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A Flexible Ship and A More Responsive Navy

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Faced with uncertainties about the nature of future conflicts at sea as well as continuing economic constrictions on the size of U.S. defense expenditures, the Navy finds itself in the difficult position of having to maintain today's combat-ready forces while trying to develop and acquire new weapons systems. By designing a new ship type adaptable enough to serve a wide variety of functions in both peace and war, the Navy would not only gain needed flexibility but new savings could be realized as well. The concept of the air capable ship potentially can make significant contributions to enhancing America's continuing role as a maritime power. (The opinions in this article are those of the authors and do not necessarily reflect those of the Naval Air Systems Command.)

A FLEXIBLE SHIP AND A MORE RESPONSIVE NAVY

An article

prepared by

F.W.S. Locke, Jr., and Virginia Withington

Introduction. Withdrawal from Vietnam will urge an exhaustive reconsideration of priorities both in the United States as a whole and within the Navy Establishment. Many changes in the allocation of national resources can be expected, and if the international climate appears comparatively benign, the proportion of the budget allotted to the military will be sharply reduced.

It is not too early for the Navy to be examining its future in the light of the impending reductions, for "nothing, it seems is quite as effective as a sharply reduced budget to force an organization to reveal its true priorities,"[1] and it is possible that a sizable effort will be needed to induce the Nation to maintain a Navy in times of low tension. A major consideration will be how to maintain readiness, to insure the ability to meet any future emergencies, to take continuing advantage of the growth of technology, and to persuade the Nation that these matters are of importance to the realization of national policy.

It is the intention of this paper to propose means whereby the Navy can maintain a high degree of training, develop a pool of vessels and aircraft capable of fast conversion to unforeseen military duties, and perform a variety of tasks that have broad applications in the international political arena.

The Navy and the Nation. In the current period of economic difficulties and with U.S. participation in the Vietnam war sharply reduced, the U.S. Navy confronts the type of dilemma it faced during the twenties and thirties: within a circumscribed budget, it must on the one hand, maintain itself in a healthy state of readiness for any eventuality, and on the other, it must develop and acquire new combat systems, both ships and aircraft, for future conflicts. And it must do this at a time when the competition for national resources will be extremely keen.

There is a major responsibility for the military and Congress to maintain communications: the military must persuade the Nation that it is preparing for *future* eventualities and is not—as is often unfortunately apparent—making ready to refight the last war; and the Congress must formulate its changing policies with due reference to their implementation, making sure that the military arm is instructed as to its duties in relation to these policies. Recent history of U.S. policy certainly shows the benefit of flexibility in military planning.

The Navy has a unique responsibility among the services to maintain a diversified capability, since a Navy can be equally useful to a nation in peace and war. As Mahan says in his seminal work: "Naval strategy has indeed for its end to found, support and increase as well in peace as in war the Sea Power of a country." And he quotes "a recent French author" as saying that naval strategy differs from military strategy in that the former is much broader and is as vital in peace as in war.[2] While these early writers probably meant that a maritime nation must at all times be alert to the need for well-spaced coaling stations and strategically located overseas bases, one can also infer that a properly employed Navy may also represent a nation overseas in friendship.

The proper design of naval forces implies providing for a range of vessels useful in a wide variety of situations. For example, a CVA task group is too costly and warlike to be used in short-of-war confrontations;* smaller, less obviously aggressive forces should be available for less dangerous situations. The ideal Navy is prepared for a wide range of peaceful errands—showing the flag, enforcement of international agreements, prevention of piracy, assistance in navigation on the high seas—escalating to full battle posture when called upon. This is a radical idea in the context of the post-World War II Navy. The current Navy consists of groups of highly specialized warlike vessels, all very costly and incapable of being modified for other tasks without extremely expensive yard periods, and few officers can conceive of any other composition of forces. As a radical idea, the flexible Navy will be difficult to introduce, and possibly even more difficult to set in motion promptly through the layers of the entrenched establishment of the Department of Defense.

Many years ago Jane pointed out "the conservatism so inherent with nautical men who as a class are averse to going either forward or backward."[3] Not only is there continuing conservatism, but there apparently also exists the classic lack of communication between the technical and operational officers which further inhibits change. Vice Adm. H.G. Bowen, Sr., in his lively description of his efforts to improve destroyers in the thirties, tells of his exasperation when operational officers made technical as well as operational decisions, with no knowledge of the technical facts and possibilities.[4] Today the technical man must usually await the writing of "requirements" before he is allowed to spend money on new devices that might well influence the content of these same requirements, and he is seldom, if ever, consulted in the

*The CVA and embarked aircraft cost approximately $1 billion, plus escort vessels (total personnel about 6,000). This investment makes it extremely difficult to justify using a CVA task group for anything but warlike action at a high level.

preparation of basic policy. The system tends to inhibit the adaptation of technology and appears to perpetuate the conservative outlook.*

Potential International Situations. It is, of course, impossible to predict accurately the comparative political and technical strengths of the United States and the other nations of the world for more than a few months ahead. The only way to manage such projections is to postulate wide-ranging assumptions and then assess the role of the Navy under the assumed circumstances. Yet, regardless of the general nature of future world politics, some conflict must be anticipated, and therefore a surface Navy capable of rapid response to varying degrees of provocation must be continued. In fact, the major threat to our free use of the seas will be the submarine which can launch both underwater and airborne weapons. No very effective countermeasure has yet been developed, and no breakthrough in underwater sensing can be foreseen. Thus the Navy of the future, no matter what the scenario, must be capable of the best available antisubmarine and antiaircraft warfare.

Since it is clearly impossible to predict accurately the alignments and animosities of 10 years from now, the only useful attitude to take is one of preparing for almost anything. It is probable, however, that some combination of "withdrawal," "cooperation," and "conflict" will characterize U.S. politico-military posture to the end of the century and that the role of the United States at sea will be increasingly various. Its tasks will be military: antisubmarine and antiair warfare, mine countermeasure, amphibious assault, attack, and protection of shipping; paramilitary: protection of trade routes, enforcement of international agreements on the high seas; and peaceful: protection of trade routes, rescue and relief, establishment of navigation systems at sea, transportation, and pollution control.*

Mobile Support System (MSS) the Air Capable Ship (ACS).** To meet the requirements of flexibility for the future within the parameters of reduced expenditures for defense, Navy planners would be well advised to recognize the potential significance of what we shall refer to as the MSS/ACS concept. Initially the flexible ship was studied in NAVAIR with a view to supplying an inexpensive and effective escort, primarily in antisubmarine warfare. The resulting vessel was called a mobile support system to emphasize its basically passive role. The use of helicopters and other VTOL for primary weapon systems allows for the use of a small, simple carrier, since VTOL do not need catapults or arresting gear and require only a pad from which to operate. The

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*Col. Raymond C. Shreckengost, USMCR, in an article on "Technology and the Establishment," *Naval War College Review*, March 1972, p. 16-32, points out that technological advances, by challenging organizational status quo, represent a threat to the "Establishment" and thereby can be expected to be resisted strenuously.

*While much of this peacetime activity may fall to the Navy, it is realized that the U.S. Coast Guard, now performing many such tasks in local waters, could well expand its scope, given the proper vessels and aircraft and the encouragement of the Congress. To the extent that Navy vessels are appropriate, the Coast Guard has employed them; thus, to the extent that the flexible vessel to be discussed herein will be appropriate, the Coast Guard should make use of it. Therefore, the function alone will be discussed without reference to whether the actor is the Navy or Coast Guard.

**The designation "air capable ship" (ACS), first employed in NSSM 50, is used herein in preference to the later term "sea control ship," since the latter is in the system, having graduated from the conceptual stage. An ACS might very well become a sea control ship.

flexibility of the concept is based upon the judicious use of containerization. For example, housing, maintenance, parts stowage, squadron offices and ready rooms, and even the aircrew personnel berthing, galley, and other hotel functions could be accommodated aboard the MSS/ACS in the form of standard containers. This technique was first successfully demonstrated in part aboard *Wasp* in late 1971, when the maintenance shops, spares, and files for Helicopter Squadron 5 were housed in 8 by 8 by 20 foot containers in Hangar Bay 3 for a 2-week deployment.[5] Very possibly the containerized operation could be used on the beach as well as at sea—with the multiple advantages of simplifying deployment, reducing dependence on fixed installations ashore, and keeping all squadron property and files in one organizational array regardless of its general location.

Part of the rationale for keeping the ship small is cost reduction, and, in furtherance of this desideratum, crew tasks must be kept manageable by automating as many functions as will profitably serve to limit the number of officers and men needed. It is estimated that the ship, whose sole function is supporting aircraft, could be operated by 62 officers and men. All aircraft operating personnel would be supplied by the squadron.

As an ASW base, the mobile support system ship (figure 1) could keep two SH-3 helicopters airborne continuously while it steamed 8,600 nautical miles at 20 knots (nearly 18 days). In a strike role the ship could mount 350 sorties with 10 AV-8A Harriers during about 10 days before the magazines would need to be replenished. This could be accomplished by a ship estimated by knowledgeable people to displace from 6,400 to 7,800 tons. Six thousand five hundred tons was taken as a design goal for discussion purposes.

Removal of the aircraft and the maintenance containers on the hangar deck makes the ship into a roll-on/roll-off ship without further conversion. There is space for fifty 10-ton trucks and room below for the drivers and auxiliary personnel. Since these living quarters below the hangar deck are containers, they can be readily removed

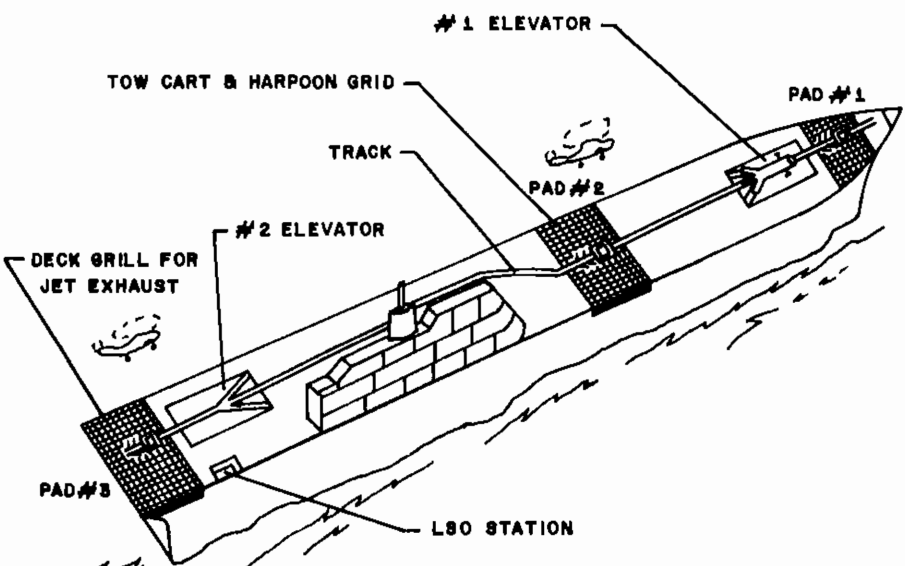

Fig. 1—Mobile Support System Ship

—converting the ship into a logistics transport capable of being loaded with 387 standard 8 by 8 by 20 foot containers, by increasing its displacement to 9,500 tons.

Reduction of ship's crew can be achieved by automating many crew functions. In the field of command and control, for example, the bridge could be designed to resemble the cockpit of an aircraft such as the P-3, with ship control, navigation, engine, and tactical displays arranged conveniently for the captain and an assistant. A direct view of the flight deck and closed circuit TV displays of blind areas and certain critical portions of the ship, such as the elevators, would keep the captain informed of the ship situation with a minimum of oral communication. The navigator and engine controller would be similarly situated behind the bridge with the displays and controls of their particular functions in a convenient arrangement. The engine controller would be assisted by four men whose function would be maintenance of the propulsion machinery and power sources.

The air controller, on the inboard side of the island, would have a bay window through which he could see the entire flight deck with its three pads and two elevators. Three sets of lights under his control would direct landing and takeoff. The harpoon grill securing aircraft to the ship is mounted on a cart which, in turn, can be attached to a cable through a slot in the deck by which the aircraft can be moved on the command of the air controller to the selected elevator without the need for deck crew. Using closed circuit TV for information from the hangar deck, the air controller can also control the elevators themselves. With proper automation and displays, it is hard to see why this job would need assistants, particularly in view of the much more leisurely operation of the VTOL launch and retrieve. When the ship does not have to turn into the wind for air operations, launch and recovery cycles can be arranged for the convenience of the crew, except for tactical situations calling for a multiple launch in an emergency. A shelter at the flight deck level should be available for the landing signal officer (LSO) and crash crew and any special service equipment needed at this level of the ship.

The combat information center aft of the air controller would need ready access to the bridge. An overall situation board could be monitored by TV camera for remote display. Both air controller and CIC officer would be linked by radio to the aircraft. In the event of need for special mission electronics for analysis and communication, as in the ASW mission, a van containing these services could be secured to the deck aft of the island or on the hangar deck under the island with suitable interconnections to the CIC and bridge.

The current crop of VTOL aircraft which might operate off this ship would be the Sikorsky SH-3 and the Hawker Siddeley "Harrier." These aircraft are in the 20,000-pound class, and their design sinking speeds are about 12 feet/second. The vertical motion of the deck is a function of sea state, and the acceptable vertical motion cannot be accurately determined at this time. However, if a maximum of 5 feet per second is permissible, then the forward pad would be usable in sea state 5. Studies indicate future VTOL ASW, fighter, and attack aircraft may be somewhat over 30,000 pounds. In physical size these aircraft may be somewhat larger than the Douglas A-4. The indications are that local deck temperatures could exceed 1000^0F. from advanced jet lift engines or deflected thrust engines. The three landing pads should be in the form of grills to carry the fast-moving hot gasses overboard. Sufficient design and research has been done on these grills by the British and the U.S. Army to ensure an acceptable design.

The hangar deck would be bare of shops and storage spaces as far as the ship is concerned. Instead, the ship would supply plug-in connections for light, power, and communications to standard 8 by 8 by 20 shipping containers. These containers would belong to the embarked aircraft squadron. The various maintenance shops would be permanently set up in the containers. The ship's complement of aircraft could be all kept on the hangar deck, and the number of aircraft carried would be such that any one aircraft could be moved to the flight deck without too much trouble. The aircraft could be launched and retrieved with the aid of the French "Harpoon" recovery system, and the general arrangement of the flight deck would be as shown in figure 1.

By initial estimates it appears that the ACS could be operated as an escort or strike vessel by 62 officers and men. It may be that the accommodations for these people, essential to almost any role of the ship, would be most economically included in the ship "weight empty," to use an aircraft term. That is, the accommodations for the ship's crew could be built in, on the grounds that under almost any circumstances these facilities would be required.

An aircraft squadron of 13 SH-3 helicopters currently requires about 36 officers and 180 men. The number of pilots and flight crews will most likely be increased in the future as the aircraft functions multiply, but the number of men in the ground crew may be susceptible to reduction to about a half of the present requirement. This will require the design of aircraft with a particular objective of reducing maintenance problems. Until this is accomplished, the first generation ship would need about 220 spaces for the aircrew which can be supplied in standard containers in a compartment below the hangar deck where there is space for 108 containers in two layers, or 17,280 square feet of floor space.

The two main propulsion GE LM-1500 gas turbines would be located in one engineroom. It may be desirable to consider a twin-screw installation. In any case, the propellers probably should be controllable and reversible in pitch for two reasons—setting the pitch for best efficiency as a function speed would reduce fuel consumption and noise, and incorporating reverse pitch would ease gearbox problems. Adjacent and using the same intake and exhaust—up through the island—would be another gas turbine for driving the electrical power system.

Estimating the cost of this ship is fraught with difficulties. One estimate was made considering the ship to be a warship, and the price tag came out to be $60 million. On the other hand, if it is considered to be a piece of mobile support equipment and not a warship, the price is quite different. The authors' estimate of the ship in its MSS configuration is $11.3 million as broken down in figure 2. The Naval Air Development Center, using a Rand study, estimated the cost of two families of commercial cargo ships and naval vessels without electronics for fire control or command control. These results are shown as straight lines in figure 3. In addition, a curved line shows the cost of some small carriers as estimated by Naval Ship Engineering Center (NAVSEC) which would be built to full Navy specifications. The price of the Lykes Seabee is

MOBILE SUPPORT EQUIPMENT SHIP

Cost Breakdown

Hull	2.6 M$
Propulsion (Two LM1500)	4.0
Electric Plan (2500KVA)	0.5
Auxiliaries	2.1
Command & Control (P3B Suit)	0.6
Outfit	0.5
Design	1.0
Total	11.3 M$

Figure 2

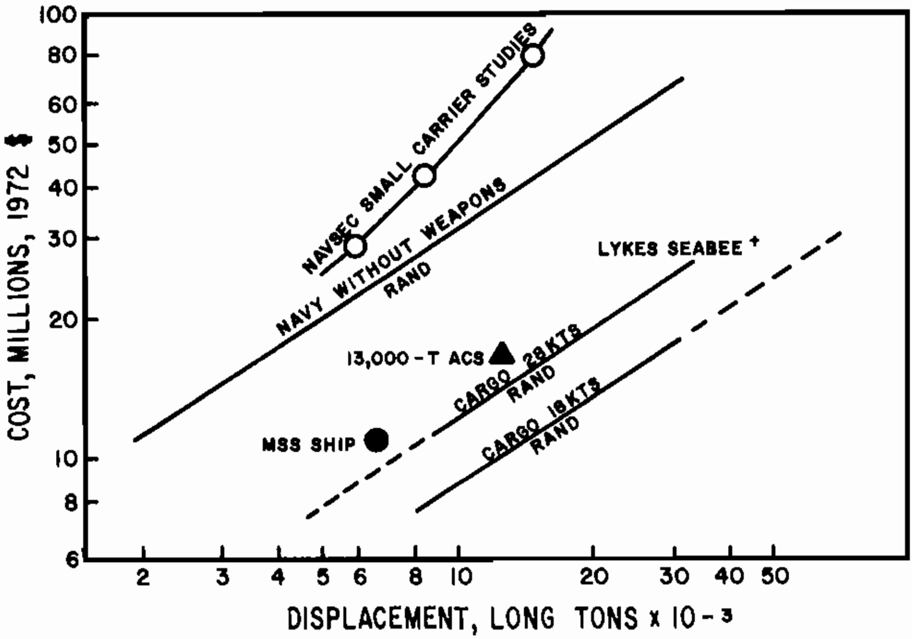

Fig. 3--Ship's Costs

shown as lying above the Rand 18-knot cargo ship line though it is not a fast ship. This vessel has an elevator with a capacity of 2,000 tons that can lift two fully loaded barges and deposit them on any one of three decks. The decks have tracks and mechanisms to move the barge to its proper position in the ship. It is therefore a fairly complicated and relatively slow ship. In order to accept the MSS cost estimate, there is one serious proviso that needs to be accepted first; that is, that the ship be built to cargo ship standards. This means it is to be built to American Bureau of Shipping rules and not Navy specifications.[6]

Roles and Missions of the ACS. As it was first conceived by NAVAIR, the missions of the MSS were solely those of escort and strike. However, a greater measure of economy and flexibility would be achieved if the new ship were designed from a broader perspective than was the case with the MSS. Using individualized equipment packages as enclosed in easily transferable containers, this new ship which we shall refer to as an air capable ship (ACS) would be able to perform those missions originally assigned the MSS in the NAVAIR study as well as being readily convertible to other configurations useful in performing vital peacetime roles. Any VTOL aircraft discussed in this portion of the study will be those that are sufficiently operationally proven to keep the concept in the "low risk" area.

However, if the ACS concept provides the proper impetus, it could ultimately provide the support for almost any naval capability and encourage an active VTOL development, and as the capabilities of the embarked aircraft are improved, it may be necessary to improve certain aspects of the ship's performance. For example, when VTOL aircraft become capable of escorting very high value targets, the ship may need a higher speed to keep up with the force. (Merchant ships are being built today with higher speeds than formerly —up to 33 knots—implying the necessity that the ACS must be able to do the same.)

There is a group of functions, best performed by a trained and disciplined force like the Navy, which will need to be done whether or not there exist international agreements administered by international bodies of adequate strength. Defense of merchant ships against piracy, patrol of trade routes, rescue on the high seas, protection of oil wells and undersea mining, protection and conservation of fisheries—all these necessary tasks can be performed by ship-based helicopters with suitable sensors and weaponry. Most applicable equipment is already in existence and needs only to be adapted for airborne use.

There are several advantages in demonstrating peaceful capabilities of the ACS: First, the Congress may be more eager to support building a fleet in peacetime if it is shown that this fleet will be useful in all geopolitical climates. Second, the Nation will have at its disposal at all times the tools for dealing internationally on and from the ocean, whether in anger or in friendship. Third, the more ships of a given type that are built, the lower the individual cost, further increasing the numbers that can be available to the Navy. Fourth, a higher degree of readiness can be maintained if men are continuously exercising ships and aircraft in real tasks, forcing ships' crews and aviators to be proficient in their skills. Finally, continued development of aircraft, the equipment for handling them on board the ship, and navigation and low-visibility flight instrumentation will be encouraged by demonstrating a continuing need.

The usefulness of the ACS in peacetime, whether operated by the Coast Guard, by civilian operators, or by the Navy itself will be determined by careful planning to select a size, speed, and general arrangement that will prove most adaptable. To indicate possible approaches to this planning problem, a few missions have been selected for discussion and preliminary analysis. Wherever possible, the peacetime function has been related to a comparable military one in the hope that by this means it will be easier to keep from compromising military capability in the effort to achieve adaptability.

Conservation, Navigation, and Pollution Control. It is not necessarily true that the absence of war will necessarily lead to any significant improvement in international cooperation. However, it is reasonable to believe that some degree of international agreement will be reached concerning the uses of the high seas, particularly since efforts in that direction are already underway in the United Nations. The United States is, in fact, engaged in attempting to draft such agreements in the U.N. Committee on the Peaceful Uses of the Sea Bed and Ocean Floor.[7]

Clearly, the adoption of any such agreements will call for the establishment of machinery for their enforcement, both by the individual coastal nations and by the international body. The U.S. Coast Guard, for example, will probably find its sphere of action considerably expanded. The ACS with helicopters equipped for surface surveillance and even with weapons to enforce obedience to international law would provide a much needed capability in this area of enforcement.

Growing interest in preventing ocean pollution is coupled with increased hazards associated with undersea oil wells and the stranding or collision of huge tankers. Prevention of this latter danger will require the development of new navigation and control systems. The draft of new tankers is up to 100 feet, and their ability to avoid trouble is minimal. For example, a crash stop by the 200,000-ton *Idemitsu Maru* (a comparatively modest-sized tanker) takes 21 minutes and 2.5 miles, during which the ship is essentially out of control.[8] There are very few ports in the world that can accommodate these tankers, but in many areas they may approach shore to offload into smaller ships. In the continental shelves around the world there are many underwater peaks and shallows that have been safely ignored to date because the draft of even the largest ships hitherto has been small enough to render them invulnerable. It will shortly become desirable to resurvey vital straits and continental shelf areas, to develop means for marking hazards on the "high seas" in some manner that calls the attention of the most heedless crew, and, in extremely tight cases, to introduce "positive control" by which an external observer with suitable sensors cons the ship.[9] The ACS could act simultaneously as a survey vessel, a deep-sea buoy tender and as the controller.

There are no particular configurational demands on the ship for these purposes: Installation of a winch and suitable construction of the overhead rail on the hangar deck would ease buoy handling through the door already recommended for possible roll-on/roll-off operation. The provision of a van with communications and a situation board for positive control by the ship, acting through an airborne radar system, is entirely feasible, requires little development, and is comparatively inexpensive.

Transportation, Logistics, and Cargo. As illustrated in figure 4, an MSS/ACS type ship would be highly adaptable for use as a carrier of logistic supply containers. The same type of employment in peace would require that the ship be capable of carrying goods at a *profit*.

In altering the originally proposed MSS in order to give it a true dual purpose role, three primary compromises are needed. First, the elevators should be designed for a 100-ton capacity rather than 20 tons if only aircraft were handled. Second, the overhead crane should probably also be capable of lifting 100 tons instead of 20 tons. This looks as if it might make it both heavy and expensive, so for want of a better number, initial design should consider 50 tons for this item. Third, a portion of the hangar deck needs to be hinged. There are a couple of other minor changes that might have to be done, such as heavier tow cables in the slots in the hangar deck. None of the compromises seem very serious if they are incorporated in the early stages of preliminary design and should not really affect the cost or performance of the ship.

In the logistics configuration, the MSS ship should require a crew of 30 officers and men, and the maximum feasible payload is 3,800 tons of containers. It is likely that the usual payload of containers will be somewhat less than that because of loading considerations and average container weight. The question remains as to the desirability of the mission—whether this ship would be sufficiently profitable. Many interrelated factors contribute to profitable operation—speed, turnaround time, length of voyage, crew size and required skills, fuel consumption, and cargo capacity, among others—but, all other things being equal, size is of paramount importance. Studies reveal that cost reduces as size increases, but not linearly; the rate of improvement falls off at between 500 and 700 containers per ship.

Enlarging the ACS to a larger capacity would not be expensive as space in surface ships is relatively cheap. Figure 3 shows that ship acquisition costs increase very slowly with size. As an example, it is assumed that a simple ratio exists between ship capacity and its displacement; in that case, an ACS capable of carrying 750 containers will be about twice the size of the 6,500-ton MSS and cost well under $20 million.

It might, therefore, well be advisable to consider an air capable ship somewhat larger than that initially proposed

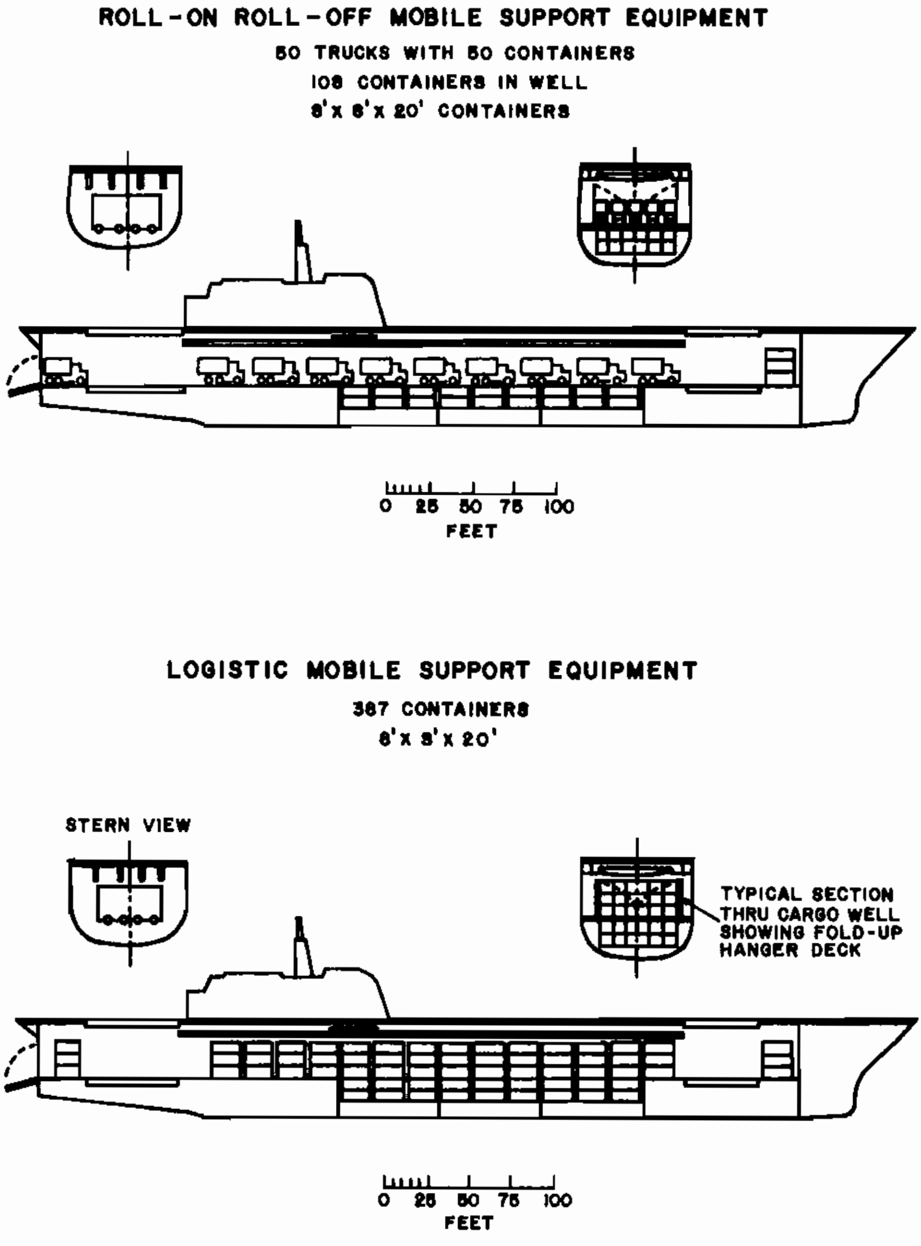
ROLL-ON ROLL-OFF MOBILE SUPPORT EQUIPMENT
50 TRUCKS WITH 50 CONTAINERS
108 CONTAINERS IN WELL
8'x 8'x 20' CONTAINERS
0 25 50 75 100
FEET
LOGISTIC MOBILE SUPPORT EQUIPMENT
387 CONTAINERS
8'x 8'x 20'
STERN VIEW
TYPICAL SECTION
THRU CARGO WELL
SHOWING FOLD-UP
HANGER DECK
0 25 50 75 100
FEET

Figure 4

in the interests of a more universal and profitable application. Little disadvantage to the original concept will result if the growth is not excessive; there may, in fact, be some advantages accruing from the increased space available for habitation and supplies and, in the opportunity for using a longer ship, a higher fineness ratio, and a higher speed for the same power.

The Hospital Ship. The ability to take medical/surgical facilities to sea is one of great utility in war or peace, but at this date the U.S. Navy has neither a hospital ship nor adequate facilities aboard other vessels. The potential of the ACS in this regard is considerable.

The medical mission to be examined is that of caring for the wounded in amphibious operations during the first month after D-day, until an airport and shoreside field facilities can be made available. This requires a special hospital with major emphasis on the surgical care of serious wounds; if such a hospital can be supported aboard the ACS, other hospital equipment intended for the care of civilian casualties after flood or earthquake can also be accommodated. Quite precise space estimates for the Navy hospital ship can be made, since the Bureau of Medicine and Surgery has recently completed studies of mobile medical facilities in cooperation with the Marine Corps. The figures used below were obtained in discussions at BuMed and should not be considered officially to represent the Bureau's requirement. They are entirely the responsibility of the author with suitable references provided.[10]

The unit to be supported is a double 60 surgical bed hospital, entirely housed in 8 by 8 by 20 foot containers or some multiple that involves combining two or more units. The practicability of such modularization of medical/surgical facilities has been demonstrated in part by Army and Marine Corps field hospitals, and, as previously noted, the use of inhabited containers aboard ship was recently proven aboard *Wasp*. An estimate of hospital space required for equipment alone is approximately 19,700 square feet.

It must be assumed that the rescue helicopters will need space for maintenance and spares and one helicopter on the hangar deck. This, together with the after elevator, may require as much as 150 feet of the after portion of the hangar deck, leaving only about 18,000 square feet for the hospital—inadequate for this mission.

Again, a ship larger than the original 6,500-ton MSS option will be needed. Looking at the ship selected for cargo transportation at about 13,000 tons, we find that the dimensions of its hangar deck would measure 500 by 70 square feet. Since its beam is wider than that of the original proposed ship, only about 70 feet or so of the afterdeck will be needed for helicopter maintenance and the elevator, leaving about 30,000 square feet for the hospital. Since the overhead is about 25 feet high, it is entirely possible for an overhead rail and crane to stack those vans used for storage or laboratory work, involving able-bodied personnel, on top of the containers on deck. Standard containers are more than able to support the load, and catwalks and ladders can easily be rigged.

The complexities of patient flow and sterilization requirements may also increase the use of deck space beyond what meets the eye; passageways and the need of some vans to be interconnected by sterile passageways will consume much valuable deck space. This hospital will be staffed by 26 officers—doctors and nurses—and about 135 enlisted men, a number that should provide no particular support problem. Galleys on the hangar deck will be largely for the serving of patients and for the use of staff for quick lunches during a busy period. BuMed has experimented with "convenience foods," those prepared and frozen, requiring only to be melted in infrared ovens, and has found enthusiastic acceptance. Requirements for cooks and stewards are thus kept to a minimum, reducing the need for nonmedical personnel.

It seems quite clear that a useful hospital ship version of the ACS could be made if the basic ship is in the 13,000-ton class. Peacetime uses of such a ship would require modification of the type and arrangement of the hospital vans, since the medical care required by sufferers from earthquake, flood, or famine is different from that called for by battle casualties. Provision of vans suitable for the various special functions should be quite straightforward and feasible. The major advantage of this configuration versus a "built-in" hospital is precisely its flexibility. The nature, situation, and degree of any great disaster cannot be foretold. For just this reason, a rapid means for placing the required equipment aboard to fit the situation is most desirable. One or more properly fitted ships can be readied and underway within a very few days after being alerted. Finally, since medical/surgical techniques and equipment are constantly being improved, replacement of obsolete gear is desirable. This can be accomplished easily in a container configuration.

Mine Countermeasures. Like the naval surgeons, the mine countermeasures forces are currently in want of a ship. Their requirements include the provision of space for RH-53 helicopters and associated maintenance facilities, together with the mine countermeasures gear with its maintenance facilities. Somewhat arbitrarily, a force of 16 helicopters has been selected for examination. Numbers and space requirements have been taken from a recent study prepared for NAVAIR which examines the modification of the LPH for the mine countermeasures (MCM) task.[11] Some figures have had to be estimated since there are spaces already available aboard the LPH, and translating these into terms of empty deck is not entirely straightforward.

To begin with, the flight deck launching and landing pads must accommodate a helicopter with a 72-foot rotor diameter, about 89 feet long, somewhat larger than the vehicles we have been discussing so far. Folded, this same machine measures 56.5 feet by 15.5 by 17 feet high. When these vehicles are on the hangar deck, space around them must be left open for passage and for introduction of work carts with tools and spare parts. An overall space of about 19,000 square feet for the 16 helicopters is assumed to be adequate.

The largest MCM gear is supported on a sea sled 36 by 13 by 14 feet high. Storage area for 10 of these, spaced for easy access, will be about 6,000 square feet. Other large gear, such as underwater fish and cutters and paravanes can be placed in standard vans. About 10 will be necessary, occupying roughly 2,000 square feet. In addition, 30 maintenance vans for helicopters and MCM gear will take about 4,800 square feet if all are on deck, bringing the total space needed to about 32,000 square feet or about that needed for the hospital.

Special equipment includes two winches that can be mounted on the hangar deck in the fantail to handle and stream the mine sweep cable and cutters. The overhead rail and crane installed for handling containers will be useful in this connection, particularly if it is designed to be extended aft to handle material over the stern. Other than this arrangement, the disposal of the rest of the equipment is far from critical, if proper attention is paid to basic convenience. Manpower requirements for the 16 helicopters and associated gear are 53 officers and 312 enlisted men.

No particular imagination is needed to extrapolate this ship to peacetime uses, where handling comparatively heavy gear into and out of the ocean is needed. Oceanographic and seabed exploration, deep-sea buoy tending, bringing supplies to deep water mining and oil rigs, et cetera—all these are tasks for which the ACS would be useful.

Aircraft for the Air Capable Ship.

Sea Control Aircraft. Up to this point in the discussion, the missions of the ACS have been limited essentially only by the limitations of the three aircraft employed; however it is reasonable to suppose that there will be further development in VTOL aircraft technology. As a first step in this process, a list of suggested capability goals for the next generation "sea control aircraft" has been set forth.

The sea control aircraft is small and has three separate missions: to find and kill enemy submarines; to intercept and destroy enemy cruise missiles and to obtain and keep plots of air, surface, and submarine situations; and to act as a command and control center for task forces and convoys. The external configurations of the aircraft will be essentially identical for the three missions, but the weapons load, avionics, and crew dispositions will be quite different, and it may not be possible to change configuration from one mission to another except during construction.

The aircraft will be operated primarily from austere bases afloat where sophisticated maintenance equipment and personnel will not be available. They will be required to fly an average 16 hours per day for up to 30 days under these conditions, or two sorties of about 8 hours each.

Particular attention is to be paid to crew comfort. The crew is to be kept at a minimum but will bear important independent responsibilities in performing the airborne work which can be successfully carried out only by alert and vigorous personnel. Irritating conditions of noise, vibration, ride quality, lighting, and air conditioning which may impair crew performance are unacceptable. Serious consideration should be given to automating as many functions as possible, including the flight controls.

Since it is planned to operate this aircraft from a variety of small ships, it must have a vertical take off capability. The rate of climb at zero forward speed must be at least 500 feet per minute on a standard Navy hot day. The aircraft is to be capable of being landed under zero-zero conditions, and the gross weight is not to exceed 25,000 pounds with a limiting maneuver load factor of at least 3.5 g. (gravity).[12]

The ASW configuration of the sea control aircraft will have the role of finding and killing enemy submarines. The crew is to consist of a pilot, tactical coordinator, and sensor operators. Whether this makes the crew three or four men depends almost entirely on how much automation can be provided. In any case the aircraft is to be self-sufficient and capable of autonomous operation; in particular, its capabilities shall be such as to minimize communications by the ship. The recoverable or expendable stores are not to exceed 1,000 pounds. In addition, two mark 46 torpedoes weighing 530 pounds each must be carried internally in a heated bomb bay. The aircraft must be able to fly out 150 nautical miles to a radius point and spend at least 7 hours on station. The cruise altitude and station altitude may be selected to meet the needs of the aircraft and sensors, respectively. The aircraft must be capable of executing at least one attack before returning to the ship with the usual reserves.

For the antiair warfare (AAW) configuration of the sea control aircraft, the crew will consist of a pilot and a missile control officer. The primary targets are enemy cruise missiles. The aircraft is to fly out to a CAP station at a radius of

50 nautical miles. The altitude is to be chosen to maximize the effectiveness of the AAW missiles. Endurance on station should be at least 8 hours.

The airborne early warning (AEW) version would provide for the command and control configuration of the sea control aircraft. Its role is to perform the main command and control functions in the vicinity of a U.S. Navy task force or convoy. The crew will consist of the pilot, tactical commander, and two radar operators. The avionics system, plus the portable extended surface plot, is not to weigh in excess of 3,800 pounds. The radar must be capable of detecting at 200 miles enemy bombers flying at 50,000 feet at Mach 2.7 and presenting a radar cross section of 1 square meter. The radar must also be capable of detecting ships and cruise missiles. Finally, the system must easily vector friendly aircraft to meet enemy bombers, cruise missiles, or to identify and attack surface targets. The portable extended surface plot is to keep track of aircraft, ships, and submarines as well. The aircraft is to be capable of flying out 200 nautical miles and spending as much time on station as possible before returning to the ship with the usual reserves. Since this configuration will at times be acting as a forward picket, it shall carry at least two Agile missiles as a "last ditch" self-defense.

The utility transport configuration should be considered definitely subordinate to the preceding three. However, it can be provided with little or no penalty if considered early in the design. For instance, the location of cables, wiring bundles, hydraulic lines, et cetera, needs to be located so that eventually a large side loading hatch and windows can be cut in the fuselage without having to reroute any of these systems. Furthermore, the fuselage structure needs to be designed so that the necessary reenforcing for a large hatch and windows can be easily added without interference. It may also be possible to add a hoist which would allow this configuration to be used for search and rescue (SAR). If the basic design is carefully thought out, these applications should cause little difficulty or penalties.

A second small multipurpose aircraft, the seapower aircraft[13] would be used either to intercept and destroy incoming bombers flying at Mach 2.7 at a high altitude or to strike a wide variety of enemy land and sea targets. It is to have extremely high longitudinal acceleration and great agility. The basic external configurations of the aircraft are identical for the differing roles. The avionics systems, weapons loads, and probably the cockpits will be quite different. It may not be possible to change from one configuration to another except during original construction. This aircraft, like the sea control aircraft, will be operated from austere bases afloat and ashore where sophisticated maintenance equipment and personnel will not be available. The aircraft is required to be able to maintain five sorties a day for up to 30 days. To perform its various roles, the following modification packages may be envisioned:

- Configuration A (deck launched interceptor)—The aircraft is to have an average longitudinal acceleration of 25 knots/second from a standing start at sea level to Mach 2.6 at 36,000 feet on a standard Navy hot day. It will then fly at Mach 2.6 cruise climb to 70,000 feet at a radius point of 150 nautical miles. A climb profile that reaches the radius point in less than 7 minutes will be acceptable. It must be able to engage in combat for 2 minutes and return to the ship with the usual reserves. Deceleration from Mach 2.6 and descent from altitude may count in the distance made good returning to base.

The aircraft is to be single place. Because of the high load factor capability of the aircraft, it will be acceptable to put the pilot in a semisupine position. Superb visibility for the pilot is essential. It is expected that the installed avionics will weigh about 1,750 pounds. The primary armament load will be four long-range missiles of the Super-Sparrow type and a 20mm. cannon. When the long-range missiles are carried, it is not necessary to carry ammunition for the cannon. No internal modifications are to be made to carry Sparrow, Sidewinder, or Agile in lieu of Super-Sparrow.

The aircraft design gross weight is not to exceed 25,000 pounds. In a ready alert condition, the time from engine start to airborne is not to exceed 30 seconds.

• Configuration B—Identical to configuration A except that it is able to perform the other fighter roles. It should take off and climb to best cruise altitude with minimum fuel expenditure and fly at best cruise for 500 nautical miles, loiter for 1 hour at best altitude, engage in combat for 5 minutes, and return to base with the usual reserves.

The weapons load should be four, and preferably six, missiles of the Agile type, plus ammunition for the 20mm. cannon. The additional fuel required for this mission may be carried externally, but it must be protected. The overload of fuel and ordnance compared to configuration A shall be arranged to minimize the effect on the superb agility of the baseline aircraft. The gross weight may be increased to, but not exceed, 36,500 pounds.

• Configuration C (light attack) —This is the strike configuration and is identical to configuration A except for the cockpit and installed avionics.

This is a single place aircraft capable of day and night attack missions. It is probably desirable for the pilot to be seated upright provided his vision is not impaired. It is expected that the installed avionics will weigh about 2,750 pounds. The gross weight may be increased to, but not exceed, 36,500 pounds. The permissible weight increase over configuration A is 11,500 pounds; 1,000 pounds of this increase is due to avionics, the remaining 10,500 pounds may be divided between external protected fuel and weapons.

The maximum range mission is to be 500 nautical miles at best cruise speed

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Miss Virginia Withington earned her B.A. from Vassar College. She served in the Bureau of Aeronautics during World War II as Naval Aviation Observer (Navigation) in charge of development and procurement of air navigation equipment. Her subsequent civilian positions have included teaching physics at the Escola Técnica de Aviação, São Paulo, Brazil; project engineer on the periscopic sextant and advanced navigation systems, Kollsman Instrument Corporation; research assistant at Yale University's Marine Physics Laboratory; and supervisor of ASW research, Sikorsky Aircraft. Miss Withington is currently a consultant with the Advanced Concepts Division of the Naval Air Systems Command and the Naval Undersea Systems Center, Newport.

and altitude, plus 1 hour loiter. The ordnance load for the maximum range mission should be at least 4,000 pounds. The maximum ordnance load desired is 8,000 pounds but not necessarily on the maximum range missions.

Conclusions. In the uncertain future, the Navy's best strategy will be to adopt equipment that will serve numerous functions so as to be responsive to the changing international climate. Not only will this provide resources that can easily be adapted to respond to a range of unexpected threats, but it could also provide a believable rationale for the Congress and the voters that is now lacking.

The philosophy of the air capable ship provides an almost infinitely variable capability when suitable aircraft, modularized maintenance facilities, and specialized mission equipment are embarked. By exploiting containerization to the utmost, a simple and inexpensive ship can be made to play many roles to which it could be converted in less than a week's time.

The consequences of this are enormously significant and can deeply affect the Navy's force composition. Some of these are:

- The cost of such individual ships being small, the Navy can afford to purchase them in significant numbers, thus driving individual unit cost down. Also, the program should be palatable even in peacetime, since the ships have many uses to the Nation under a wide variety of circumstances.
- Since aircraft and aircraft equipment can be built very much more rapidly than can ships, the discovery of new weapons and technology—ours or theirs—can be respectively rapidly deployed or countered.
- A high degree of readiness of vessels, aircraft, and personnel can be maintained, since real-life missions will constantly require the application of skills relevant to combat preparedness as well.
- The merchant marine can acquire a substantial number of these ships under subsidy, inasmuch as their indubitable value will not have to be argued. And since the merchant marine is one component of seapower, any naval influence on its healthy development should be looked upon with favor.
- The necessary impetus will exist to encourage the development of VTOL aircraft of varying performance and capability. The payoff to the Nation will be not only in terms of naval capability, but also in terms of commercial air transport.
- Finally, the alternative to the air capable ship seems to be large, costly, and specialized vessels of questionable utility and capability in the face of some of the possible threats. While some of these vessels will undoubtedly be necessary, total reliance on them would appear to be unwise. The cumulative factors, the Nation's skepticism, the uncertainties of the future, and rapidly developing technology enforce a major reliance on the air capable ship, flexibly employed.

FOOTNOTES

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Weapon systems are changing so rapidly that between the time Congress authorizes and appropriates for a ship and the time it is built, the weapon system is often obsolete; therefore, we must build the type of ship that is capable of having its weapon system changed in the future. You need the kind of platform that can take different types of weapons systems; if necessary, every 5 or 10 years.

VADM Hyman Rickover, USN,
House Appropriation Hearings FY 1967