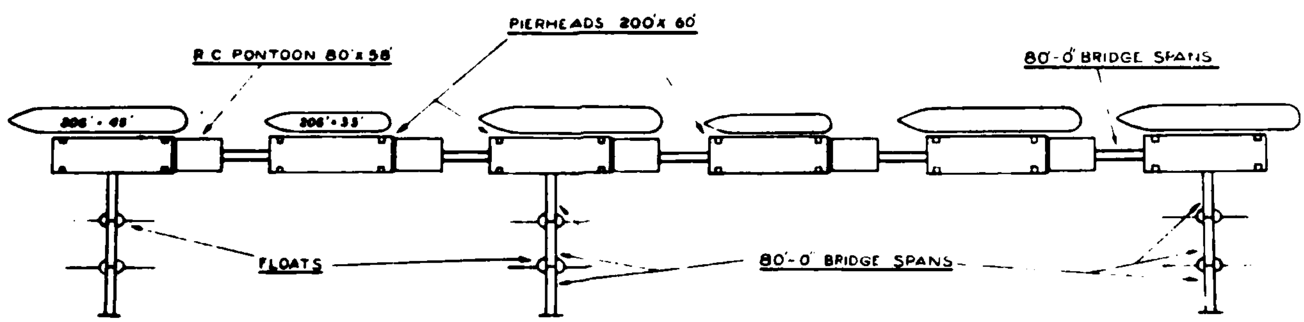
Floating causeway sections



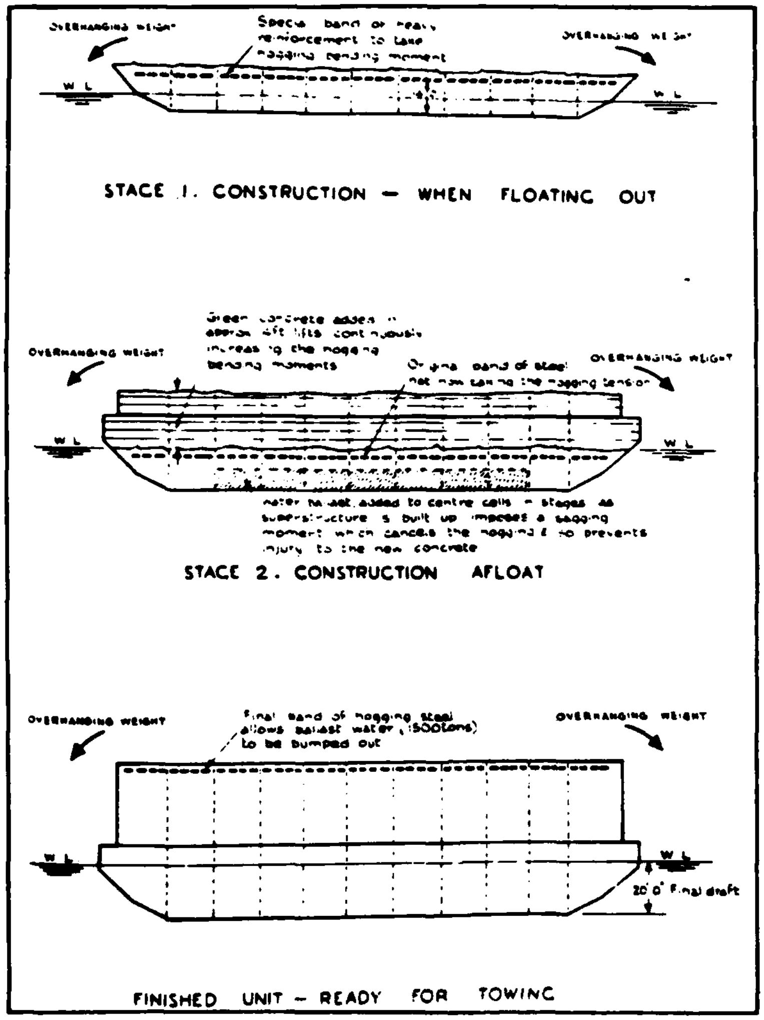
Whale unit: spud pier and causeway spans



LST Pierhead



Stores pierhead



a type Phoenix

Sketches on pages iv through viii courtesy Code Name Mulberry, by Guy Hartcup, Hippocrene Books Inc., New York, 1977, pp.21,23,34,36,40,50 51,64,69, and 74.

ENTERING A CONTINENT: AN HISTORICAL ANALYSIS OF PORT AND BEACH OPERATIONS IN THE EUROPEAN THEATER OF OPERATIONS, WORLD WAR II

> Perhaps the most significant lesson of World War II is that the military potential of a nation is directly proportional to the nation's logistical potential. That our resources are not unlimited is the first hard fact faced in applying that lesson. Next is that the slightest delay or inefficiency in harnessing our logistics resources may cost us victory. . . . It is inescapable that logistics will play a predominant role in any future conflict. . . . The rapid movement of troops and equipment to threatened points throughout the world will be of the utmost importance. . . . The destruction of logistic potentials will be the primary objective of warfare, the defeat of combat forces in the field becoming a secondary consideration.[1]

Clearly, if the last statement above is true, there is considerable work to be done to insure that logistics can be made to prevail on the next battlefield. Current priorities for force modernization concentrate on tanks, artillery, infantry fighting vehicles, aircraft and air defense systems at the expense of near-term (30-120 days) readiness, sustainability and mobilization. The ability to sustain the combat forces beyond the initial thirty days of conflict, particularly in a short or no warning situation is heavily mortgaged on the call up of reserve forces to provide transportation, ammunition, maintenance and engineer services in the theater of operations, and they must be prepared to go to war as they are. In the event of a short warning outbreak of hostilities in Europe or anywhere where US forces must project resources from offshore or resupply pre-lodged forces already on shore, ports, harbors and beaches will be of crucial importance to that mission. In order to plan for a worst case scenario, it must be assumed that enemy forces occupy the far shore, have recently vacated the area and endowed it with obstructions to navigation and the continuation of life, or are capable of delivering devastation by means of long-range aviation, rockets or missiles. Since the invasion of Normandy was the largest, most complex amphibious operation ever conducted, it seemed logical to revisit these operations to see what problems were faced, how they were surmounted and what "lessons learned" seem relevant for today.

With the evacuation at Dunkerque, the fall of France in 1940 and the continued pressure from the Soviet Union for the opening of a second front, it was only a matter of time before the Allied forces would have to reenter the continent of Europe. At the Casablanca Conference in January, 1943, the Combined Chiefs of Staff agreed that it was time to begin planning for the invasion of Europe in what became known as Operation OVERLORD. They selected Lieutenant General Sir Frederick Morgan who, on 13 April 1943, was designated as Chief of Staff to the Supreme Allied Commander (COSSAC) to conduct the planning phase for OVERLORD. His headquarters consisted of US and British Commmonwealth personnel, and after a round of successive debates, battles and analyses, it was determined that western Normandy was the most appropriate location for the Allied invasion _vice_ the Pas de Calais area, since proximity to Cherbourg and the Seine and Loire River provided the necessary port facilities needed to augment and eventually replace the assault beaches. The OVERLORD plan was adopted at the Quebec Conference in August 1943; however, for COSSAC and most of the logistics planners the real work was just beginning.[2]

Although the Norman coast of France in the aggregate is considered a poor coastal area, the _rias_, of Brittany, particularly the Rade de Brest and the sizeable bays on the southern shore of the Brittany Peninsula, were perhaps capable of being the greatest harbors in Europe. All naval and commercial ports have a major requirement: sheltered water against the effects of wind, wave and swell.[3] While maritime trade figures showed over

100 ports in France, very few were considered of useful military significance in the OVERLORD plan since most were small and subject to tidal influences. Planners on both sides of the Atlantic became preoccupied with the problem of sheltered water. The problem was divided into two areas: how to protect the harbor from the effects of the weather; and how to operate the ports and beaches in austere areas within the harbors. First let us look at developing artificial harbors.

The US Navy Bureau of Yards and Docks was familiar with this problem and in cooperation with the Admiralty and the Directorate of Transportation in the War Office in London began to consider ways of attacking the problem. At that time there were five candidates for breakwater devices. The "Lie-low" later shortened to "LILO" designed by Robert Lochner of the Admiralty's Department of Miscellaneous Weapon Development was a 200 foot long, 25 foot wide, hollow cruciform designed to be anchored at fifty foot intervals at the seven fathom line to break up seas and in a force 5, or half gale, wind reduce waves from 8 feet to approximately 3 feet. The LILOs, later renamed Bombardons, became the outer defenses of the open harbor and under normal circumstances would have been sufficient to accomplish their task had not their employment concept been changed. Admiral Ramsay, Commander of the Allied Naval Expeditionary Force, at the last minute changed their employment from a double line to a single line which increased the mooring stresses while reducing wave reduction and then compounded the problem by mooring them along the 11-13 fathom line instead of their maximum effective depth of 7 fathoms.[4] Needless to say, when put to the test of a real storm the Bombardons were not up to the challenge as we will see later.

A second candidate for breakwaters was a bubble breakwater which consisted of fixed underwater pipes through which compressed air was passed. On a small scale the bubbles proved effective in reducing wave actions, but the project proved technically impractical due to the time and effort needed for installation, the magnitude of scale involved and the insurmountable problem of finding enough electrical power to support continuous operation of generators and compressors. The third solution considered was the use of floating ships which would be anchored much like the slender Bombardons. However, experiments proved that the anchoring requirements for holding a ship broadside to wind, sea, surf, and swell were enormous and that solution was swiftly eliminated.

The fourth harbor experiment proved successful. The Admiralty recognized the need for a shallow draft vessel shelter since Navy responsibility went as far inshore as the high water mark on the beach and that meant landing craft, barges, lighters and patrol craft needed some protection from storms. Despite the critical shortage of shipping, the Admiralty calculated that they would need approximately 25,000 feet of block ship protection for the three Allied beaches and when the US agreed to provide 22,000 feet of that, it no longer became an issue for the British Navy. The block ships, tired or damaged merchant or naval vessels, would be sunk along the 2 fathom fathom line to provide sufficient freeboard for the 21 foot tidal range in the Bay of Seine. The ships were ballasted to eighteen feet depths and charges were placed about three feet below the waterline on each side of the hold. Sinking the block ships would be a problem as their descent was not always controlled and they sometimes ended up where they were not wanted.[5]

The final harbor development method was probably the most controversial and by far the most prodigious effort of the whole OVERLORD port plan. The British Army, in a fashion similar to the Admiralty, had its own concerns, for it had the responsibility for operation of the port facilities and the discharge of the cargo within the harbor. While the use of open beaches gives landing craft and dryed-out vessels some discharge capability, it is a very wasteful method and significant tonnage does not begin to generate until freighters begin to discharge either in the stream or at a pier. The Army concern, therefore, was for a deep breakwater capability, one that would shelter Liberty ships and large coasters programmed to move supplies from the United Kingdom. 5,530,000 measurement tons of supplies had been stockpiled in the British Isles in the year preceeding D-Day, and a large portion of that would be shuttled to the allies in France on these two types of craft.[6]

The British convened two committees in late September 1943; the first was to design a caisson: (1) capable of withstanding 8 foot high waves of 120 foot length; (2) a height which if sunk in 50 feet of water would provide 6 feet of freeboard at high tide; (3) capable of being sunk without being swamped; (4) towable in the channel at 4 1/2 knots; and (5) built of materials readily available. The second committee, made up of contractors, was responsible for production engineering and construction planning. After considerable experimentation, and continuing modification throughout the production period, the Army eventually modified the 4 knot to a 2 1/2 knot speed criteria, strengthened the internal bulkheading, modified the ballasting and expanded the production facilities to prepare 147 caissons for use in two artificial harbors known as "Mulberry A" on Omaha Beach and "Mulberry B" off the British landing beach at Arromanches. The number of caissons, code named "Phoenix," built for OVERLORD had the following dimensions and displacement:

Type Unit	Height (ft)	Length (ft)(in)	Width (ft)(in)	Displacement (Tons)	# Built
A1	60	204	56 3	6,044	60
A2	50	204	56 3	4,773	11
B1	40	203 6	44	3,275	25
B2	35	203 6	44	2,861	24
C1	30	203 6	32	2,420	17
D1	25	174 3	27 9	1,672	10

The magnitude of the task must be surmised from some of the statistics surrounding the project. The largest units (A-1) took up to seven months to construct, with the quickest time eventually being two months. The project consumed 545,000 cubic yards of reinforced concrete, 30,000 tons of reinforcing bars, 15 million linear feet of tubular steel scaffolding, 50 miles of wire rope, 3,500 sluice valves and fittings, and 20,000 tons of timber. Construction of the Phoenixes used up virtually every available drydock, yard and basin in Southern England, and in order to reach the required number by D-Day, massive shifts of laborers were needed to complete the work and every available ocean going tug was needed to park them at Selsey and Dungeness and then subsequently tow them to France.[7] With the harbor problem solved, the port problem was now addressed.

You will recall that the second phase of the lodgement problem dealt with the requirement to discharge vessels and other water craft in the austere environment of the assault beach and the reopened port; that job requires a different mix of equipment.

The US Navy, while contributing to the caisson project, was experimenting with its own port problems and in conjunction with the British, five different options were considered. The French roll bridging option, which involved flotation spans on the surface of the water, was abandoned due to problems of stability and limited load bearing capacity. The United Kingdom pontoons and the Hughes piers were tested but found unsuited for the mission. The examination finally settled on two feasible approaches. The first was the spud pierhead connected to flexible floating pontoon bridge spans; the other was the use of pontoons and pontoon ferries. The spud pier, known as the Lobnitz pier after its designer and manufacturer, was a rectangular floating steel hull 200 feet long, 60 feet wide and 10 feet deep. In each of the four corners were spud legs four feet square and no less than 89 feet long, which were raised or lowered at a rate of 2 1/2 feet per minute by twin wire cables attached to a 20 hp. electrical winch. The pier was designed to be raised 6 inches above the free flotation level thereby putting 42 tons of pressure on each spud to hold the pier in place; in rougher weather the pontoon was raised to 12 inches with a pressure load of just below 84 tons on each leg. The spud pier would be positioned in open water capable of berthing a vessel at low tide and would be connected to floating causeway sections eighty feet long supported by steel or concrete floats at each end of the bridge section. Sufficient numbers of the eighty foot floating spans, code-named Whales, would be connected to extend shoreward to the high water mark and preferably to an anchored shore connection. Each whale section would have its own anchoring harness and special kite anchors were provided to hold them in the anticipated seabed.[8]

If the British had their innovators in Lochner and Lobnitz, America had its pride in Captain John Laycock, USN, who in late 1939 and early 1940 was in charge of experimentation at the Navy's Bureau of Yards and Docks. The Navy had used for years pontoons and cubes of various sizes for flotation, camels and a host of odd jobs, but only seriously addressed their use as war approached. After several tests the Navy settled on a rectangular 5′ X 5′ X 7′ cube as standard with two other optional wedge shaped cubes of lesser dimensions for use as ramps or as seafacing surfaces. The tops and bottoms of the cube were of 1/4 inch steel while the sides were 1/8 inch. The cube had an internal pressure capacity of 25 psi., a payload of one ton, and a buoyancy capacity of 4 tons. The main problem Captain Laycock faced was how to connect the cubes together to avoid bending transverse moments and how to make strings of cubes. The first problem was solved by slicing off the top and bottom corners diagonally and placing open wedges with predrilled holes in them through which the cubes could be bolted together.

The second problem was solved by the use of channel and angle irons along the tops, bottoms and edges which were bolted and then welded together initially into three standard sizes: a 3 cube by 7 cube section could carry a 50 ton load; a 4 cube by 12 cube section carried a 100 ton load; and 6 cube by 8 cube section carried 150 tons and became the most common size, although it was frequently doubled and sometimes tripled to improve speed and efficiency. The Navy Pontoon Gear Manual listed 31 specific assemblies that had been approved following tests at the Advanced Base Proving Ground at Allens Harbor in Davisville, Rhode Island. The pontoons in different configurations could be used as lighters, Rhino ferries, crane transfer barges, pile drivers, casualty evacuation vehicles, bowsers (fuel barges), warping tugs, causeways, floating/submersible drydocks, causeways, and on land they served as liquid storage tanks, antitank traps, bridges, bunkers and at Port Lyautey in North Africa they were used to construct a 100,000 gallon water storage reservoir.

Normally two 2 X 30 pontoons were slung along either side of an LST. As the LST approached a beach the pontoons were cut loose from the sides so that they floated alongside the ship. As the ship approached the beach at full speed the causeways would be cut loose to ride onto the beach on their own momentum. A line from the bow of the LST would connect with the stern of one of the two sections and once the LST had beached, the tethered section would be pulled slide rule fashion back to the LST ramp while the other end overlapped the beached causeway section. The total elapsed time from casting free the pontoons to driving off the beach could be as little as eight minutes.[9] Once secured, vehicles would disembark from the LST. Discharge of vehicles would take anywhere from 30-60 minutes. One finds it hard to say enough for the simplicity, flexibility, and durability of the pontoon and its systems. The tribute to the pontoon by Rear Admiral Lewis B.

Combs, USN, must be at best an understatement; "When the history of World War II is written, it will record that the lowly pontoon played a significant role in virtually all of the major campaigns."[10] Many called them the "Jeeps of the Seabees."

How did the equipment work? The best test is war and storm. On 19 June a storm commenced along the Normandy Coast which has been described as the worst in 80 or 100 years, depending on whom you believe. In any case, Force 6-7 winds prevailed on 19 and 20 June and only abated slightly on 21-22 June. What happened on those days depends on whether you were American or British and whether you were at UTAH, OMAHA or Arromanches. Evidence indicates that the British were more prepared for the storm and with great alacrity took precautions that far exceeded the very optimistic weather forecast for that day. The British beach being furthest east of the three had some protection from the Cape de la Have. Mulberry B was not as far along to completion as Mulberry A and therefore had less to lose and its pontoon bridges were not as fully extended from the beach. Additionally the British took the precaution of doubling the anchors on each float bridge section while the Americans still had only one anchor per every other section. The British also sent cargo vessels out to sea in some cases at gunpoint, cleared the windward side of the pier of all shipping and had tugs standby to protect the piers and pier-heads from anything breaking loose. If anything did break loose they either towed it to where it would wash up on the beach or in other cases they intentionally sank vessels to protect the shore connections of the float bridges from being hit by flotsam. UTAH beach which had no Mulberry, only the small Gooseberry made up of the shallow block ships, fared better than OMAHA and it too for part of the storm was more protected by the Cotentin Peninsula.[11] OMAHA Beach was severely damaged.

The Bombardons, due to the employment changes by Admiral Ramsey described above, did not do well. Most broke loose principally due to separation of the bolted connections on each end which sheared off when faced with forces that exceeded design requirements. In some cases tugs were able to tow them harmlessly to shore, but most caused havoc by crashing into the Phoenixes, landing craft or the Whales, doing considerable damage in the process. Their effectiveness was never seriously tested at designed stress and had some device been incorporated into the design for one end to be cast free and ride with the sea they may well have survived for their original purpose. Several years ago a test was conducted off the Southern California Coast utilizing large plastic/steel/fiberglass floats based on the principal of the lane dividers used in swimming pools and they worked as well as the bombardons at considerably less cost in terms of the materials used. The concept is marginal, but except in severe weather the floating breakwater, <u>when employed redundantly</u>, has the potential to reduce wave action to manageable proportions.

The Phoenixes fared better than the Bombardons, but showed some problems as well as some advantages. OMAHA Beach lost 19 of the 27 Phoenixes during the storm. A few were battered by Bombardons that broke loose and a few more broke up when the surge of water between them scoured away the sand and gravel underneath the ends and the Phoenix literally broke its back and began to disintegrate. The vast majority were demolished by the force of the water which filled up the inside and which could not escape fast enough when the passage of a wave exposed the shoreward side to stresses beyond the breaking point.

Eventually 212 Phoenixes were constructed and after the initial emplacements showed that scouring could be prevented by using square rather than scow-like ends, that problem resolved itself. The caisson could have been modified to let water escape as quickly as it entered, but engineers chose the more practical method of filling in the hollow hull with dredged sand, and later on debris and rocks, before they capped the tops with corrugated steel roofing.

The British took some of the remaining caissons earmarked for Mulberry A, after the US Navy Salvage Chief scuttled plans to repair it after the June storm, and doubled up the row of Phoenixes at Mulberry B thereby extending its use well into November when the weather, distances, and other factors made its retention unnecessary. Also some of the spare caissons were later used in reconstructing the port of Le Havre which suffered extensive damage at the hands of German demolition experts. When used as extensions of existing piers, as new piers connected to land by causeways or jetties, or even as cargo islands for transshipment points they worked well. The major drawbacks, however, were their size, deployability, and vulnerability, and, most of all, the tremendous construction effort involved just to provide the required quiet water.

The pier-heads at both beaches were able to ride out the storm and were back into operation in a matter of hours. The Lobnitz pier has been improved upon by self-erecting pier units such as the De Long pier which saw extensive use during the Vietnam War and a very limited number of which still remain in the Army today for contingencies. The limited number of military pier units available may be offset by the wide availability of technically advanced platforms of this type used universally for oil and mineral exploration in virtually all the oceans of the world. A standard design could be produced rather easily with existing equipment and skills in a matter of weeks or months and other nonstandard systems could probably be modified to suit our needs. Similarly, the floating causeways at Arromanches survived with only moderate damage and their use in the future, while feasible, is, like the caisson, probably less desirable than the elevated pontoon causeway designed by the US Navy Civil Engineering Labs which combined the advantages of the causeway with the spud legs of the Lobnitz pier.

Generally everyone praised the block ships except the 1st Engineer Special Brigade which had responsibility for port and beach construction at UTAH Beach. They considered the Gooseberry "essentially useless, and [it] did not justify the time, effort or materials put into its construction."[12] This is the only adverse report noted on the block ships and one wonders if they confused the Gooseberry with the Mulberry Phoenix, for there was little effort required to prepare a ship for scuttling. It is possible that the report reflects the initial problems encountered when the Navy sought to emplace the first block ships. The combination of an inaccurate survey, a rip tide moving faster than expected and faster than the tugs could handle, an unexplained delay in detonation of the explosives later traced to rats eating the insulation and shorting out the primer cords, a Naval Officer in charge who was incapable of handling the situation and who was summarily relieved, and crews totally inexperienced in this type of operation all led to difficulties in the first two days, but from then on everything worked. Except for the ships that broke up due to scouring resulting from placement too far apart, most block ships rode out the war intact. There may be some latent interservice rivalry in the criticism, but there is little else to impugn the efficacy of the block ship.

The floating causeways received most of their damage from the June storm. The next most considerable damage was caused by rough handling of the concrete pontoon float. The plethora of landing craft and the ability to ground the LSTs on a very firm beach gradient of 1:250 to 1:150 made the sections superfluous. In some situations they would be useful and the technology should be upgraded and packaged for possible employment. The pontoon causeway, either floating or submerged, could in sheltered water do everything expected of the Whale bridges.

Was the Mulberry necessary? The Chief of the COSSAC planning group sums it up as follows; "No responsible group of officers could ever have been found to approve the whole OVERLORD scheme if it had not been for the idea of Mulberry." Secondly, the absence of the Gooseberries and the Phoenixes on 19-22 June might have resulted in the loss of all the landing craft and a good share of the lighterage. With the invasion less than two weeks under away such a disaster could have had irreversible effects on the outcome of the plan.[13] Portions of Mulberry could work in an estuary without the need for breakwaters and achieve the same ends. The Mulberries were a success and had landing craft been unable to beach and/or discharge their loads directly onto the shore, they would have been absolutely essential to execution of the plan.

Before we leave the harbors and beaches and head for the port it is necessary to address lighterage. Lighterage, generally flat bottomed barges used in the loading and unloading of ships, was generally plentiful in the Normandy area of operations since the Channel and European ports rely heavily on barges and small coasters to distribute cargo. There are, however, many areas in the world that do not possess lighters in large numbers and planners must consider their availability.

The small coastal freighter and the now extinct Liberty ship were the major participants in the invasion force and like the lighter these other two classes of vessel are becoming fewer in number and larger in size thus limiting the flexibility of the planner as well. The Liberty ship was replaced by the Victory ship and todays breakbulk commerce moves in Mariner class and other vessels with larger capacities, deeper drafts, longer exposure times, and far fewer numbers; this too must concern the planner. The record of the OVERLORD buildup reveals that one of the pivotal reasons for delaying the invasion of Europe until 1944 was the time needed to build the landing craft needed to mount the invasion. Even as critical as the Phoenixes were, nothing was allowed to reduce the output of landing craft. The situation today is just as critical. Since World War II we have moved up from the LCM-6 to the LCM-8. The LCT of World War II has evolved to the LCU then to the 1600 class LCU and now we have the Landing Craft Air Cushion (LCAC) of the Navy and the Lighter, Air Cushion Vehicle (LACV) of the Army. We also now have the Newport Class LST. In most cases the numbers of such items are insignificant, and they are mostly old, one of a kind makes for which repair parts are unattainable. For the more modern craft the procurement buys are in the single digits annually. They just don't have the visibility and the pizazz of a tank or a helicopter, yet they do so much for both.

One piece of equipment which did stand out in World War II still hangs on valiantly in its latest version. In what must be considered typical British reserve, the 21st Army Group Final Report comments; "the most interesting feature concerning transport was undoubtedly the operation of the 2 1/2 ton amphibious truck, known as the DUKW."[14] It was noted that even during the worst part of the storm of June 1944, American DUKWs at the British beach at Arromanches continued to discharge vessels at anchor, landing almost 1,500 tons (mostly ammunition) on the worst day of the storm. The 1st Engineer Special Brigade was more forthright when it reported that "the DUKW (2 1/2 ton, 6 X 6 amphibious truck) is worth its weight in gold in an assault landing such as NEPTUNE. No self-respecting invasion should be without them."[15]

DUKWs (their manufacturer's code system had D stand for the year, 1942; U for utility; K for front wheel drive; and W for its two rear driving axles)[16] were praised wherever they went. In the Pacific campaign they were fitted with A-frames on their sterns and using the power take-off winch, were able to load/unload other DUKWs as they transitted the supply dumps. An attempt to fire 105 mm. howitzers from their cargo compartment had to be given up as impractical, but DUKWs specially adapted with rocket launchers proved successful at giving supressive fire during the assault on New Britain and in subsequent campaigns.[17] The DUKW also was instrumental in providing the first combat exposure and then grudging acceptance of the Negro soldiers who operated the DUKWs in each of the theaters.

The LARC V, an upgraded version of the DUKW, has left the Army's inventory and token numbers of LARC-XV and LARC-LX still exist today, but no action has been taken to procure an improved wheeled amphibian which was the principal recommendation of the Trans-Hydro Study conducted by the US Army Transportation School in the mid-1970s. The absence of such amphibians in adequate numbers creates a bottleneck at the waterline. By equipping each of the DUKWs with a compliment of nine cargo nets, loose cargo could be slung from the ships hold in the net into the DUKW, which would then go to the onshore dump or the waters-edge transfer point and exchange empty nets for loaded ones. Regardless of where one looks in World War II histories one is continually impressed by the role of the DUKW. Until we have its counterpart in sufficient numbers we will have difficulty in sustaining beach operations.

Once the beachhead is seized or the beach is no longer usable, it is time to open up the ports of the area. OVERLORD plans went to great lengths to work up estimated capacities based on prewar statistics as well as extensive surveys of topographical maps, hydrographic charts, and engineer estimates. One could easily double or even quadruple the length of this report by going into a detailed analysis of the arguments surrounding the question of ports and resupply particularly after 17 August 1944. Harold L. Mack, who was one of the original OVERLORD planners and who later served as the Chief of Movements, Communications Zone, in a monograph recently published by the National Defense University reopens the debate that has raged since the beginning of OVERLORD.[18] COSSAC initially envisioned an assault force of 3 divisions (which was subsequently raised to five) with eventually 26-30 divisions to be supplied by Christmas; in reality the number reached 39 by May 1945, with 20 US, 17 British Commonwealth, one French and one Polish divisions. Plans had to be adjusted, re-adjusted, re-written, and then expanded.[19]

The original OVERLORD plan called for a breakout from Normandy, once the initial lodgement area was secured. The US Third Army would then establish a line running from Avranches through Rennes to Nantes sealing off the Brittany Peninsula and would then seize the ports of St. Malo, Morlaix and Brest on the north side and Lorient, Quiberon Bay and St. Nazaire on the south side of the Peninsula. The Brittany ports would give the allies an alternate rail supply line, running from Vannes to Rennes to Paris and on to Trier and Coblenz, which would parallel the line of communication running from Cherbourg to Langle to Paris. Still yet another supply route running from St. Nazaire/Nantes through Tours to Orleans and then to Paris would give the allies almost unlimited logistical capability.[20]

Quiberon Bay with 3,000 yards of excellent beach, a sheltered anchorage for 200 Liberty ships, and four minor ports plus excellent rail and road nets immediately adjacent to the discharge points was counted to be the main supply port with men and equipment continuing to use the Normandy ports/beaches. Securing Quiberon Bay would not require the crossing of the defended Loire River considered a major obstacle. In addition, the establishment of an extensive beachhead with large numbers of troops could be avoided.[21] The plan called for the expansion of the lodgement area to include most of France north of the Loire and west of the Seine Rivers by D+ 90. After the Seine line had been reached a period of three months would ensue for the necessary buildup of supplies and forces preparatory to an advance to the East.[22]

However, once Third Army broke out, its commander and some of the divisional commanders, smelling a quick kill and a possible race to glory across the Rhine, could not countenance being bottled up in Brittany. Major General John Wood, CG, 4th Armored Division, recounted on numerous occasions how he asked his Corps commander, Major General Troy Middleton, for permission to turn east and chase the disintegrating German Army.[23] The official record shows that Third Army penetrations into the peninsula were not seriously challenged and elements of the 4th Armored Division secured the Quiberon Bay area but reports passed to higher headquarters gave the Corps commander the perception of a battle of attrition which they wanted to avoid. There is little doubt that Wood had no intention of sticking around to secure the Brittany ports and his perseverance eventually convinced Patton and Bradley to get the SACEUR to approve the Lucky Strike Plan B on 3 August, which gave Third Army the go ahead to chase the Germans.[24] If, as Mack suggests, someone (perhaps Bradley) had taken the time to explain to Patton that Third Army's progress was tied directly to resupply through the Brittany ports, he (Patton) would have spared no effort to secure the necessary logistical facilities before advancing. Mack further states that upon visiting Middleton's headquarters Bradley recognized immediately that Patton had not carried out his mission, yet did nothing about it. Middleton's forces were wasted in the quest for Brest which was never planned for as a major port. Bradley never carried out Eisenhower's instructions to secure the Brittany ports because he overestimated the German threat, never trusted Patton or his tactics, and did not understand the logistical necessity of Quiberon Bay.[25]

The delay in the breakout was both a blessing and a curse. It was a blessing in that the delay allowed a build up to 17 days of rations, 10 days of POL, 18.6 units of fire for small arms and 11.1 units of fire for artillery ammunition. The Normandy ports were averaging 32,000 tons per day of supplies.[26] It was a curse in that serious logistical problems would surface because the speed of the August advance consumed reserve supplies, stretched the available transportation, and provided too little time to extend rail and pipelines toward the front. Eisenhower, blinded by the tactical successes begun in late July and early August, could see no reason not to jettison the carefully developed OVERLORD supply plans, but supply did not and could not keep up with the tactical flow. Supreme confidence was not matched by reality and no alternate supply plans were drafted to complement the Lucky Strike plans.[27]

While Patton and others villified COMZ and logisticians in general for failing to keep up, a postwar General Board concluded that "the change in tactical plans and accelerated schedules were as satisfactorily responded to as could be expected." But the same report also pointed out clearly the folly of ignoring the ports. By D+ 60 in early August only 1,032,045 tons of the required 1,640,850 tons or 62% had come ashore, and by D+ 90 only 1,944,025 of the required 3,070,160 or 63% had been received; clearly the 12th Army Group was in trouble. Even with the Brittany ports which were not captured, the forecast of supply showed a 22,000 ton per day shortfall at D+ 180 onward and that figure could only get worse. Daily discharge of 19,735 tons versus the 41,600 tons planned occurred in October, 19,925 versus 50,100 prevailed in November, and 27,365 against 64,100 in December shows dramatically how crucial was the absence of the ports. Quiberon Bay alone was rated at over 13,000 tons per day with potential expansion to 20,000 tons.[28]

The first major port to fall into US hands was Cherbourg. Originally scheduled for capture by D+ 8, it was D+ 21 before it was secure. Cherbourg, ranked only 22nd among French ports in 1937 with an average daily cargo capacity of 900 metric tons, was principally a passenger port with meager cargo handling facilities and few vessel berths. Cherbourg was scheduled to clear 7880 tons per day in the initial plan; that was subsequently raised to 18,000, then 22,000 and the last plan called for a capacity of 28,300, but by the time the facility reached a capacity of 24,800 tons in early November no attempt was made to reach design limit as Le Havre, Rouen, and some of the Channel ports were open, Antwerp was due to open shortly and railroad clearance problems from Cherbourg had not been overcome. That 24,800 ton capacity consisted of 28 Liberty berths, 2 Twickenham (Railroad) Ferry berths, 14 LST ramps, 13 coaster berths, 75-120-foot barge berths and 1 tanker berth totalling 133 berths in all.[29]

For his efforts to deny the Allies the use of Cherbourg, the German Naval Commandant there was awarded the Knights Cross of the Iron Cross for "a feat which is unprecedented in the annals of coastal defense." It took nineteen days to open Cherbourg to commerce vice estimates of from 3-10 days for clearance. The first day of operations was on D+ 40 and a grand total of 7 tons was landed by DUKWs since only one approach lane had been cleared. Minesweeping began on 30 June, and 268 planted mines, plus virtually every other type mine including some never experienced until then were found. An especially insidious one was a ratchet type mine planted on the bottom. Each time an object passed overhead, the ratchet on the mine would advance and when it reached the preset number of clicks the mine would rise from the bottom and detonate on the next contact. In spite of continuous sweeping through September, five vessels were sunk within the harbor area.[30] COSSAC had planned for certain damage: 90% of the quays were expected to be damaged with 50% repairable within a few days and 20% beyond any repair in a reasonable time; no workable port equipment, locomotives or rolling stock would exist; 75% of the railroad track in the port area would be destroyed; and all railroad, docks, and highway bridges in the port area would be destroyed. Cherbourg damage came very close to those estimates, as did that at Le Havre.[31]

The principal problems experienced by both the US and the British in port rejuvenation were: (1) gaining seaward access by the removal of mines and block ships; (2) defusing mines and booby traps; (3) clearing debris and rubble from berths; and (4) dredging channels closed or impaired by silting. Another problem in the heavily damaged ports was finding adequate space for locating base depots, otherwise the ports became quickly congested and discharge operations became difficult.[32] At its peak, Cherbourg had 4,400 Engineer troops, 400 civilians and 1,000 POWs working. In the 171 days before repair was curtailed, 7.13 million man-hours of labor were expended and 9.34 million board meters of heavy timber, 7,100 barrels of cement and 23,000 sacks of abandoned German cement, 300 tons of structural steel, 75,250 bolts, 108,500 drift pins and 500 tons of reinforcing steel were used in the rehabilitation efforts headed by the 1056th Engineer Group.[33] By the end of August, Cherbourg was up to 12,000 tons per day and within a short period of time began to displace UTAH Beach in August and OMAHA Beach in September as the principal source of supply in Europe.

Approximately 20% of the total rehabilitative effort of the Normandy Base Section was committed to ports, another 17% was spent on repair of the railroads and 14.5% was spent on quarry, water and utility projects to put Cherbourg up to the task.[34] One of the more interesting sidelights to the use of Cherbourg is the fact that in order to provide sufficient electrical power to begin the cleanup, a US Navy destroyer escort was brought to the Digue du Homet and hooked up to the city's power lines pending repair of the demolished generators.[35]

Since Cherbourg was not dependent on the tides for operation, the port was expanded very rapidly using field expedient solutions. The seaplane base ramp was quickly turned into LST ramps. There were large segments of the port used for swimming beaches and with the construction of hard stands, they were used as exit/entrance lanes for DUKWs as well as LCT and LCI discharge. Quay destruction was overcome by driving pilings off the facings of both damaged and incomplete wharfage and constructing wharf platforms, most of which included railroad trackage. Stiff leg cranes were also constructed every 256 feet along the full-length of the barge piers on the Terre Plain to provide for lighterage discharge and concrete platforms were built to facilitate transfer of cargo from DUKW to truck or train. Repairs to the damaged lock gates in the arsenal area proceeded slowly due to mine clearance and higher priorities but even that area was back into operation by the end of the year. In short, Cherbourg had a great deal of expansion potential, much more than might be expected in any future port operation.[36]

Even with Cherbourg in operation the port paucity remained and when Rouen fell on 2 September, Antwerp on 6 September and Le Havre on 11 September the Americans became both desperate and cocky. The capture of

Antwerp, Dieppe and Ostend by the British seemed to indicate that Germany would soon collapse completely and that ports were no more significant than they had been after St. Lo; the single purpose being pursuit. With these ports in their hands the British, who were suffering a critical shortage of ground transportation so acute that they grounded the 8th Corps in order to free up their lorries, had no objection to transferring Le Havre and Rouen to American control because the latter desperately needed to shorten their supply lines as well. Dieppe was opened within five days after capture and by the end of the month was capable of 7,200 tons per day. Ostend, more heavily damaged, took a little longer to repair but nevertheless provided additional capacity much closer to the battle area.[37]

While Antwerp itself had been captured on 6 September, the port was not to open for almost three more months since the approaches on either side of the River Schelde were still under German control. The "failure to open Antwerp until late in November forced the allies to develop an interim port that could relieve Cherbourg and the beaches. This port was Le Havre." Damage to Le Havre, which is essentially a tidal port, was as extensive and not as readily redeemable as Cherbourg. In addition to the gates to virtually every one of the twelve basins or drydocks being damaged or destroyed, the bridges over the basins were crippled, making movement within the port almost impossible. An even stranger situation developed, however, which had not been foreseen. As the locks and basins were designed to have water within them on most occasions the hydrostatic pressure on the walls was generally balanced; however, when the lock gates were destroyed, the water went out of the basins on the tide and the absence of a countervailing pressure on the walls cause the latter to collapse into the basins causing additional construction problems. Planners called initially for 1,500 tons a day from DUKWs and 7,000 tons a day from Libertys with a target tonnage eventually of 31,300 tons; the average attained during 218 days of operation was only 5,904, placing Le Havre midway between the capacities of UTAH and OMAHA beaches. Another unique problem faced in Le Havre and nowhere else, but one with portent for any future operations was civilian labor. Due to heavy allied bombing which caused appalling destruction in the city, the citizens of Le Havre were unwilling to assist in port rehabilitation and some delays were caused by the shortage of skilled workers and the difficulty in locating plans or knowledgeable personnel for operation of the locks, the utilities and the port itself. It was almost like occupying an enemy port.[38]

On 3 October, Rouen and the Seine River ports were transferred from British to US control and work on clearing the canal from Rouen to Paris proceeded. By 4 November capacity had been raised to 3,000 tons per day; after obstacles over the canal were removed or repaired the capacity was raised to 10,000 tons a day, only half of its peacetime capacity, but still something in a very hectic world. Rouen began operations on 13 October and during November averaged 4,100 tons per day which climbed to 6,900 tons daily in December, a very respectable tonnage for that port. Seven block ships sunk by the Germans at Calais were quickly removed and that British port soon began accepting large numbers of troops and backloaded casualties on the channel ferries for all the nations involved.[39] Ghent was captured the day after Antwerp, but damage to the Terneuzen Locks was so extensive that it took two months to repair the channel for reopening and the first discharge of cargo did not take place until 19 December. The port was not officially opened until 24 January and was not fully operational until February. Initially it was planned to use Ghent as a back-up for Antwerp, but when the V-1 and V-2 rockets started to fall on Antwerp, Ghent was used primarily as an ammunition port by both the US and UK.[48]

The port of Antwerp which was under British control and responsibility, but in which the US received a tonnage allocation of almost half, was a dream. Captured virtually undamaged, the port had 30 miles of docksides and quays with over 85% of its cranes still in working order. Most of the POL facilities and pipelines were still operable. With 500 miles of double tracked sidings in the harbor alone connected with 3,250 miles of standard gauge rail inland, 1,370 miles of navigable waterways, 800 warehouses, 24 grain elevators, and 208 acres of petroleum storage, there was virtually nothing that Antwerp did not offer. In 1937 the port had handled 57 million tons of cargo and the military cargo capacity was estimated at between 40 and 50,000 tons per day or one fourth its capability.[41]

Antwerp was an answer to a prayer in more ways than one. The port congestion problem caused by inadequate transport led to ships waiting at anchor to be discharged and in some cases ships were used as floating depots intentionally. In October there were 290 ships backed up in European ports and after some heated exchanges between Europe and Washington including direct traffic on the subject between Eisenhower and Marshall, supplies from CONUS were embargoed until the shipping glut was reduced. Europe was not the only theater of operations and what scarce shipping that did exist had to be equitably allocated and <u>used</u> by all claimants.[42] Antwerp also cut the length of supply lines; where it was 1,044 miles from Cherbourg to Liege, the principal depot area, it was only 200 miles from Antwerp. For every ton moved by rail from Cherbourg, 2 1/2-3 tons could be cleared from Antwerp by rail, road, or canal. Although it had taken 28 days to survey, minesweep and dredge the channel to Antwerp, it was well worth the effort since the allocated capacity of 22,500 tons per day was reached within two weeks of opening. In fact Antwerp's total tonnage in its first month of operation exceeded the output of any other facility including Cherbourg at its best, and its capacity was expanding steadily as the war ended.[43] Even in December when the German breakout at Bastogne occurred, there was only a momentary pause as to the safety of supplies, and the surge capacity of the transportation net was so great that much of the supplies were held in mobile storage in rail cars and barges and as soon as the threat was over cargo moved forward for discharge with only minimal impact on port operations.

Port clearance and construction in Europe at its peak involved 7 Engineer Port Construction and Repair Groups, 6 General Service Regiments, 1 Special Service Regiment, 5 port repair ships, 4 seagoing hopper dredges, 3 British grab dredges and 2 British bucket dredges. This does not include any of the British effort from Rouen north to Antwerp. It also does not include the US Navy Seabees who had responsibility for mine clearance, block ship removal, and navigational aids. The Army had to assist the Navy in the latter activities particularly on the beaches for demolitions, obstacle removal, and equipment repair. The Chief Engineer of the European Theater in his final report stated that the Port Construction and Repair groups were extremely effective in virtually every type of work assigned since their equipment was multi-purpose; when ports were repaired they could just as readily construct bridges, repair canals, replace railroad right of way and perform general construction. The only capability they lacked, and no engineer unit in theater possessed, was tunneling experience which was critical in some railroad projects. The Engineer Special Service Regiment was particularly valuable in Europe and MacArthur thought the world of those he commanded in the Pacific, but both were disestablished shortly after the Army transferred proponency for amphibious training to the Marine Corps. There was a shortage of dump truck companies, and the 2 1/2 ton dump truck was underpowered for the movement of debris. Organic lift for heavy equipment did not work well in a pooling arrangement, and the American hopper dredges proved to be too big to get into the channels, rivers and ports to begin the repairs to piers and quays. Zeebrugge, today a key ammunition port, was so heavily silted that it could not be used before the war's end. The Chief Engineer also felt that there should be at least one port repair ship for each major port where their extensive machine shops, generators, compressors, welding equipment, and heavy material capability made them valuable for a number of tasks.[44]

The port construction mission is an important one even if adequate beaches exist because the efficiency of a port is so much greater. In World War II we had time to survey the needs, assemble the forces and equipment, train them, exercise them through progressively larger and more difficult operations, and, even when given time to plan it all out, we still ran into monumental problems that were never fully rectified by the end of the war. Two jobs that will be near the top of any list of Engineer achievements in World War II will be the Normandy beach operations and the opening of Cherbourg combined with the increase in its capacity.[45] The impulse to charge off in new directions must be resisted when the resources to follow through are not enough. The logistical lesson of the August breakout was manifest also in the tactical lesson of Operation Market Garden; too much was sought too quickly by too few.

There were additional problems experienced in the OVERLORD operation. Some of them seem patently obvious, but for whatever reasons, they still were problems in being. Operational control must be combined into one superior headquarters; this was evident from the beginning in both the American and British efforts to develop and coordinate the ports, harbors and construction efforts. It was also evident in the musical chairs played with the senior staff logistician who vacillated between five different headquarters at one stage of the operation or another. It again surfaced on planning responsibilities between seven different headquarters during the operation.[46] It's a lesson we don't need to relearn every time. Special equipment to perform unusual missions must be constantly reviewed. The success of the DUKW cargo transfer operations was significantly premised on a minimum of nine cargo nets per vehicle; this doesn't mean that every DUKW in the world needs nine nets, but those that do really can't do without them. Army demolition teams on UTAH and OMAHA beach had to place explosive charges in socks weighted by rocks and then tied individually to demo cord to do the same thing the Navy demolition crews did by placing an M-1 satchel on the obstruction and fuzing it. Some people said the 7 1/2 ton crawler crane was useless in Europe, but most in the Pacific said the same thing about the 7 1/2 ton truck mounted crane because the beach materials and gradients were drastically different yet both were fine pieces of equipment. The problem was that there were not enough of either of them to do both construction work as well as all the cargo transfer operations not only on the piers, quays, wharves and beaches, but also at the supply dumps, railheads and depots where all that "stuff" is handled again. At one point in time the stevedore gear needed to expand some ports and open new ones was loaded on the vessels in England for discharge on the Continent, but nobody thought to do that with the first increment of shipping from CONUS where the cargo was tightly block-stowed administratively instead of readily accessible in the tactical load used in England. There was, is now and probably always will be a shortage of materiel handling equipment (MHE), particularly electrically powered gear required for ammunition operations. Their efficiency in terms of man-hours of labor saved is far greater than their purchase price. Time and time again one sees cases of fire bucket type hand to hand exchanges that could have been abbreviated by conveyors and other labor saving devices, and today's logistics for the most part is palletized if not containerized to reduce the manual labor involved, but the chain of custody equipment to move it is not always in like configuration and inefficiencies are created.

In summary, for beach operations we need: breakwater systems, rapidly deployable and employable; EOD teams; spud piers and causeways; pontoon systems; tugs; landing craft and lighterage; amphibians; and abundant MHE. For port rehabilitation we need: a port repair vessel or machine shop equivalency; mine sweeping resources; shallow draft dredging; floating barge/derrick cranes for lock repair and obstacle removal; piles and pile driving equipment; debris relocation capabilities (dump trucks, conveyors, etc.); and utilities repair. To put both together we need a single integrated headquarters capable of defining the missions and assigning tasks and priorities. Presently, most of these requirements are lacking to some degree in every area, and the "get well" date is getting further and further away.

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