I. BACKGROUND

A. PROJECT SELECTION

The board of advisors for the Wayne E. Meyer Institute of System Engineering (WEMISE) is made up of flag officers and distinguished civilians and assists the institute in choosing project work that is academically challenging as well as relevant to DOD interests and needs. Students in the System Engineering and Integration Program provided inputs to this advisory group. The board selected Expeditionary Warfare as the topic area and in April 2002, the Office of Chief of Naval Operations (OPNAV) N7, the Office of the Deputy Chief of Naval Operations (CNO) for Warfare Requirements and Programs tasked the Institute to conduct an Expeditionary Warfare study (McGinn, 2002).

The initial objective of this effort, according to N7, was to "explore design concepts for future Expeditionary Warfare systems using a 'system of systems' approach" (McGinn, 2002, 1). This project is to take place over a two-year period. The mission of the first year of this project is to engineer an architecture and overarching set of system requirements for a system of systems to conduct expeditionary operations in littoral regions, explore interfaces and system interactions, and compare current, proposed, and conceptual sea-based platforms against these requirements. Additionally, excursions to examine the effects of speed, reduced footprint ashore, Sea Basing, modularity of design and reduced manning were also requested.

B. WHAT IS EXPEDITIONARY WARFARE?

As described in *Expeditionary Operations MCDP 3*, a Marine Corps Publication, (HQ USMC 1998) an expeditionary force is an armed force organized to accomplish a specific mission in foreign lands (far from a supportable home base), that is supported by temporarily established means, and being temporary, will leave the foreign land when the mission is complete. Within this definition, expeditionary operations are any operations that require troops on the ground. A Tomahawk strike by a warship or an attack only with aircraft is not an expeditionary operation. While an expeditionary operation is characterized by the presence of troops on the ground, all combat and logistical systems that support the troops are included in the scope of this definition.

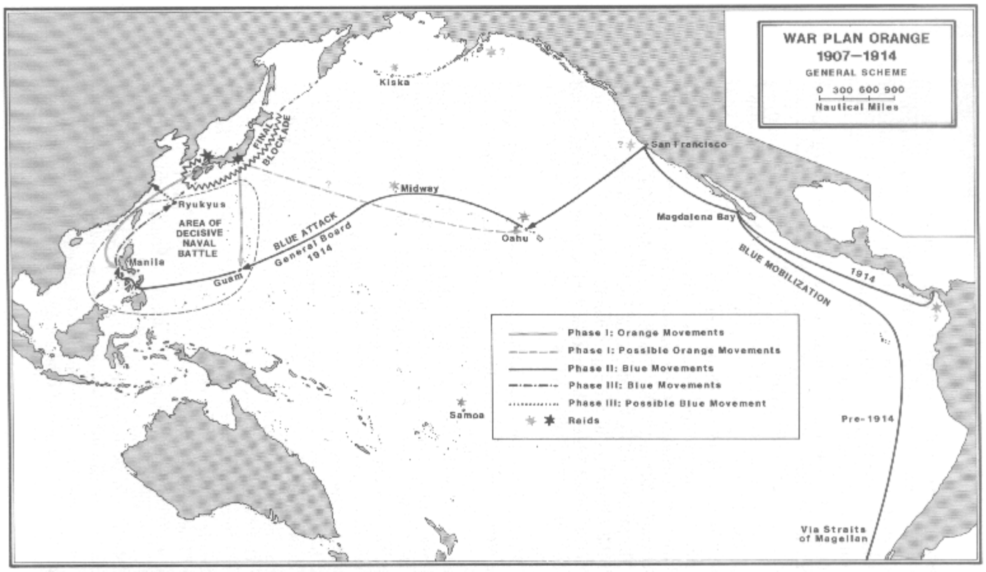
C. WHY EXAMINE EXPEDITIONARY WARFARE?

The Navy, Marine Corps team has been doing expeditionary operations since their inception. The first true doctrine of expeditionary warfare came with the development of War Plan Orange in 1890. This War Plan was never enacted by Congress or signed by the president until after the attack on Pear Harbor in 1941. War Plan Orange changed several times from its initial inception. Theodore Roosevelt started War Plan Orange in case of war with Japan. The annexation of Hawaii in 1898 relieved tensions of possible Japanese claims on the island, but the United States (U.S.) remained wary and continued to update War Plan Orange, which consisted three phases.

Phase I: The U.S. expected the loss of the lightly defended outposts south and west of Japan. The U.S. knew it could not defend these outposts successfully. The War Plan envisioned the concentration of U.S. Navy ships at their homeports. These forces could be deployed from the Eastern Pacific on short notice.

Phase II: The U.S. with superior naval and air power would advance west. Small-scale attacks against Japanese occupied islands would capture them and establish supply routes and overseas basing. Due to U.S. production power, the U.S. anticipated that the Philippine Islands would be reoccupied within two to three years.

Phase III: The U.S. would then advance toward Japan utilizing islands that were parallel to and near Asia. These newly acquire bases could choke Japanese trade and allow air bombardment of Japanese cities and industry, leading to victory without invasion of the Japanese homeland.



MAP 4.1

Figure I-1: Picture of War Plan Orange (Miller, 1991)

War Plan Orange recognized that the U.S. had a need to build expeditionary forces. History shows that, in essence, War Plan Orange was a success. Within three years of losing the Philippine Islands, General MacArthur landed back in Leyte Gulf to reoccupy them. Several expeditionary operations were required to make War Plan Orange a reality. Success occurred because the U.S. had the ability to gather equipment and personnel in a shorter period of time than its enemy. The rapid buildup of U.S. industry and the resolve of the American people allowed for the victory in the Pacific. This victory, though, entailed great loss of life. The expeditionary forces of this period conducted what was largely a war of attrition to complete their mission objectives. In today's environment the war of attrition and the accompanying loss of life are unacceptable. Yet the expeditionary forces of today still have many of the characteristics of the expeditionary forces of World War II. Is this the correct way to perform expeditionary warfare in the 21st century?

D. PROBLEMS WITH TODAY'S FORCES

The development of today's expeditionary forces was influenced by lessons learned from both World War II and Korea. They both showed the essentiality of supporting our troops ashore. In order to identify improvements to today's expeditionary forces, we looked at the force structure in the context of present and future doctrine. The systems engineering process is a way to organize the capabilities and requirements and the operational doctrine. Using this process four major problems were found in today's forces.

- Acquisition process
- Threat-based versus capability based
- Outdated force structure based on doctrine
- Reduction in overseas basing.

1. Acquisition Processes.

Military forces acquire systems one at a time. Typically integration problems between older systems and newer systems occur. It is unrealistic for the military to replace all its systems at once. Program Mangers responsible for the acquisition of individual programs find it difficult to assure integration between systems.

Examples of these integration problems can be seen in past acquisition processes. For example, the Amphibious Assault Ship General Purpose (LHA) has become top heavy due to a newer design and heavier aircraft, which created a stability problem for the ship. The Navy fixed the problem by adding ballast lower in the hull, but this affected the ship's performance. Another example is the Marine Corps acquisition of a new light artillery piece that requires a heavy truck to transport. The artillery piece can be air lifted, but the truck cannot. Since the military procurement process looks at individual items there is no mechanism that balances the system as a whole. From these examples it is apparent there are benefits to enhanced "system of systems" thinking for expeditionary warfare.

2. Threat-Based Versus Capability Based Forces

Our expeditionary forces were designed and built under a threat-based system. During the cold war era it was easy to design forces to counter a known enemy. At the end of the cold war it became very difficult to design forces where there was no clear "likely adversary." As the former Soviet Union reduced its forces, the U.S. military had a hard time justifying the forces it had and even a harder time building new forces. The U.S. military decided to shift to a capability-based force. A capability-based force is a force built on required capabilities needed to perform the required operational tasks. The U.S. has little experience building a capability-driven force. It is also very difficult to re-engineer existing threat-based expeditionary forces to address desired capabilities.

3. Initial Force Build Up and the Accompanying Operational Pause

As previously stated, the expeditionary forces were built on lessons learned from Korea and World War II and are not much different from the ones that existed in the 1950's. It is true we have done operational upgrades by changing individual systems, but the forces still look similar. Under the principles of war from *The Art of War* by Sun Tzu and *On War* by Clausewitz, victory requires attacking the enemy's Center of Gravity (COG). To attack the COG means having the ability to get to the objective area with the proper amount of force to achieve the objective. Past expeditionary forces required an operational pause after coming ashore from the sea before the objective could be approached. This pause is sometimes seen as a build up of forces ashore. The landing force has always required time to get enough combat power positioned to complete an expeditionary mission. Current forces were optimized to address this need. Typically the build up of force was done at the beachhead and was known as 'building the Iron Mountain' (logistical support base for expeditionary operation). Designers of our military forces knew they did not have the ability to go directly to the objective area with enough force to win. The build up of the Iron Mountain was essential to assembling and positioning sufficient force to achieve the objective.

It is easy to see why our expeditionary forces were optimized to build a beachhead Iron Mountain. With the passage of time, military forces have upgraded their capabilities. The ability to move, communicate, command, support, and operate troops drastically improved. These improvements came in discrete steps. Major acquisition processes like shipbuilding did not change as rapidly as military capabilities.

As military commanders realized they could do more, tactics and doctrine started to change. Changes in doctrine can be seen in such documents as *Expeditionary Maneuver Warfare*, (Headquarters (HQ), United States Marine Corps 2001), *Operational Maneuver from the Sea* (HQ), Marine Corps, 1996), and *Ship-to-Objective Maneuver* (STOM) (MCCDC, 1997). Ideally military forces have always wanted to go straight to the objective, but did not have the capability.

The progression of the doctrine of expeditionary warfare shows the gradual trend towards STOM. The Marine Corps, prior to STOM was performing small operations that looked like STOM. As technology has developed STOM has emerged as doctrine rather than just a future concept.

Is a force structure that was designed in principle back in the 1950's correct for today's future? Recall that current forces were optimized for building an Iron Mountain. Afghanistan has broken the mold on how military forces can be used. The Marines showed they had the ability to go 600 nautical miles (NM) from the ship to an objective. This accomplishment came from the use of aerial refueling and Forward Arming and Refueling Points (FARP). Because of Pakistan's support of the campaign in Afghanistan, it was not a true STOM operation since it required assistance by outside forces. What changes need to be incorporated to get a STOM-optimized force?

4. Reduction of Overseas Basing

The number of US overseas bases has declined over the last twenty years and the trend is likely to continue. This becomes a very significant constraint when fielding expeditionary forces. How do we project and sustain forces when we have no (or limited) access to land staging areas? Desert Storm success was ensured by the ability to build-up forces prior to the removal of Iraqi forces in Kuwait. Current forces are not designed to work without secure staging areas. It is wrong to assume that US forces will always have a secure staging area to operate. What changes in force structure are required to support troops without staging areas?

E. OTHER ORGANIZTIONS INVOLVED WITH THE EXPEDITIONARY WARFARE PROBLEM

Many groups have contributed to evaluating portions of the expeditionary warfare problem. The Center for Naval Analysis (CNA) and the Marine Corps Tactical System Support Activity (MCTSSA) are examples of activities which have performed various studies on portions of the big problem. No organization, to our knowledge, has attempted to look at the problem of expeditionary warfare as a complete system. Many studies have contributed good analyses to a problem when given a specific question to be answered. The bigger question of how we should organize, as a system of systems, to maximize expeditionary warfare capability has not generally been addressed.

1. Center for Naval Analysis

CNA has performed the Analysis of Alternatives for the LHA Replacement (LHA(R)), looking at three alternatives. The alternatives studied were a smaller LHA, adding a plug to the existing LHA, and a dual Tram (ability to conduct fixed wing and rotary wing operations simultaneously) larger LHA. Each of the three concepts was examined in the context of how it would accomplish the 3.0 Marine Expeditionary Brigade (MEB) lift requirement. Portions of the findings of the analysis helped generate the *Concept of Operations of LHA(R)* (Naval Sea Systems Command (NAVSEA) 2001). CNA's analysis was conducted within the assumption that a ship to do the LHA mission was what was needed. A broader question would be "Do we need a simple replacement of the LHA or can a better capability be provided by other means?" What capabilities do we need and which ones can today's forces already cover? These questions need to be asked and answered before studies on variants of LHA become relevant.

2. Marine Corp Tactical Systems Support Activity (MCTSSA)

MCTSSA is tasked to support the acquisition of Marine Corps systems by providing technical knowledge to Program Managers. Their goal is to fix integration problems before they hit the fleet. MCTSSA hopes to use systems engineering to create a roadmap of all the capabilities the Marines need. MCTSSA is taking on a very ambitious systems engineering effort that, if successful, could create a clearly defined architecture. This architecture can give the Marine Corps a sound basis to justify the required purchases in the acquisition processes.

F. NAVAL POSTGRADUATE SCHOOL (NPS) AND EXPEDITONARY WARFARE

NPS has been in the forefront of defense relevant research and education for many years. The research and the education offered at NPS are specifically designed to enlighten military officers and to support future military decisions. NPS 2001 Project CROSSBOW, which was a distributed small Unmanned Aerial Vehicle (UAV) carrier force, employed and coordinated many different groups including Total Ships System Engineering, Aeronautical Engineering, logisticians, the physics department in free electron laser research, and the Operations Research department through a tailor made Campaign Analysis course. This endeavor took a revolutionary look at distributed forces and how they can be used to fight in the littorals. NPS has a wide spectrum of faculty and student expertise which can provide useful insights to such military problems. Coordination between these many groups becomes very difficult. Partly to handle these coordination problems, NPS established the Wayne E. Meyer Institute of Systems Engineering (WEMISE) with the task of providing project leadership for wide-ranging studies involving multiple campus organizations and skills. WEMISE provides the facilities and faculty leadership to assist in integration between disciplines within NPS. In this report, the 2002 Expeditionary Warfare Study, groups such as the System

Engineering and Integration, Total Ships System Engineering, Aeronautical Design Group, Space Operations Design Group, and Command and Control Class were involved.

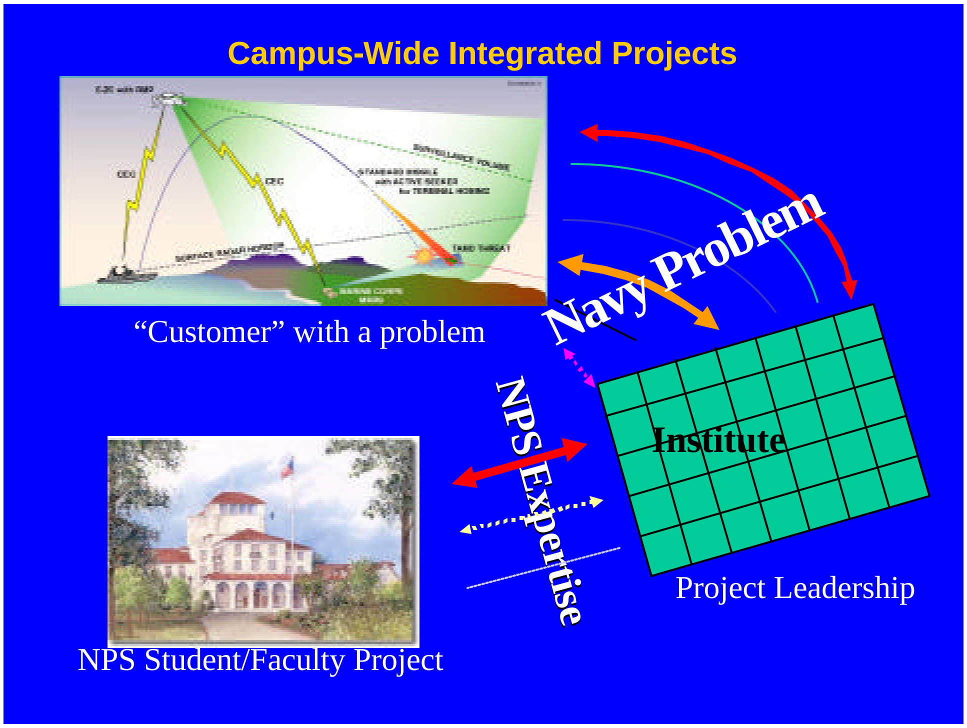


Figure I-2: What the NPS provides for the Navy (Calvano, 2003)

1. System Engineering and Integration (SEI)

The SEI Curriculum was developed and designed for the war fighter. It blends the war-fighting experience of students with a careful mixture of systems engineering and analysis. Thirteen students in the third SEI class (SEI-3) were assigned the development of the overarching requirement and architecture for expeditionary warfare. This group was also responsible for integration among all the other groups involved with the project.

The SEI group extracted the following problem statement from the N7 tasker:

> "Engineer an architecture and overarching system requirements for a system of systems to conduct expeditionary operations in littoral regions, exploring interface and system interaction; and comparing current,

> proposed and conceptual sea-based platforms against these requirements." (SEI-3, 2002).

The SEI-3 group decomposed the problem. They first developed the architecture that clearly defines all the requirements of Expeditionary warfare. By the use of systems engineering tools, expeditionary warfare was then broken down to the required functions/capabilities. The required capabilities were then evaluated and compared to the capabilities expected to result from programs of record in DOD. Key gaps in required capabilities were identified.

From these gaps, the SEI-3 students generated requirements for the Aeronautical Design Group, Total Ships System Engineering Design Group, and Space Operations Design Group for conceptual definition and design of platforms to "plug" these holes in capabilities. At the completion of designs they evaluated present, planned and conceptual forces and examined the impact of both planned systems and conceptual systems on the conduct of Expeditionary Warfare.

Communications and integration among all responsible parties were the responsibilities of the SEI-3 group. Weekly meetings similar to an Integrated Product Team (IPT) were held to analyze risk areas between designs and to resolve interface problems between design groups. At the end of this process the SEI students integrated and documented the final report.

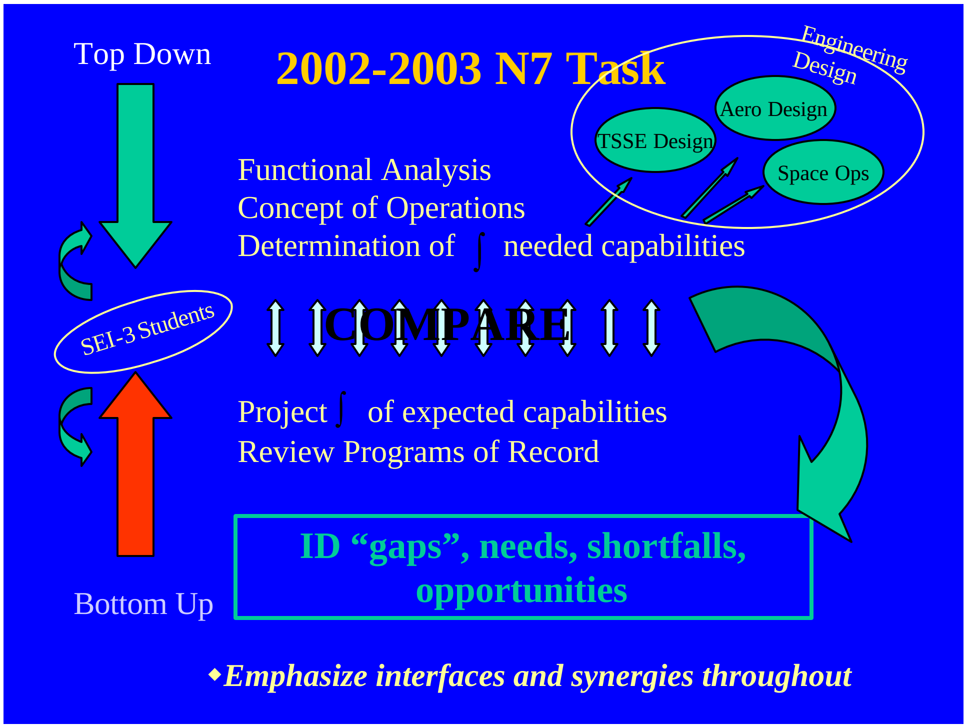


Figure I-3: Pictorial of SEI-3 Workload (Calvano, 2003)

2. Total Ships Systems Engineering (TSSE)

The TSSE program "provides a broad-based, design-oriented education focusing on the warship as a total engineering system." (TSSE Website) A group of 11 TSSE students supported this project: five US Navy, one US Coast Guard, two Turkish Navy, one Tunisian Navy, and two Singaporean Navy Officers. Theses officers evaluated the ship requirements that were generated by SEI-3.

The TSSE team, guided by requirements from the SEI-3 team, explored ideas for a class of ships to replace the LHA, the Maritime Prepositioning Force (MPF), and current logistic support ships. Their major task was to create a single class of ships with the sum of the capabilities now envisioned for these multiple ship types with a view toward permitting sea basing while avoiding the need for ship-to-ship transfer of large quantities of cargo. TSSE then performed trade off analyses of different design concepts and studied the feasibility of proposed new technology. They also evaluated modularity of design, economic trade-offs, and designs for reduced manning for operation of the ship. Their work is presented in Chapter XV and Appendix XV-1.

3. Aeronautical Engineering Design Group

As part of the Masters degree for Aeronautical Engineering the students are required to complete a design course. Due to curriculum changes in the Aeronautical Engineering department, the scheduling of design courses did not coincide with SEI-3 requirements for completion. This was remedied by having 10 students perform an independent study prior to the one-quarter design course. Eight U.S. Navy Ensigns, one Marine Major, and a Lieutenant Commander (LCDR) Naval officer completed the independent study. During this study the Aeronautical students performed trade off studies among design concepts, starting from the unbounded requirements given by the SEI-3 group. The SEI-3 team gave requirements for required lift, distance to travel, and required interactions with other platforms.

Typically, a normal Aero design class would analyze trade-offs in the first two weeks of the quarter. This forces the Aeronautical group to lock in a design relatively quickly. Subsequent integration between Aero and other design groups would be difficult. With the independent study approach utilized, good trade off analysis between designs and groups occurred. This was done at the price, though, of delaying the actual aircraft design phase.

The Aeronautical group performed trade off analysis on two primary design concepts, a Compound Helicopter and a Quad Tilt Rotor aircraft. Trade-offs of speed, reliability, weight lift, and fuel consumption were analyzed. Further discussion of the Aeronautical design will be in Chapter XIV and Appendix XIV-1.

4. Space Operations Design Group

The space operations curriculum has a required capstone design project for their degree program. The SEI-3 group generated the requirements for an imaging satellite which can be used to relay battlefield images to the combat commander of an expeditionary operation. The Space design group is made up of eight U.S. Navy

Officers, one Army Officer, and one Marine Officer. The resulting satellite design project is reported in Chapter XVI and Appendix XVI-1.

5. Command and Control Project Class

The Command, Control, Communications, Computers, Intelligence (C4I) curriculum supported the project by creating and analyzing a C4I architecture for expeditionary operations. The analysis included examination of the performance of the architecture in the various campaign scenarios. This work is summarized in Chapter XVII and Appendix XVII-1.

G. NPS CONTRIBUTION CONCLUSIONS

NPS, with the WEMISE, has the ability to bring multiple ideas and disciplines to bear to explore a coordinated solution to a broad problem. The students at NPS bring significant operational and fleet experience to their work. The school has a unique and highly capable faculty to combine with experienced student war-fighters. The power of the combination of both student and faculty brings out solutions that are both realistic and innovative. The students involved in the project came from different backgrounds, several U.S. armed forces as well as officers from other nations. The foreign involvement gave a perspective that the U.S. officers alone would not have given the project.

H. REPORT FORMAT

The report is divided into three major parts. The parts are: the Top Down look; the Bottom Up look and finally the analysis of the three principal architectures. The Top Down look is a “clean sheet of paper” approach to expeditionary warfare. This is where SEI-3 defined the required capabilities needed for expeditionary warfare. The Top Down approach creates the framework to verify and missing capabilities in the Bottom Up look. The Bottom Up look examines three architectures based on a concept of operations and the existing or planned forces. The first architecture is essentially the existing expeditionary warfare capability employing a scenario containing the operational pause to establish an Iron Mountain ashore. The second architecture incorporates STOM with the system of record expected to be available in the time frame 2020. The last architecture is the STOM scenario at a 2020 time frame with designs based on gaps identified by the SEI group. The last section contains the analysis of the various concepts, draws conclusions, and makes recommendations for additional project work and support theses.