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CONSTRUCTION: the FOUNDATION of NATIONAL DEFENSE

by

Gregg Forrest Martin

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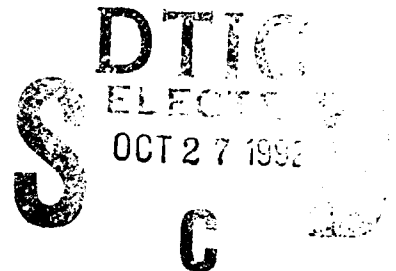
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Signature of Author Gregg F. Martin
Department of Civil Engineering, April, 1988

Certified by Fred Moavenzaden
Fred Moavenzaden
Thesis Supervisor and Director, Center for Construction Research

Accepted by Richard de Neufville
Richard de Neufville
Chairman, Technology and Policy Program

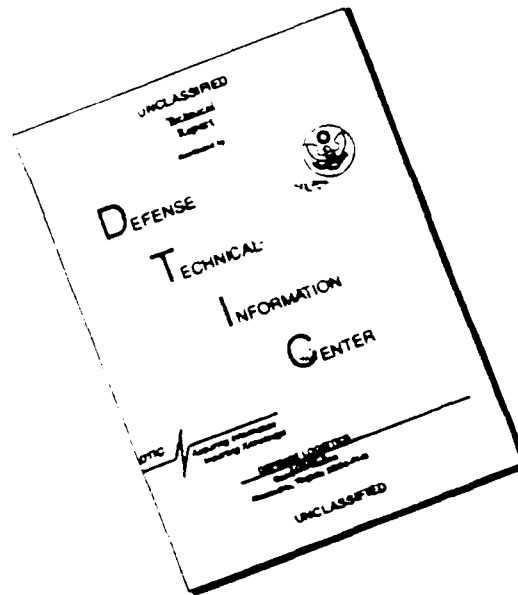
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by

Gregg F. Martin

Submitted to the Department of Civil Engineering on April 10, 1988
in partial fulfillment of the requirements for the Degrees of Master
of Science in Civil Engineering and Master of Science in Technology
and Policy

ABSTRACT

As we enter the 21st Century, and the role of high-tech weaponry increases, construction's once crucial role in national defense is no longer obvious. The extent to which construction has maintained its importance as a component of the US military's war-fighting capabilities is unclear. The purpose of this thesis is to develop a current understanding of the role of construction in US national defense, military construction requirements, and the military's construction delivery system.

After a brief historical review of the subject, the author analyzes current US defense policy and identifies the role, nature and extent of construction that is needed; and assesses the extent to which this construction demand has changed, in scope and complexity, since the Vietnam war. Next, the author describes and analyzes the military's construction delivery system, and identifies shortcomings and inconsistencies in the delivery system's ability to respond to the demand. Finally, the author offers recommendations and policies to improve the military's current construction delivery system, and bridge the gap between requirements and capabilities.

Thesis Supervisor: Professor Fred Moavenzaden

Title: William E. Leonhard Professor of Engineering

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My parents, Pat and Don, for their encouragement and moral support.

Last but certainly not least, my wife Margaret, whose unwavering support, encouragement and love helped make it all possible.

BIOGRAPHY

Gregg Martin was born in Holbrook, MA, and is now a resident of Gilford, NH. He graduated from West Point in 1979 and was commissioned in the Army Corps of Engineers. He has served as a Platoon Leader, Executive Officer, and Company Commander in Combat Heavy Engineer units on NATO's Central Front. He has also served as a Construction Officer and Project Engineer on numerous construction projects. He is an Airborne-Ranger, and a graduate of the Army's Engineer Officers Basic and Advanced Courses, and the Combined Arms Services Staff School. He is married and has two sons.

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CHAPTER 1 INTRODUCTION

Throughout history, construction has played an important role in the ability of nations to deter war, and if necessary, to project military power and wage war successfully. Today however, in an age of intercontinental nuclear missiles, high-tech conventional weapons, and development of the new Strategic Defense Initiative, the role and importance of construction is not as clear.

Traditionally, construction has been a crucial component of US national defense. The mobilization construction requirements in both World Wars I and II, the crucial development of bases and facilities in WW II and Vietnam, the military justification for the interstate highway system, and the urgent construction of the Israeli airbases to satisfy the conditions of the Camp David Accords, all illustrate construction's historically important role in the defense of this nation.

In recent years, researchers have studied the social and economic benefits of construction in the US, however little work has focussed on the role of construction in military and defense issues.

Defense analysts tend not to focus on such a basic, non-lethal, and every-day need, particularly when it involves a medium-tech industry like construction, while construction analysts tend to be pragmatic types, more interested in mainstream construction and engineering issues than in military or political matters.

1.1 Purpose and Motivation for Research

As we enter the 21st Century, and the role of high-tech weaponry increases, construction's once crucial role is no longer so obvious. The extent to which construction has maintained its importance as a component of the US military's war-fighting capabilities is unclear. My purpose is to develop a current understanding of the role of construction in national defense, military construction requirements, and the military's construction delivery system.

My motivation for conducting this research stems from the fact that both the US construction industry and the US military are at important crossroads in their histories. Confronted by a record of

decreasing productivity and having to compete with ferocious foreign competition, the US construction industry must make some very important decisions about its future. Similarly, the US military is faced with a rapidly changing geo-political and economic world situation. The military is beginning to face the stark reality that many of the materials, components, products and industrial capabilities upon which it depends are, to an increasing extent, no longer produced or available in the US. Simultaneously, defense experts argue the merits of maintaining traditional conventional forces versus the development of radical new defensive systems such as the Strategic Defense Initiative (SDI). This interesting confluence of events has provided the motivation for my research.

1.2 Research Methodology

The research for this thesis has depended heavily upon primary sources in the form of interviews with, and speeches and papers by, experts from both the military and the US construction industry, and to a lesser extent on secondary sources.

My research on this topic began with coursework and study on construction and military technology and the nature, organizational structure and politics of both the US military and the US construction industry. This background research was fundamental and essential in understanding and analyzing the issues.

Next, I researched construction's historical military role, from as early as the Roman Empire to as recently as the US-Vietnam War. This historical work relied primarily upon secondary sources.

Third, I conducted an extensive study of current US military doctrine, strategy and tactics. Based upon this work, I then analyzed and determined the current role of construction in each of the major categories of military effort. To the maximum extent possible, I identified and quantified the military's construction requirements. This phase of the research depended mostly upon primary sources.

Fourth, I studied the organization and system through which the military intends to deliver the required construction. I analyzed how the military will respond to the demand, and tried to determine if the military's construction delivery system is capable of supplying its

own demand for construction.

Fifth, I identified shortcomings and inconsistencies between the requirements and the capabilities, and assessed the potential consequences. Finally, I offered recommendations and policies to bridge this gap and improve the current situation.

1.3 Thesis Organization and Scope

Chapter 2 provides the reader with a brief historical background on the role of construction in the military. The example of the Roman Army offers a flavor for the classical role and fundamental nature of construction's important military role. It then briefly traces the historical role of construction in the US military experience.

Chapter 3 describes the mission of the US military and the potential scope of conflict for which it must be prepared. It then identifies the role, nature and extent of construction that is needed. Finally, it assesses how much the demand for construction has changed in scope and complexity since Vietnam.

Chapter 4 describes and analyzes the military's construction delivery system. It assesses how the military construction delivery system has evolved to meet the demand for construction, and identifies shortcomings and inconsistencies in the delivery system's ability to respond to the demand.

Chapter 5 analyzes the gap between construction requirements and capabilities. Specifically, I examine construction R&D and the military's foreign construction dependence.

Chapter 6 summarizes all previous information and analysis, offers recommendations and policies to improve the current construction delivery system, and concludes with some thoughts on implementing these recommendations.

"Construction is not only the biggest single part of defense, it is also the first step in defense. Before we can produce guns and planes and tanks, we must build defense plants or alter non-defense plants to new production. . . . Similarly, if we are to train our Army well, our soldiers must be provided with proper living conditions in camps and cantonments." ¹ -- Presidential adviser Sidney Hillman, 1941

CHAPTER 2 HISTORICAL BACKGROUND

As long as armies have existed, military engineering and construction have played a significant and often vital role in the conduct of war. Like artillery, communications and intelligence, military engineering has always been a crucial component of tactical combat support to the infantry and cavalry. Battlefield engineering support has historically consisted of improving the mobility and survivability of friendly forces, impeding the mobility of enemy forces, and constructing any facilities which will support military operations.

Table 2.1 Historical Role of Tactical Engineer Support

Mobility

- * Clear enemy obstacles
- * Breach enemy fortifications
- * Construct tactical bridges

Countermobility

- * Construct obstacles
- * Destroy bridges, roads

Survivability

- * Construct fortifications
- * Construct defensive positions

General Engineer Support

- * Construct military camps
- * Construct roads, bridges and other facilities

At the strategic level, constructed facilities have always played a crucial role in the ability of states to project military power. Roads, ports, railroads and airfields have been absolutely critical in the strategies of great powers in both deploying military forces and in deterring potential rivals. These constructed facilities have added to military capabilities and shown rivals that they probably had the will to use their military power if necessary.

2.1 The Roman Example

The Roman Army provides the best example of construction's historical military role. At the tactical level, every legionaire was first a combat engineer, and second an infantryman. He carried both his tools for war and for building. Constructing roads and fortifications were an integral part of the legionaire's daily life and of the Roman Legion's tactical battle plans. At the strategic level, the Roman Empire defended itself and protected its interests through political, diplomatic and military means. At the core of Rome's military strategy was a highly mobile army which could quickly deploy to the farthest reaches of the empire to extinguish any rebellion. An elaborate road network, interconnected with military forts and pre-positioned supply bases, gave Rome the capability to deploy its forces. The physical infrastructure which the Roman Army constructed also served as visible and tangible evidence to Rome's enemies of her willingness to use military force if necessary.

Nearly two-thousand years after the Roman Empire, another leader rose from what was once part of the Roman Empire. Like the Romans, he too sought to control all of Europe. Adolph Hitler's vision of a "Third Reich" depended upon the use of constructed facilities -- roads and railroads -- to project military power to the farthest reaches of Germany's envisioned empire. Interestingly enough, Hitler also considered his military engineers to be one of the most crucial elements of his feared German Wehrmacht.²

2.2 The American Experience

2.2.1 The Revolution and the Early Years.

Although the American colonies won their war for independence from the British, they could not have done so without considerable help from European military powers, especially the French. One of France's most important contributions was in the area of military engineering and the construction of fortifications. So lacking were the new United States of America in native engineering skills, that President George Washington urged Congress to establish the nation's first college of engineering at West Point, modelled after France's Ecole de Polytechnic. Founded under President Thomas Jefferson, the U.S. Military Academy's mission was to train and educate military officers who were skilled in the art and science of engineering. Presidents Washington and Jefferson clearly saw a

fundamental link between the need for a young nation to develop and also to defend itself

From the end of the Revolutionary War through most of the 19th Century, the US was primarily an isolationist island state. Her military concerns were two-fold: first, to defend her shores from foreign invasion and second, to protect the nation's westward expansion against the native American population

Construction of coastal defenses and fortifications in and around America's seaports constituted the core of her defensive strategy. With the exception of the War of 1812, the U.S. has never been invaded by a foreign military force.

Economic development and westward expansion were inextricably linked with the Army, particularly the engineers. Army engineers explored and mapped the western wilderness (ie. Lewis and Clark, John C. Fremont). The Army provided the protection necessary for settlers and developers to survive against hostile native Indians. Finally, Army engineer officers provided the scarce technical expertise and knowhow to construct the nation's first railroads

2.2.2 The Civil War

The bloodiest war in American History, the Civil War was in many respects America's first modern war, and a gloomy pre-cursor of future wars. The Union States, after early losses to a numerically inferior but tactically superior Confederate Army, mobilized their

superior industrial and technological capabilities to crush the Confederacy. The Industrial Revolution gave the Union the ability to mass produce arms, ammunition and war materiel of every sort.

One of the most revolutionary developments in the conduct of the war was made possible by the construction of a nation-wide network of railroads. For the first time in history, large, well equipped armies could rapidly move hundreds of miles and arrive fresh for battle. By altering the time-space dimension, railroads radically changed the nature of warfare.

2.2.3 The Spanish American War

The war with Spain marked the emergence of the US as a world power. From a military viewpoint, the war was a new type of challenge in which the nation had virtually no experience. For the first time, the US mobilized its manpower and industry, rapidly expanded its military forces and invaded a foreign land.³ Although Spain capitulated within two months, the war highlighted the immense complexity and difficulty of raising and deploying a modern military force for battle beyond our own shores.

Although the Army was quickly demobilized back to its pre-war size, the nation's top leaders were so alarmed at the military's inability to mobilize for an emergency, that Elihu Root was appointed Secretary of War and given sweeping power to institute reforms. Root founded the Army War College and became known as the Father of

the Modern American Army. Under the new system, the Army was completely reorganized and its top leadership charged with insuring that the military could respond to any threat to US interests. Under Root, the true power of directing the Army shifted from the technical corps officers (ie. Engineers, Quartermasters and Ordnance) to the combat arms officers (ie. Infantry and Cavalry)

2.2.4 World War I

Unfortunately, the nation's civilian leadership failed to provide adequate funding and resources to the military (particularly the land forces) prior to WW I. Then as now, the Congress had to allocate scarce resources to many worthwhile competing interests.

When the US decided to enter WW I, the problems experienced in the Spanish American War surfaced once again, but on a vastly greater scale. For the first time in its history, the US committed itself to totally mobilizing its economy, industry and manpower for a war. Like the Spanish American War, the biggest problem was not in mobilizing the needed manpower. Rather, it was in organizing, equipping, transporting and maintaining a huge modern army in a war far from our own shores.

The first major constraint on America's mobilization efforts were in the unprecedented construction effort needed to build or expand facilities of every type. Reception and training facilities were needed to house and train the millions of men being mobilized. But

even more critical were the construction and expansion of weapons and ammunition plants, factories, depots, warehouses, railroads, shipyards and other facilities required to equip, transport and maintain the forces.

So chaotic and maddening were America's efforts to mobilize, that after the war President Wilson called for a Congressional investigation and the formation of societies and organizations dedicated to keeping the nation's industrial base in a state of preparedness for war.

Born during the post WW I hearings and inquiries were two important and influential construction engineering societies that still exist today -- the Associated General Contractors and the Society of American Military Engineers.

In the actual theatre of operations, the construction, maintenance and repair of roads, railroads and bridges were among the top priorities of combat commanders. These transportation facilities were absolutely essential to moving the men, equipment, ammunition and supplies needed to fight the war. If and when these lines of communication (LOC's) were closed, soldiers of every branch -- infantry, armor, artillery, etc. -- were lent to the engineers in order to expedite the necessary work. Many of the construction difficulties which plagued the engineers of WW I, such as maintaining and building roads under rainy and muddy conditions, are still with us today.

2.2.5 World War II

Amazingly, the same types of problems, only on an even greater scale, occurred again as the US attempted to mobilize for WW II. Military budgets had once again been slashed after WW I (again, the land forces in particular), and military readiness had sunk to abysmally low levels. So chaotic and disorganized were our efforts to mobilize that Congress commissioned the Truman Hearings in 1941⁴ to find out what went wrong and why. Again, construction was identified as the pacing item needed to enable the nation to achieve a wartime footing. Construction of every conceivable kind was in many cases a prerequisite to raising the men and equipment needed to fight the war.

The military itself, the construction industry and other sectors of American industry competed within a command economy for scarce materials, equipment and manpower. Through trial and error, US planners often learned the hard way that construction was a fundamental and critical element of wartime mobilization. For example, one cannot produce the ships, guns and bullets needed to fight until the shipyards and factories have been constructed.

In every theatre of operations, constructed facilities -- or lack thereof -- proved to be the major constraint on combat operations. For example, during the Tunisian Campaign in North Africa in 1942, the Allied offensive ground to a halt as its planes became mired in the mud of fair-weather airfields. Utilizing paved airfields close to the

battlefields, Axis planes enjoyed complete air superiority. Until the rainy season ended or airfields were paved, Allied forces had little chance of cutting German air and sea supply routes from Italy.⁵

In the Pacific, the war against Japan progressed only as fast as Army engineers and Navy seabees could construct forward airfields, and logistical bases needed to support the combat forces across LOC's that stretched from the west coast all the way to Asia.

In the Italian campaign, the retreating Germans, who fully appreciated the importance and difficulty of wartime construction, destroyed as many key transportation and logistical links as possible. They demolished all bridges, culverts, airfields and port facilities as they retreated in the face of the Allied advance.⁶ Indeed, Allied forces could progress only as fast as Army engineers could reconstruct roads, bridges and the other infrastructure needed for a modern army to advance.

Perhaps Lieutenant General (LTG) Lucian Truscott, a combat Corps Commander of the US Army, best expressed the crucial role of combat construction when he said: "There was no weapon more valuable than the bulldozer... no soldiers more valuable than the engineers who moved us forward."⁷

2.2.6 The Korean War

Within six months of the end of WW II, the most powerful military force the world had ever seen had been largely demobilized

once again. The call to "bring the boys home" and stick to America's time honored tradition of maintaining only a small, skeleton, peacetime standing army once again prevailed. However, the events of June 1950 precipitated another mobilization, and America's military policies have not been the same since.

When the North Korean Communists invaded South Korea to "liberate" their brothers, the US once more committed itself to a military conflict far from America's shores.

Smaller in scale than WW II, the mobilization effort for the Korean war went relatively smoothly. One of the major reasons was that the facilities constructed for WW II were still standing and in relatively good shape. The institutional memory was not too dimmed and the needed expertise still existed. Thus, the chaos and confusion of the two world wars was not experienced during the mobilization for Korea.

Although a "limited war" (as distinguished from the "total war" witnessed in WWII) and confined to the Korean peninsula, the combat was every bit as bloody and intense as that of WW II. Again, engineers played as critical a role in Korea as in WW II, with one major exception -- the US had complete control of the sea lanes across the Pacific, and was able to use Japan as a safe sanctuary for air bases and logistical facilities and support. These ready-made facilities, free from enemy attack and destruction, lessened considerably the scope of construction in the theatre of operations.

2.2.7 The Vietnam War

In contrast to the sudden communist invasion of South Korea, the US found itself slowly drawn into a deepening and ever-widening conflict in Vietnam. Ultimately, in late 1964, President Johnson decided to commit US ground combat forces to Vietnam in significant numbers.

Unlike America's previous three wars of the 20th Century, the US did not mobilize in a significant way for Vietnam. After the Korean War, the US did not demobilize as it had done in the past, and most of the state-side facilities needed to support the buildup for Vietnam were already in place.

However, as the military situation quickly deteriorated in 1964, and US forces were rushed into South Vietnam to stave off defeat, it became painfully obvious that a lack of constructed facilities in South Vietnam was the major constraint on America's ability to wage war. The physical infrastructure was simply inadequate to support the modern, well equipped force which the US was deploying. Suddenly, the need for ports, airbases, petroleum farms, roads, warehouses and other facilities were magnified under the urgency of battle.

Exacerbating the problem was the President's adamant refusal to mobilize the nation's military reserves. Unfortunately, more than half of the US construction battalions were in the reserve forces. With nowhere else to turn, the military called on the US construction

industry to fill the breach. Raymond-Morrison-Knudsen, Pacific Architects and Engineering and others, responded to the call. Within six months they had mobilized to South Vietnam and begun work on a massive, around-the-clock construction program that ultimately changed the face of the nation. As these construction firms built under a "cost plus" arrangement, military engineers began building roads, airfields and base camps further into the heartland of South Vietnam. The construction effort in Vietnam was truly a team effort in which private contractors accounted for more than half of the construction effort.⁸

The role of construction in this war is best expressed by LTG Dave Palmer, a cavalry commander in Vietnam, military historian, and currently the Superintendant at West Point:⁹

"When all the final accounting is made it may well be concluded that the single most important branch in Vietnam was not the infantry or the artillery or the air force, but the grimy builders of roads and ports and bridges and airfields -- the Corps of Engineers."

Chapter 2 Endnotes

1. Sydney Hillman, Presidential adviser, Senate Special Committee Investigating the National Defense Program, 77th Congress, 1st Session, **Hearings**, Part 8, p. 293, from Lenore Fine and Jesse A. Remington, **The Corps of Engineers: Construction in the US**, (Washington DC: US Government Printing Office, 1972), p. 3.

2. The Honorable Tidal W. McCoy, Assistant Secretary of the Air Force for Readiness Support in a speech to the Society of American

Engineers in Washington DC on 10 September 1987.

3. The US also invaded Mexico during their war in the 1840's, however this was on a relatively small scale, and part of a border war.

4. Colonel Edward G. Rapp, **Construction Support for Mobilization: A National Emergency Planning Issue**, National Security Affairs Monograph Series 80-9 (National Defense University Research Directorate, Washington DC, December, 1980), p. 29.

5. Alfred M. Beck, Abe Bortz, Charles W. Lynch, Lida Mayo, and Ralph F. Wald, **US Army in WWII, The Technical Services, The Corps of Engineers: The War Against Germany**, (Washington DC: US Government Printing Office, 1985), pp. 83,85.

6. Beck, pp. 166,233.

7. Beck, p. 166.

8. David R. Palmer, **Summons of the Trumpet, US-Vietnam in Perspective** (San Rafael, California: Presidio, 1978), pp. 82-90, and Lieutenant General Carroll H. Dunn, **Base Development in South Vietnam 1965-1970**, (US Government Printing Office, Washington DC, 1972).

9. Palmer, p. 87.

"The day before the war we had time but not enough money
The day after the war began, we had money but not enough time
-General George C. Marshall on the eve of WWII

CHAPTER 3 THE ROLE OF CONSTRUCTION IN MODERN WARFARE

Prior to WWII, the US was an important industrial and economic power, but only a secondary military power. During and after the war the US emerged as the world's pre-eminent superpower -- industrially, economically and militarily.

Parallel to the US's rise as an industrial power, a uniquely American way of war has evolved. This style of war was clearly seen in WW II, Korea and Vietnam. Basically, it consists of exploiting America's superior technological and industrial capabilities through the selective application of overwhelming firepower. The intended result is the maximum destruction of enemy forces with the least possible loss of American lives.

This American way of war requires massive and sustained logistical support. Fundamental to this logistical support is the need for a wide variety of constructed facilities. In fact, constructed facilities are a key link in the logistics chain. In the 20th Century, a lack of constructed facilities -- due either to undeveloped infrastructure (as in the Pacific theatre of WW II, or in Vietnam) or destruction by the enemy (as in the European Theatre of WW II) has constituted one of the major constraints on America's ability to successfully wage war.

The role of construction in modern warfare is immensely important both in deterring war, and is necessary in mobilizing for and successfully waging war. It is a critical component of every conceivable conflict, from terrorism to total war, and its importance permeates the tactical, operational, and strategic levels of war. It is a crucial part not only of logistical support, but also of the actual war-fighting itself, both in an offensive and defensive mode. Construction also plays a critical part in damage recovery operations resulting from wartime destruction.

This chapter will explain the potential scope of conflict which faces the US today. Next, it will analyze the role of construction in each type of conflict, and identify the nature and extent of construction that is needed. Finally, it will assess how much the extent and nature of construction has changed in scope and complexity since WW II (our last total war) and Vietnam (our last small war).

3.1 Modern Warfare -- The Potential Scope of Conflict

"War is an extension of politics by other means"
- Clausewitz

Background

From the ashes of WW II, the US emerged as the dominant world power. With Germany and Japan in ruin, and Great Britain and France reduced to second rate status, the US and USSR filled the power

vacuum. Unfortunately, the allied victory in ww II sowed the seeds for new trouble and discontent in the form of a "Cold War" between East and West, and a multitude of revolutions, national liberation movements and power struggles in the Third World.

Today the US is still the acknowledged leader of the "Free World". As such, its vital national interests are defined in a global context and extend throughout a world which many perceive to be hostile and dangerous. When these interests are threatened, the US has a variety of capabilities -- political, economic and military -- to respond to the threat.

As an instrument of political power, the US military plays a vital role in protecting the national interests of the US.

The Mission of the US Military

The mission of the US military is to deter war. By being so powerful and combat-ready, it is hoped that no adversary would be foolish enough to risk a military confrontation with the US. If deterrence fails, the mission is to settle the conflict as quickly as possible, in a manner favorable to the interests of the US. This deterrence strategy is known as "Peace Through Strength".

The Scope of Modern Warfare

The US Military must prepare for and be capable of responding to a wide variety of potential conflicts, involving diverse political

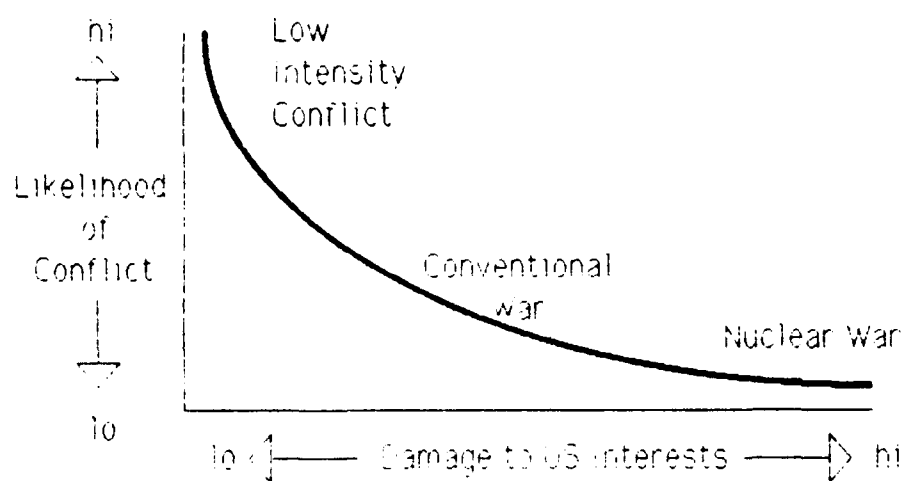
circumstances in every corner of the globe. The most likely occurrence along the continuum of violence is "Low Intensity Conflict", or LIC. LIC includes terrorism, guerilla wars, insurrections, brush-fire wars in the Third World, and even conventional, limited wars like that fought in Korea. Although LIC is the most likely scenario facing US military planners, it is also the one which least threatens our vital national interests.

Next along the continuum, is the possibility of a full scale conventional war in either Central Europe or Northeast Asia (Korea and Japan). Due to the alliances and political commitments we have made to defend these vital interests, along with the forward deployment of US forces, it is less likely that an aggressor would threaten our interests in either of these areas. None the less, these areas, especially Western Europe, are of vital national security to the US and we must be militarily prepared for conventional war.

Finally, we must be prepared for the least likely, but potentially most disastrous scenario, which is a total nuclear war in which the US mainland comes under nuclear attack. Figure 3-1 illustrates the potential scope of conflict.

In the rest of this chapter, I will analyze the nature, role and extent of construction in deterrence, conventional war, total war and low intensity conflict, as well as some recent military developments which may require new construction technology and techniques. Finally, I will sum up the military's demand for construction.

Figure 3.1 POTENTIAL SCOPE OF CONFLICT



3.2 Unique Nature and Needs of Wartime Construction

Unique Nature

The military has peacetime and wartime construction needs. Like civilian construction, the nature of these **peacetime requirements** emphasizes economics, permanence and durability. The construction industry, using traditional construction practices, equipment and materials, normally executes these projects in the same manner that they would execute any other civilian project.

Wartime construction requirements are of an entirely different nature. Whether executed by private contractors (such as the mobilization construction in WWII, and the base development in Vietnam), or by troops, wartime requirements emphasize the following:

- * speed of erection--extremely time sensitive; the military wants immediate access to the desired facilities
- * mobility--resources must be at the needed place when and where required
- * ease of transportation and storage, with compact shape in undeployed form
- * reliability--structures must not break, bend or collapse, since they often involve life and death situations
- * rugged and "soldier proof"
- * relocatable and reusable

- * ease of erection/fabrication; minimum skill requirements for erection and relocation; must be simple to use (ie. the user will not have to learn and follow complicated instructions or long procedures, but rather deploy the structure through just a few simple steps)

- * low cost; minimal consumption of resources

Unique Needs

Along with the unique nature of wartime construction, the military has many unique requirements. Due to the inherently different nature of both peacetime and civilian construction, the construction industry has been of little use in helping the military to meet these unique needs. In order to address these requirements, the military must fund the R&D as it does for other technical military needs. Some of the different types of requirements are:

- * rapidly erectable buildings and military facilities for mobilization construction requirements in the US

- * deployable buildings to serve as barracks, warehouses, hospitals, maintenance facilities, aircraft hangars, etc. for theatres of operation

- * deployable structures such as bridges, ports, piers and docks for logistics over the shore (or ship-to-shore) operations, airfield matting, petroleum pipelines and storage facilities

- * special materials to rapidly stabilize airfields, roads, beachheads, etc.

- * special materials to rapidly repair bridges, port facilities, airfields, roads, etc

- * remote control construction capabilities for work in hostile areas where workers would be subject to enemy fire, unexploded ordnance, chemical agents, or nuclear contamination

- * use of indigenously available materials for construction in remote areas

3.3 Deterrence

Military deterrence is defined as capability *times* will. It is the product of capability and will, not their sum¹. Thus, even if national capability is high, but national will is low, deterrence will be relatively low. For deterrence to succeed, both capability and will must be strong and evident.

When military strategists assess the relative military power of an adversary, they calculate **known** capabilities and **demonstrated** will -- not expressions of intent or mere words.² Thus, if we want our deterrence strategy to succeed, it is vitally important to lay our military cards out on the table. It is in our national interest to make sure that we know and understand what our military capabilities are and to make sure that our adversaries know what these capabilities are as well. If an adversary underestimates either capabilities or will, the results can be disastrous. For example, prior to the attack on Pearl Harbor, Japan grossly

underestimated both the military capability and the national will of the US. Had the US understood and made known its capability and will to Japanese strategists, Japan may have reconsidered the potential costs and benefits of initiating such an attack.³

Construction plays a variety of roles in deterrence, ranging from the readiness of peacetime forces and the ability to project power, to ensuring a viable national infrastructure and mobilization capability. Additionally, the act of constructing facilities which add to our military capability is a measurable indicator of national will. I will now analyze construction's role in deterrence in greater detail.

3.3.1 Combat Readiness of Military Forces

The combat readiness of our military forces is both an important military capability, and a strong indication of national will. Raising, equipping, training and maintaining a large, combat-ready force requires a massive national commitment in terms of money, manpower, industrial production and political will.

Construction plays a critical role at two different levels of combat readiness. First, we must insure that we do in fact have the wartime construction capabilities needed to ensure the success of our conventional forces. Our adversaries fully appreciate the importance of construction capabilities and weigh it accordingly when assessing relative military power. This role will be discussed in section 3.4.

Second, military forces require modern living, training and maintenance facilities. A well equipped force will quickly lose its morale and motivation if its soldiers and family members live in old, run-down housing. Likewise, it will not be a viable and ready force, if it lacks the training facilities needed to test and exercise the capabilities of the modern weapons systems. Finally, it requires adequate maintenance facilities to repair and maintain the machinery of war needed to be combat ready. The Reagan defense buildup has allocated unprecedented resources to military construction around the world. This construction has served the dual mission of actually improving combat readiness and clearly demonstrating national will.

By 1985, the military construction program was at the highest level since 1942, when the nation was mobilizing for WWII.⁴ Total new construction for 1985, including Civil Works, was approximately \$13 billion, or about 4% of the total defense budget.⁵

After WWII the US entered a new era in its national defense policy. For the first time, we did not demobilize our forces to pre-war levels, and after the Korean War, we maintained substantial forces in various parts of the world. Since these overseas deployments were seen as a temporary stop-gap measure to help our allies until they could recover from the war and then defend themselves, facilities for both US-based forces and overseas forces were maintained in a piecemeal, year-by-year manner which, over time, led to a widespread and serious deterioration of military

facilities around the globe. Part of the Reagan legacy has been a recognition that our large peacetime forces were a crucial element of national defense, and that if we were serious about deterrence, we needed to fund a comprehensive construction program for building and maintaining the required facilities.

The scale and scope of this military construction program is unprecedented during peacetime. Yet, military construction represents only about 3 to 4 percent of the total construction in the US. Given the size and elasticity of the US construction industry there has been no problem in accomplishing this work. The military is concerned, however, with finding new and innovative ways to repair and maintain its existing physical infrastructure at reduced costs. This will become even more important as defense budgets will be trimmed in the future.

Like the national infrastructure crisis, deterioration of the military's infrastructure will have serious readiness implications. Failure to adequately address these problems will also indicate a lack of national will. Thus, it is important that the military work with the construction industry to develop and implement new methods and technologies to repair and maintain the infrastructure in more cost effective ways. *Currently, this is a major shortfall where military needs are not being adequately met by the US construction industry.*

3.3.2 Projecting Military Power

The Truman Doctrine expressed a US policy of "containing Communism". Through a series of treaties and military alliances, the US committed itself to assist and defend many nations around the world. Protecting our world-wide interests against the Communist threat required a global military strategy. Fundamental to our strategy was a combination of forward deployed forces to vital areas of interest such as Europe and Japan, and the ability to project military power to other threatened areas of the world.

The construction industry has played a key role in building the infrastructure which enables the US to project its military power. Starting with the nation's internal transportation and military infrastructure and extending around the world through a vast network of airbases, sea ports, and supply bases, the US has much of the physical infrastructure in place to project and sustain its military forces around the globe.

The construction of these facilities has contributed to deterrence by adding to our military capabilities and by indicating national will.

From port construction in Vietnam to the new forward naval base at Diego Garcia, the US construction industry has responded to the demand for strategically important US facilities around the world. Although the US construction industry has lost a large portion of the international construction market to foreign competitors,

there is no indication that this has had any negative impact on America's ability to construct strategically important facilities during peace time.

3.3.3 Industrial Capability

Stalin said that WW II was won in Detroit -- not on the battlefields. As both Germany and Japan discovered, they had awakened a sleeping giant whose industrial capabilities surpassed anything that the world had ever known. In fact, America's industrial capacity enabled the US to develop a military colossus the likes of which the world had never seen.

Our adversaries keep a close watch on US industrial capability. They are fully aware of the important role that the construction industry plays in building and maintaining a strong economy and viable industrial base. The construction of industrial plants and infrastructure adds to our national capabilities and also demonstrates our will to maintain our national industrial capacity.

As national construction expenditures decrease relative to our GNP (from about 12 percent twenty years ago, to about 8 percent today), and our national infrastructure continues to deteriorate faster than it is repaired, our adversaries might view this as a decline in our overall capability and an indication that our national will has declined. Although this idea has military implications, it is fundamentally an economic and political issue. Yet, most experts and

national leaders believe that the foundation of our military power is our industrial and economic strength. They argue that true national power comes from and depends upon a strong, healthy economy and industrial base.

3.3.4 Construction Requirements for Deterrence

How much defense is enough? This question has raged and been debated for two centuries. Some experts argue that we spend too much on defense and that we could adequately deter any threat to our national interests with far less military spending. Others argue that we are not strong enough and that unless we spend more on defense, we will invite aggression.

Clearly, expert opinion is divided, and it is not within the scope of this paper to enter that debate. It is safe to say however, that given the global nature of our interests, and our declared resolve to defend these interests, construction plays a vital role.

How much construction is required for deterrence? Again, this depends upon the answer to "how much defense is enough?" Given that answer (which I will not attempt to address), we can say that we need as much construction as is necessary to assure that we have the infrastructure to project and sustain our forces, and therefore make the potential use of our military power a credible threat to our adversaries.

3.3.5 Peacetime Military Construction Budget

Given the enormous size and diversity of the US military, one can understand its need for constructed facilities. It is useful, however, to gain an appreciation for the magnitude of DOD's real estate and property. Within the US alone, DOD controls 24,192,253 acres for its own use. This is an area more than three times the size of Belgium, or approximately equal to the combined acreage of Connecticut, Rhode Island, Massachusetts, Vermont and New Hampshire, with enough room left over for two Delawares. Counting only barracks and depots of significant size, full-scale military bases, defense laboratories, arsenals, office complexes and ranges, DOD controls 911 properties within the US, 25 in overseas territories and 334 in twenty-one foreign countries.⁶ Among these, DOD has more than 400,000 housing units, which is more than twice the number of public housing units in New York City; as well as the largest school and medical systems in the world.⁷

Beginning late in the Carter Administration, there has been a military construction buildup that is unprecedented in peacetime.⁸ Partly to recover from years of budgetary neglect, and partly due to a massive re-arming of the forces, the military construction budget has more than quadrupled in the past decade. The projects range from exotic missile basing systems to renovating run-down maintenance facilities, to single family houses to accomodate the substantial increase in military family members due to the all-volunteer force.

There are four components of the military construction program. They are:

- * the Military Construction Appropriation Act. These congressionally approved projects include all new military construction valued at more than \$1 million, except family housing.

- * Family Housing. This includes the construction of new housing and the renovation of existing housing.

- * Operations and Maintenance (O&M). Roughly 15 to 20 percent of the entire military operating budget is devoted to maintaining and repairing existing facilities.

- * Civil Works. Under the Energy and Water Resources Act, the Army Corps of Engineers is responsible for all projects involving the nation's inland waterways or flood control. Although the military is responsible for these projects, the funding is not part of the military budget.

Simply stated, the military construction budget is huge; and like construction everywhere, military construction is cyclical in nature. Yet, even at its low ebb in the mid 1970's, DOD constructed about \$1 billion worth of new facilities annually. Since 1981, new construction has consumed roughly two percent of the defense budget. However when one considers the Family Housing program, and the portion of the Operations and Maintenance budget that is devoted to rehabilitating and maintaining constructed facilities, the percentage

of the total defense budget devoted to replacing or modernizing obsolete facilities rises to about 7 percent.⁹

To place the military construction budget in perspective, I will describe it in both absolute and relative size.

Table 3.1 DOD APPROPRIATIONS¹⁰ (in millions of constant FY 88 dollars; numbers may not add to totals due to rounding)

	<u>FY 84</u>	<u>FY 85</u>	<u>FY 86</u>	<u>FY 87</u>	<u>FY 88</u>
Mil Construction	5,157	5,103	5,668	5,320	6,599
Family Housing	2,997	3,153	2,987	3,236	3,485
O&M	79,433	84,420	81,296	83,425	86,563
Mil Pers	74,868	75,321	72,588	77,148	78,308
Procurement	97,918	106,678	98,698	87,935	83,974
RDT&E	30,595	34,549	36,046	35,354	43,749
Special Foreign					
Currency Program	3	10	2	4	-
Revolving & Mgt Funds	3,149	5,587	5,586	673	1,201
Trust Funds, Receipts & Donations	<u>-768</u>	<u>-491</u>	<u>-777</u>	<u>-698</u>	<u>-726</u>
TOTALS	293,383	315,331	302,094	294,397	303,295

Although not a part of the DOD budget, management of the nation's Civil Works projects adds about another \$3 billion per year to the total amount of construction under military supervision. Altogether, military civil engineers manage a construction program that is roughly equal in dollar terms to the entire DOD aircraft procurement program in any given year.¹¹

Compared to some of the well known weapons systems, construction also holds its own.

Table 3.2 CONSTRUCTION VERSUS WEAPONS¹² (in billions of FY 88 dollars)

	<u>FY 87</u>	<u>FY 88</u>
MX MISSILE	1.6	1.9
TRIDENT SUBMARINE	1.8	1.4
SDI	3.9	5.2
MIL CONSTRUCTION & FAMILY HOUSING	8.6	10.1
(does not include O&M or Civil Works)		

This construction outlay is also huge when compared to the capital investments of some of our corporate giants. DOD normally invests more in construction alone than General Motors or IBM expend on total capital investment (real estate, plant and equipment combined.)¹³

DOD's construction expenditures also exceed the construction contracts of the world's largest construction contractors.¹⁴

As large as the Defense construction program is, it is small in comparison to the industry as a whole. The portion of new military construction which takes place in the US comprises less than 1.5 percent of the nation's total new construction, and less than 2.5 percent of the nation's new, non-residential construction.¹⁵ (Note: approximately twenty to thirty percent of DOD's construction occurs overseas, which reduces the impact on the US construction industry.)

Unlike the impact that defense procurement has on some industries, DOD cannot be considered a "development banker" regarding the US construction industry. Given the size, diversity and

fragmentation of the industry, noone -- not even DoD -- has been able to exert much leverage power on the industry

Finally, it is also informative to analyze how the defense budget is divided up among the services; what percentage of their budgets they expend on construction; where the military spends its construction dollars geographically; and on which functional areas it spends those dollars

Table 3.3 DOD BUDGET BY COMPONENT and PERCENTAGE¹⁶

	<u>FY 85</u>	<u>FY 86</u>	<u>FY 87</u>	<u>FY 88</u>
Army	82,446 26%	78,911 26%	78,037 27%	80,102 26%
Navy	108,754 34%	103,105 34%	99,598 34%	102,343 34%
Air Force	108,338 34%	101,322 34%	97,926 33%	100,437 33%
Def Agencies/ OSD/JCS/other	15,724 5%	18,756 6%	18,812 6%	20,412 7%
TOTAL	315,331	302,094	294,397	303,295

Table 3.4 MILCON FUNDING/PERCENTAGE of COMPONENT¹⁷
BUDGET (in millions of dollars)

	<u>FY 85</u>	<u>FY 86</u>	<u>FY 87</u>	<u>FY 88</u>
Army	2925 3.5%	2489 3.2%	2855 3.7%	3154 3.9%
Navy	2192 2.0%	2229 2.2%	2077 2.1%	2641 2.6%
Air Force	2457 2.3%	2350 2.3%	2051 2.1%	2426 2.4%
Def Agencies/OSD/ JCS/other	350 5.6%	598 3.2%	1233 6.8%	1894 9.3%
DOD Total	3424 2.7%	8026 2.6%	8266 2.8%	10115 3.3%

Of the three services, the Army receives the smallest share of the budget, but spends both the greatest absolute amount **and** percentage share of its resources on construction. There are many reasons for this. First, the Army has more people and installations than do the other services. Second, Army facilities were in greater need of replacement and renovation than were those of the other services. Finally, much of the construction budget in the 1980's was for overseas bases, which are dominated by the Army.

Table 3.5 MILCON BY GEOGRAPHIC AREA (%)¹⁸

	<u>FY 85</u>	<u>FY 86</u>	<u>FY 87</u>	<u>FY 88</u>
US	78	77	78	76
Europe	11	14	12	13
Other	11	9	10	11

Table 3.6 FY 88/89 MILCON ALLOCATION BY FUNCTIONAL AREA

(in mil \$)¹⁹

Operation and Training	1749/1760
Maintenance & Production	790/1025
R&D	306/273
Supply & Admin	677/630
Medical/Community/Troop Housing	1054/1239
National Guard & Reserves	1478/1476
Family Housing Construction & Support	3483/3679
Other	1476/1476

In summary, construction plays a crucial role in national defense. Most of the military's peacetime construction requirements are part of the deterrence mission. They serve the dual mission of insuring that the US is prepared for war, and if necessary, to fight and win. These facilities are needed to support personnel, material and logistical requirements, and are characterized by their diversity, long life cycle, and great dispersion throughout the world. Generally, these facilities are typical of those found in any town or city. They include roads, sewage and utility lines, schools, offices, warehouses, and many more. Like the rest of the nation, much of DOD's physical

plant and infrastructure is old and decaying. As part of its effort to modernize, DOD has embarked on a massive program to improve its facilities in order to obtain maximum performance from its equipment, and enhance the morale of its people. Given its other priorities and fiscal constraints, DOD is striving to get the most possible construction for the dollar. Since these requirements are designed and built by private contractors, DOD realizes that a more productive construction industry is in their best interests. Like civilian construction, the nature of these peacetime requirements emphasizes economics, permanence and durability.

3.4 Conventional War

Should deterrence fail, and aggressors launch a conventional attack against US forces or allies, we would be drawn into a conventional conflict. Since the advent of nuclear weapons, military planners have theorized that a conventional war would be of short duration since it would inevitably escalate into a nuclear war within a few weeks. This thinking led strategic planners to think of conventional war as a short, violent, "come-as-you-are" war in which neither side would have the time or opportunity to mobilize its national resources in order to fight a sustained, WW II type of conflict.

Recent events however, have led American planners to revise their thinking in this arena. There is strong evidence in Soviet force

structure and defense spending to believe that they consider a full scale conventional war, of the WW II type, feasible and winnable.²⁰

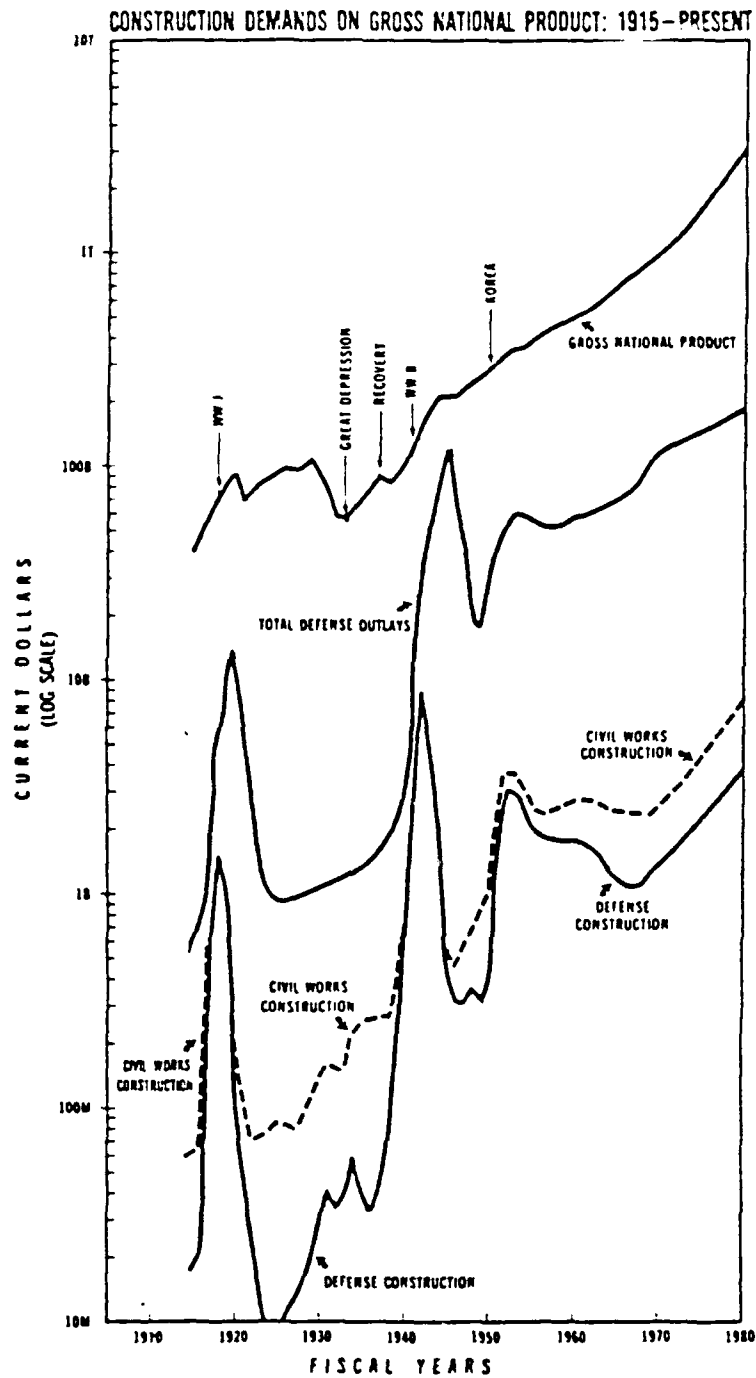
To deter, and if necessary successfully wage a large scale conventional war, we must prepare ourselves at every level. Again construction plays a critical role.

3.4.1 Mobilization for War

A conventional war would require the mobilization of American resources. Historically, the nation has had relatively little difficulty in raising the requisite manpower. The major constraint has been in adequately equipping the force. In mobilizing our industrial base to produce the materiel and equipment needed for war, construction has been and will continue to be, the "pacing item", or major constraint on industrial mobilization.

Figure 3.2 illustrates the magnitude and importance of construction as a pacing item in mobilization. Notice that the construction effort peaked prior to the total defense buildup. World Wars I and II were "Total Mobilizations", where the reserve components and individual replacements were called up, and additional units were created. The Korean War was a "Full Mobilization", where the reserves and individual replacements were called up, but no new units were created. The Vietnam War does not appear, because the nation did not mobilize.²¹

Figure 3.2 CONSTRUCTION LEADS MOBILIZATION



- SOURCES: 1. Newspaper Enterprise Assoc., Inc., *The World Almanac and Book of Facts* 1979.
 2. Dept of Commerce, Bureau of the Census, *Statistical Abstract of the United States*: 1978.
 3. Historical Statistics of the United States—Colonial Times to 1970.

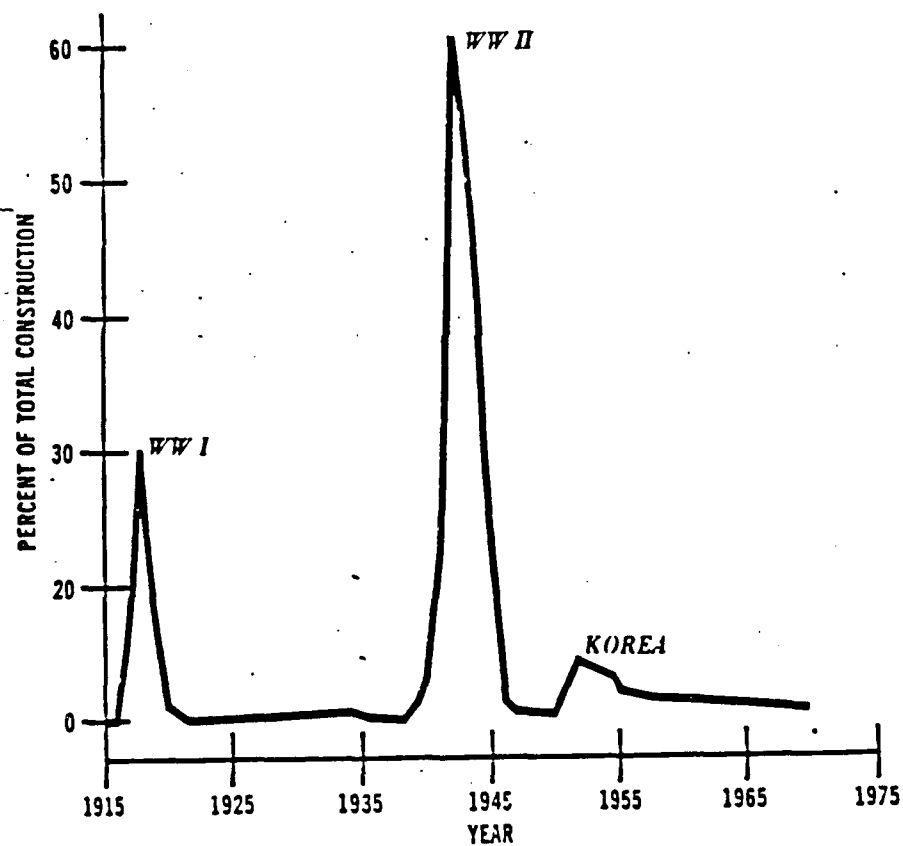
It is expected that mobilization construction requirements in the first month for the Army alone will be greater than \$2 billion and in the first 29 months more than \$40 billion²². The total amount of military mobilization construction during the first year will be from five to fifteen times the peacetime military construction workload, or on the order of \$65 to \$195 billion. In 1942, the Army Corps of Engineers alone placed more than \$65 billion worth of construction in 1985 dollars, and the entire military more than \$100 billion²³.

The work will include expansion of existing military bases and training areas to accommodate the massive and rapid influx of reservists and new recruits; the upgrade and expansion of critical transportation links, including railroads, ports, airfields, and roads; and the expansion, upgrade and construction of a wide variety of industrial plants needed to produce war materiel and equipment.

During mobilization, the nation will rely on the US construction industry to design and execute virtually all of this construction. Figure 3.3 illustrates defense construction as a percentage of total US construction from 1915 to 1975. Given the more than \$300 billion per year volume of our construction industry and its amazing versatility and flexibility, it appears that the capability to respond to a mobilization exists. The projected construction placement of \$65 to \$195 billion would represent between twenty and sixty percent of total US construction. The major problems lie in coordinating and managing the labor and materials involved in such a vast effort.²⁴

Figure 3.3
DEFENSE DEMANDS ON THE CONSTRUCTION INDUSTRY

DEFENSE CONSTRUCTION IN CONUS
AS A PERCENTAGE OF THE TOTAL VALUE OF US CONSTRUCTION PLACED BY YEAR



3.4.2 Conventional Strategy

During WW II, our military strategy depended in large part on transporting the necessary forces to the theatres of operation. This involved fighting for and capturing staging areas, from which the forces could go fight the war. Much of this problem has been solved for any future conventional war. We currently have forces stationed in the two major theaters of operation and have chains of logistical and supply bases (known as "lines of communication" or LOC's) that stretch from the Continental US (CONUS) across the oceans to the respective theatres.

Nonetheless, construction will play a vital role in conventional strategy. Soviet strategists realize that if they can cut the LOC's from the US to the Theatre of Operations (TO's) they can prevent US reinforcement, which will virtually guarantee Soviet victory. Along with naval and air attacks aimed at our sea and air bridges to the TO's, the Soviets will attempt to destroy key transportation and logistical links such as seaports, airbases, airports, railroads, roads and bridges. Construction efforts to repair war-damaged facilities and construct alternates will be extensive, on-going and absolutely critical to the success of US efforts.

Although exact amounts and types of construction are impossible to forecast, US and allied construction planners in the TO's are currently identifying probable construction requirements. Data on gross dollar amounts of construction are unavailable at this

time, although it is safe to estimate that there will be massive and sustained bomb damage to virtually all important air, land and sea transportation links. Construction efforts will be especially crucial during the early reinforcement stages of the war when the Soviets will be striving for a quick, knock-out victory. Construction resources and capabilities, which will be provided almost exclusively by the host nation's civilian construction industry and allied troop construction units, will undoubtedly be stretched too thin, be grossly over-worked and under intense time pressure to reopen vital facilities.

It is extremely important that gross construction requirements be calculated so that plans can be made for adequate construction resources and capabilities to be on hand when needed. These estimates are underway.

3.4.3 Conventional Tactics

Given the overwhelming conventional superiority of Communist forces in terms of personnel and equipment ratios, combat engineers will play an especially critical role as "combat multipliers". This means that successful combat engineer efforts will in effect multiply the combat power of the "killers" (ie. the Infantry, Armor and Artillery).

Given the overlapping nature of offensive and defensive tactics with offensive and defensive strategies, it is best to describe the

role of combat engineers in generic missions. The role of construction in conventional tactics has not changed considerably since the time of the Romans. It still falls into four broad areas: enhancing the **mobility** and **survivability** of friendly forces; denying mobility to enemy forces (**countermobility**); and performing **general construction** tasks. Examples of each mission are listed below in Table 3.7.

Table 3.7 ROLE of the COMBAT ENGINEER

Mobility

- *construct bypasses around enemy obstacles
- *construct hasty roads
- *construct bridges to cross rivers and gaps
- *clear enemy obstacles

Countermobility

- *construct obstacles to slow, block or canalize the enemy
- *destroy roads and bridges to deny enemy mobility

Survivability

- *construct fortifications, defilades and systems to minimize or deny the affects of enemy fire

General Construction

- *construct, repair and maintain supply routes to the forward fighting forces
- *construct, repair and maintain airbases and forward airstrips
- *construct, repair and maintain medical facilities
- *construct, repair and maintain fuel storage sites and pipelines

3.5 Total/Nuclear War

Although nuclear war is the least likely scenario facing US military planners, it would be by far the most damaging to vital US

interests. Only nuclear war seriously threatens vital interests within the US homeland.

Protection against nuclear attack, and recovery from the destruction of an attack, are the two major aspects of nuclear conflict in which construction plays a major role.

In the first area, the construction industry designs and builds projects intended to "harden" selected facilities from the effects of a nuclear attack. Such facilities may include missile silos, key military facilities, selected governmental command and control centers, and selected civil defense projects, designed to house and protect portions of the US population.

During peacetime, the industry has responded to this need in the same way they have responded to any other type of project. Given the specifications and funding, they can get the job done. A problem may arise however, at the time of impending crisis, when the government suddenly decides it should construct all of the civil defense projects which it has neglected for so many years. If such a crash program occurs, there will be a problem allocating scarce resources to so many worthwhile projects which all have a schedule of "immediate".

How much should we spend to construct facilities to protect ourselves against a potential nuclear attack? During the 1950's, our leaders felt that this was an important priority and they allocated considerable resources. Today the opinion is divided and we spend

relatively little on this aspect of civil defense. How much construction is required is a hypothetical question which deserves detailed attention from our military systems analysts.

The second role of the construction industry would be in the area of disaster relief. If the US is attacked, the widespread and massive destruction would be somewhat like the natural disasters (ie. hurricanes, floods, earthquakes, etc.) which occur almost every year in the US. The scale and scope of a nuclear attack would dwarf any natural disaster which this nation or any other would have ever witnessed. Nevertheless, the construction industry in its highly decentralized mode, would be **the** key actor in clearing debris, repairing and reconstructing essential utilities and facilities, and restoring some semblance of an organized society.

Given the massive destruction and death inherent in such an attack, the US as we know it, with a centralized federal government, would probably cease to function. Since all nuclear scenarios are based on extremely hypothetical assumptions, there is no reliable estimate of the amount of construction required. It is understood however, that construction and repair of every conceivable type would be needed on an unprecedented scale.

3.6 Low Intensity Conflict (LIC)

LIC is a relatively new name for a concept of warfare that has been with us for a long time. First articulated under the heading of

"flexible response" under the Kennedy administration, LIC encompasses military operations that fall short of nuclear or large-scale conventional war. It can range from fighting terrorism to fighting -- or supporting -- insurrections, small interventions (ie Grenada), brush-fire wars, guerrilla operations, and "small wars", such as Korea and Vietnam. For simplicity's sake, I will focus my analysis on the two polar ends of LIC -- terrorism and small wars.

Terrorism has become an everyday fact of life in many countries around the world. Like other forms of warfare, it is a violent extension of politics. Unfortunately, terrorists usually attack non-military targets, and are extremely difficult to engage in a face to face military confrontation.

The US has a comprehensive strategy to combat terrorism around the world and construction plays a key role. First, US contractors and designers are working closely with the military, the CIA and the State Department to harden existing US embassies, compounds and military bases around the world. Second, they are designing and constructing "physically secure" facilities in which security is an important design criteria.

Since terrorism is an ongoing form of war in which the US is a major combatant, there is considerable effort and funding for this construction. Many new and innovative techniques and technologies have been developed in military and civilian construction labs, and used to make facilities more secure. Innovative construction has and

will continue to make a significant contribution to fighting terrorism

How much construction is needed to fight terrorists? Again, there is no "right" answer to this question. Clearly, we should devote some resources to this effort, but "how much" is subject to debate

The second major type of LIC are "small wars". The US has fought in two extremely bloody and controversial small wars since WW II. Given our global interests and the large number of guerrilla wars, insurrections, and revolutions going on in the world, many defense analysts view these "brush-fire wars" as our most likely type of military conflict, and the one for which we should most thoroughly prepare. They cite the Carter Doctrine, in which former President Jimmy Carter declared that the US was prepared to go to war if the Soviet Union tried to take over any of the Persian Gulf States. Other experts argue that under the Nixon and Reagan Doctrines, the US would not send in American troops, but rather would only assist local forces in fighting the war.

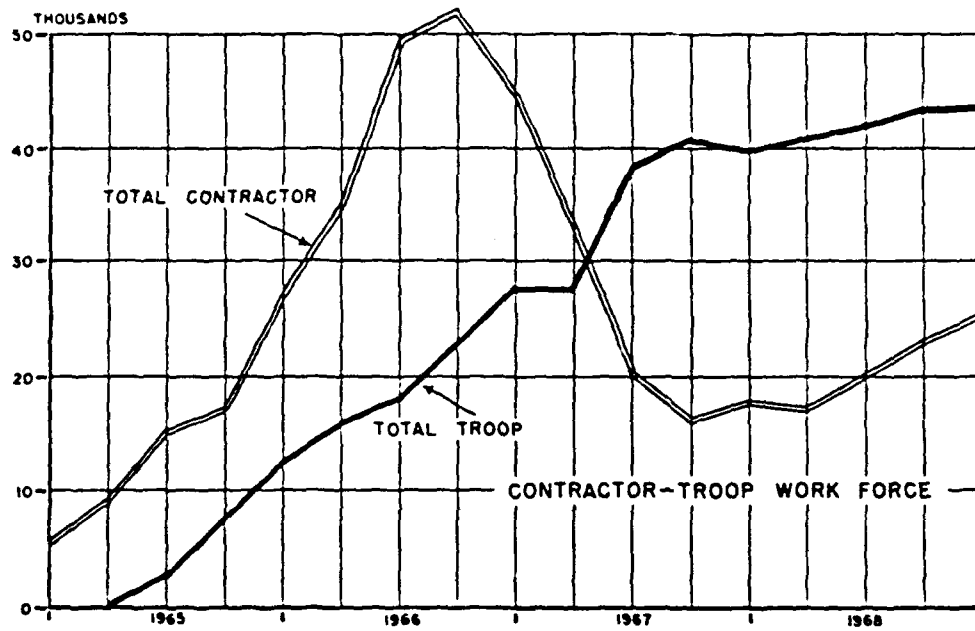
Depending upon the location, intensity and scope of such a war, construction could play a major role. The Vietnam War provides an excellent potential scenario for consideration. Initially, the US provided only advisors to assist South Vietnamese forces in fighting what was largely a guerrilla war. Later, as North Vietnam began sending large units of regular army forces into the South, the US suddenly became involved in a Korean War-like scenario in which conventional US forces fought another conventional force in a bloody,

limited and protracted war

If the US becomes involved in another Vietnam-like conflict, there will again be some fundamental construction issues which will have a critical impact on the conduct of the war. First, if the US decides to commit its conventional forces to fight a sustained war (ie longer than 6 months) in a remote, under-developed region of the world (ie Latin America, the Mid-East, South East Asia, Africa, etc.) it might again require a massive infrastructure construction program as witnessed in Vietnam. Second, the majority of US construction troops are in the Reserves. The President will again face the agonizing political dilemma faced by President Johnson -- whether or not to mobilize the Reserves. Third, even if the Reserves are mobilized, the military might to a considerable extent rely on the US construction industry -- or the contractors of foreign nations -- to construct many projects for which the construction troops have neither the technical expertise nor the necessary skills or equipment.

During Vietnam, more than half of the construction was designed, managed and built by private US contractors. For the first time in US history, private contractors played a major construction role in an active US theatre of operations.²⁵ Figure 3.4 illustrates the mix and size of the construction work force in Vietnam.

Figure 3.4 CONSTRUCTION WORK-FORCE in VIETNAM²⁶



Some industry experts feel that the decline in US overseas construction operations, due to the US's diminished share of the international construction market, could have a negative impact on the ability of US contractors to respond and mobilize quickly in the event of a war in a remote, under-developed land. Others argue that the industry is so flexible and responsive, that it could easily respond to such a demand, which might require a construction program on the order of \$1 to \$10 billion per year, depending on the duration and level of involvement.²⁷ Although opinion is divided on this topic, it is worthy of more detailed study.

Construction requirements for small wars depend upon many factors, including geography, existing infrastructure, the nation(s) involved, enemy forces, and duration. Where operational plans for specific contingencies are developed, the construction requirements are classified. Since the construction requirements for a small war are unknown, it is useful to analyze the construction requirements we faced in the Vietnam War.

3.7 New Areas of Interest

As military technology expands the frontiers of science and technology, new systems will come on line. Many of these new systems incorporate state of the art electronic and material science breakthroughs. Yet, basic considerations like construction may loom as major constraints on our ability to utilize such systems.

For example, the Air Force is developing a new generation of jet aircraft which possess vertical take-off and landing capabilities. Unfortunately, there are currently no runways in the Air Force which can withstand the tremendous heat blast of the engine. Thus, even if the Air Force develops this exotic new aircraft, it must solve the problem of constructing adequate and economical runways before it can bring the aircraft on line.

Similarly, the Air Force is developing a new family of smaller, lighter inter-continental nuclear missiles which would be based on railroad cars. Again, construction of an adequate rail system may be the ultimate constraint on deploying the new missiles.²⁸

Finally, as the military develops the Strategic Defense Initiative, as well as other space-deployed systems, the civil engineering and construction communities will be called upon to design and construct lightweight, deployable space structures. This represents a whole new facet of construction which has been largely unexplored.

Thus, the future of many new defense systems is inter-twined with the development and implementation of new construction technology.

3.8 The Demand for Construction

The military's requirements for construction are based upon hypothetical scenarios. Nobody knows with any degree of accuracy

what, when, where and at what rate, construction resources will be needed.

Where detailed studies have been made to analyze the specific construction requirements of potential scenarios in specific areas of operation, the results are classified.

It is useful however, to identify construction requirements in general terms and in gross orders of magnitude. This section will assess how much the extent and nature of construction has changed in scope and complexity since WWII (our last total war), and Vietnam (our last small war).

Deterrence (Peacetime)

Since the end of WWII, the US has had a large and powerful standing military which is deployed around the world. Many of the required facilities have already been constructed and in place for a number of years. These facilities have generally been designed and built by the civilian construction industry, emphasizing the normal civilian concerns of economics, durability and permanence.

Thus, one of the military's most serious problems -- maintaining and repairing their enormous stock of existing facilities -- is basically a new problem since WWII. This problem is exacerbated by the fact that these facilities are getting older (many are well beyond their design lives) and are not being replaced or renovated as fast as they are becoming obsolete. This demand for

economical repair and renovation of existing facilities represents a whole new challenge for the military, and it is growing larger and more complex each day

Mobilization

If we must mobilize for a major war, we are in a far greater state of readiness today than at any other time in our history (with the possible exception of the Korean war.) Construction requirements will be of the same general nature as for WWII but will probably be somewhat less in magnitude, since we will not begin the mobilization from *such* an unready state. This possible advantage is probably offset however, by the heightened importance of time. It is inconceivable that we will ever again have three years (1939 to 1942) to mobilize as we had in WWII. With the increased speed and range of weaponry, the time-space factor has reduced the time that we will have available to mobilize.

Thus, the military and the US construction industry must somehow be able to execute slightly less construction in considerably less time than during the WWII mobilization.

Conventional Strategy

If we become involved in a major conventional war in Europe or Northeast Asia, the destruction of vital facilities will be sure, swift and massive. Soviet doctrine emphasizes the need to strike deeply and

to quickly neutralize or destroy enemy lines of communication. In the past decade or so, the Soviets have developed and deployed the necessary forces and weapons systems to make this strategy credible. Until recently, US and NATO forces were relatively safe from deep Soviet strikes against airbases, ports and other key transportation links in the NATO rear area. This is no longer the case, and the entire fate of the Western Alliance -- which depends upon timely and massive reinforcement from the US -- could hinge on the availability or lack of key facilities.²⁹ Thus, the extent of the need for expedient repair, reconstruction and new construction of essential facilities in a conventional theatre of operations will be *greater and more urgent than ever before*, although the nature of the work will be essentially the same as it was in WWII.

Conventional Tactics

The need for combat engineering and construction at the tactical level has increased dramatically during the 1980's. With the advent of the new "Air Land Battle" Doctrine, which emphasizes speed, maneuverability, flexibility and the ability to strike deep at the enemy, the need for enhanced engineer support, that can keep up with the "killers" on the modern battlefield is more important than ever.³⁰ In fact, this requirement is so great and so vital to the success of our tactical forces, that top military commanders are getting involved. The nature of the demand is essentially the same as

it has always been, but the scope and urgency of combat engineering will be far greater than at any time in the past.

LIC

In the event of a small war, the demand for construction will probably not be any greater in either nature or extent than it was in Vietnam, and will probably be less. Due to political realities and the bitter memories of Vietnam, future small wars are less likely to involve sustained commitments of large numbers of conventional US ground forces, and will therefore require a smaller construction program, involving semi-permanent facilities.

Since committed forces will still require constructed facilities to support them, there will probably be a far greater demand for specially-designed, quickly erectable, pre-engineered facilities such as piers, buildings, airfields and petroleum storage systems. According to one expert, the US military may require more of these special facilities to fight small wars in remote, under-developed areas than ever before.³¹

The increase in world-wide terrorism has added a new construction requirement in recent years. The demand for physically secure compounds and hardened buildings, to help prevent or reduce the impact of terrorist attacks, has increased dramatically at US military facilities around the globe. This is a relatively new demand (post-Vietnam) and represents an increase in both the nature and

scope of military construction.

Total/Nuclear War

The potential demand for a massive reconstruction effort to recover from either a nuclear or conventional attack is a distinct possibility. In the past decade, the Soviet Union has achieved either parity or superiority with the US in terms of the ability to devastate one another's homelands, either through nuclear or conventional attack. The Continental US is no longer a sanctuary, outside the range of enemy attack capabilities. Soviet bombers, submarines and missiles are capable of utterly destroying our homeland. If total war occurs, and there is anyone left alive, construction will play a vital role in recovery, much as it does in the recovery from natural disasters.

New Areas

As discussed in section 3.7, new requirements for construction will occur as the military develops and fields new systems. The exact nature and extent of these new demands is not known, but they will undoubtedly increase the military's demand for construction.

Demand Summary

In general, the need to construct things is as important today as it has been in the past. Time constraints will probably be tighter and more critical than in previous wars, due to the reduced

time-space dimension of military operations and technological developments at all levels. How much we should build, where we should build, and at what rate, is still open for debate. What portion of the defense budget should be allocated for special, wartime construction equipment and capabilities is a matter of on-going debate. This question is part of the larger defense question of how much defense is enough, and how to optimize our resources or get the "most bang for the buck".

In conclusion, the requirements for construction will be immense. There will most likely be major problems in allocating scarce resources to execute all of the needed construction within the desired time. The next chapter will describe and analyze the construction delivery system, through which the military plans to meet their construction requirements.

Chapter 3 Endnotes

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2. Crowell

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15. These percentages are extracted from **Construction Review, US Department of Commerce**, Table A-1a, p. 18-19.

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19. Weinberger, p. 311.

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25. Lieutenant General Carroll H. Dunn, Director of Construction, US Military Assistance Command, South Vietnam, **Vietnam Studies, Base Development, 1965-1970**, (Washington DC: US government Printing Office, 1972), p. v

26. Dunn, p. 42

27. Extrapolated from Dunn, pp. 40, 41, 49, 132, 133.

28. Norman D. Falk, Senior Research Engineer, Readiness Technical Analysis Group, New Mexico Engineering Research Institute, University of New Mexico in a discussion concerning future construction needs of the Air Force with the Center for Construction Research and Education at MIT on 13 August, 1987.

29. The Honorable Tidal W. McCoy, Assistant Secretary of the Air Force for Readiness Support, in a speech to the Society of American Military Engineers, in Washington DC, on 10 September 1987.

30. General Alfred Gray, Commandant, US Marine Corps, in a speech to the Society of American Military Engineers, in Washington DC, on 9 September 1987.

31. Doctor Robert Oswald, Director of Research and Development, US Army Corps of Engineers, in a meeting with MIT's Center for Construction Research and Education, at MIT, on 6 October 1987.

CHAPTER 4 THE CONSTRUCTION DELIVERY SYSTEM

The purpose of this chapter is to assess how the military plans to respond to the demand described in Chapter 3.0, and how the military construction delivery system has evolved to meet the new demand for construction.

4.1 Military Construction Organization

From the forming of the nation, through World War II, the US military was divided into two separate components, the Army and the Navy. The Secretary of War and the Secretary of the Navy held cabinet level rank, were largely autonomous, and enjoyed direct access to the president. Accordingly, the construction delivery systems of the two services evolved separately. The Army and Navy each developed their own organizations and methods for providing construction support.

Although the nature of warfare had changed drastically in the 20th Century, the US's military organization had not kept pace. After WWII, hearings and debate on military reorganization raged in Washington. The National Security Act of 1947 resulted in the creation of a new cabinet level Secretary of Defense (SEC DEF), the

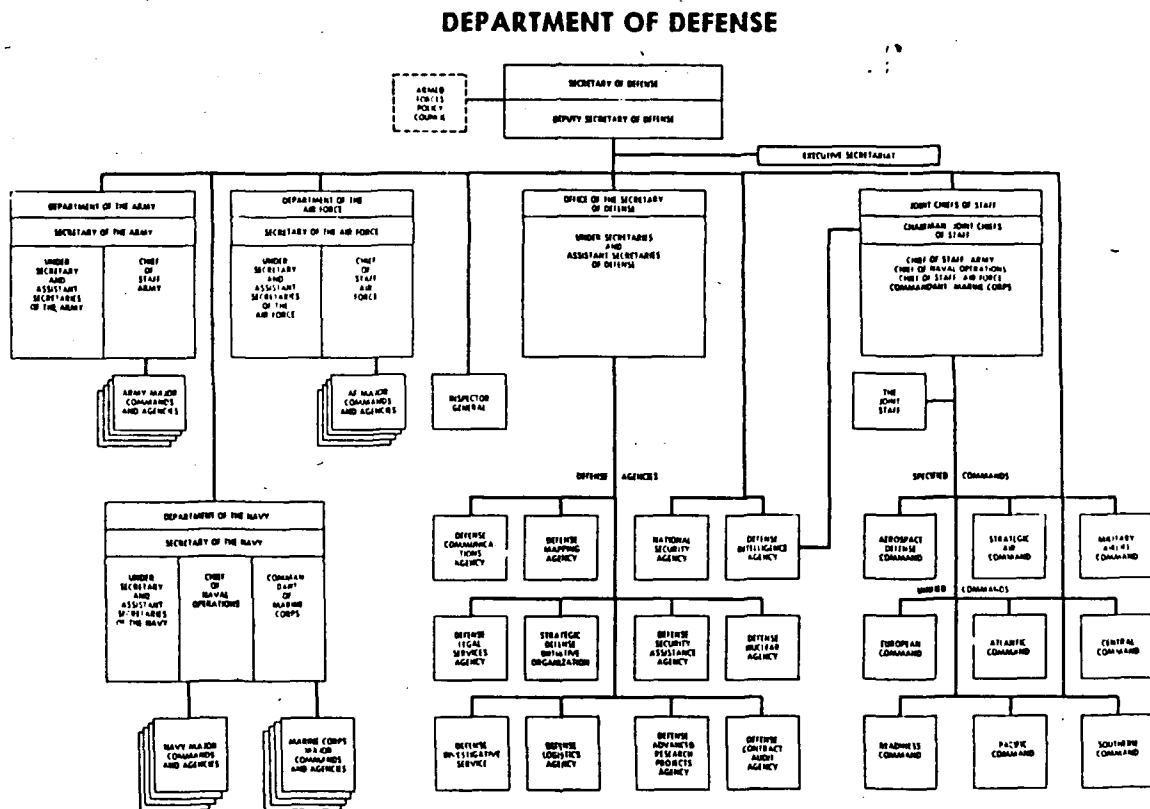
Department of Defense (DOD), the Joint Chiefs of Staff (JCS) and an independent Air Force which enjoyed equal status with the Army and Navy (previously they were the Army Air Corps). In 1949, an amendment to this act subordinated the Secretaries of the Army, Navy and Air Force to the SEC DEF, thereby eliminating their cabinet level status.

Recognizing the need for coordinated, joint service effort in modern warfare, the National Defense Act of 1958 created new "*unified*" operational field commands and "*specified*" functional commands. A single commander in chief (CINC) commands all assigned forces (Army, Navy and Air Force) in his "unified" theatre of operations or "specified" functional area. These commands are outside of the Services' jurisdiction and the CINC's report through the JCS to the SEC DEF.

The most recent of these evolutionary changes is the National Defense Reorganization Act of 1986. This act is designed to increase the power of the Chairman of the JCS as well as the CINCs of the unified and specified commands.

Figure 4.1¹ illustrates the military's organizational structure.

Figure 4.1 DOD ORGANIZATION



The Military Construction Delivery System consists of **military construction management organizations** such as the Army Corps of Engineers and the Naval Civil Engineering Corps, **military engineering staffs** who report directly to the CINC's and their subordinate military commanders, **facility and base engineers**, and **troop construction units**.

The construction management organizations have limited in-house design capabilities as well as construction R&D labs. They are responsible for managing the design and construction of large (over \$1 million), congressionally appropriated projects. Normally, they contract out to private industry for design and construction.

Every major commander, from the CINC's on down, has his own engineering staff to plan and coordinate construction within his command, military troop construction units who are trained and equipped to execute combat engineering and construction support missions, and facility engineers who play the role of city planners and engineers for the military bases around the world.

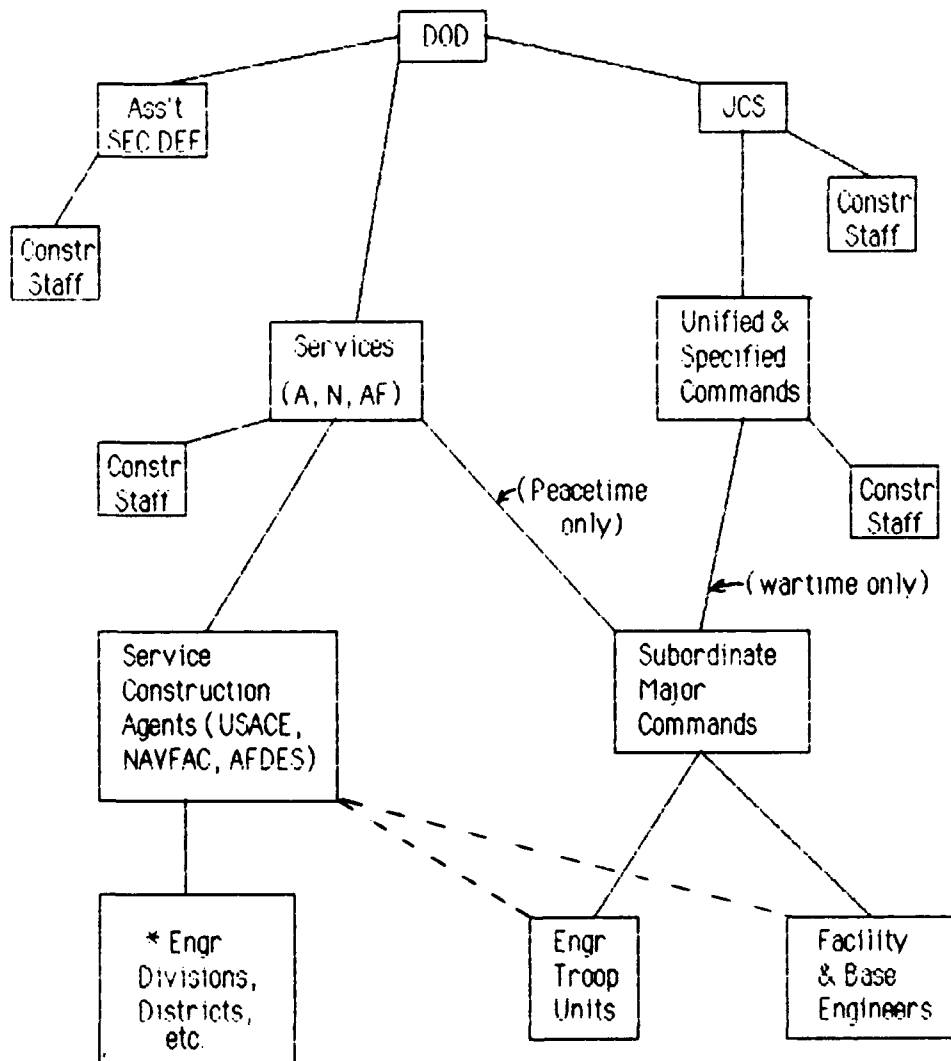
Additionally, there are other technical support commands which design and procure specialized engineer equipment and

materiel such as tactical military bridging, pre-fabricated buildings, combat construction equipment, and specialized piers for logistics over the shore (LOTS) operations. The Army Materiel Command provides this support for the Army and the other services each have their respective technical support organizations to fulfill this role.

Figure 4.2 on the following page illustrates the military's construction delivery system.

In the following sections, I will describe the organizations, roles, functions, and modus operandi of the military construction agencies of the DOD, the JCS, the Army, the Navy, the Air Force, and the Theatre Commands.

Figure 4.2 MILITARY CONSTRUCTION DELIVERY SYSTEM



* During wartime, divisions and districts within a unified command's theatre of operations, will fall under that theatre command (ie. European Engineer Division of USACE reports to the European Command).

— Direct command authority

- - - Technical advice and support

4.1.1 The Department of Defense (DOD)

DOD serves as an umbrella organization which develops and coordinates military policy. The Assistant Secretary of Defense for Installations has a construction directorate that monitors the peacetime construction program and sets policy to guide the construction efforts of the services and commands. In both peace and war, construction funds flow from Congress to the DOD, down to the services and then out to the unified and specified commands. The command authority between the DOD, the services and the commands is flexible and decentralized.

There is also an Assistant Secretary of Defense for Logistics. Within this office is a construction directorate which oversees the construction aspects of logistical support for combat contingencies. This office does not have any real control or authority over the construction organizations of the services or theatre commands, nor does it consolidate and evaluate requirements or capabilities.

Although this decentralization enhances flexibility, initiative, and innovation, *there is a glaring deficiency in that no central authority analyzes and balances construction needs against*

construction capabilities in a comprehensive and consistent way.

4.1.2 The Office of the Joint Chiefs of Staff (JCS)

Within the Logistics Directorate of the JCS is a Civil Engineering Branch, which oversees construction and civil engineering for all US forces. This branch analyzes and plans the construction required to support contingency operations around the world. This construction planning then becomes part of the overall logistical support plan which is used to formulate and evaluate various contingencies. This office does not rectify the deficiencies mentioned in 4.1.1 above.

4.1.3 The Army

The Army Corps of Engineers (USACE) is the Army's construction agent. USACE is responsible for the nation's civil works, and all of the Army and Air Force's congressionally appropriated military construction. Additionally, it provides technical advice and expertise to the facility engineers, staff engineers and troop construction units who work for the unified and specified commands.

Organized into engineer divisions and districts to execute the work, USACE operates in a highly decentralized mode, and serves as both a Major Army Command and as a technical staff.

USACE also performs R&D "in systems, equipment, procedures, and techniques relevant to engineer support of military operations and material development to meet Army requirements." Major R&D responsibilities include: topographic sciences, engineer combat support, energy, environmental quality, military construction, and facilities operation, maintenance and repair.

USACE operates four different R&D Labs. They are: the Cold Region Research and Engineering Lab in Hanover, New Hampshire, the Construction Engineering Research Lab in Champaign, Illinois, the Engineer Topographic Lab at Ft. Belvoir, Virginia, and the Engineer Waterways Experiment Station in Vicksburg, Mississippi.²

Additionally, there is a construction branch within the Army's Logistics Staff which coordinates and oversees construction as it pertains to logistical support for Army forces in contingency operations.

The best way to examine the Army's construction delivery

organization is to look first at peacetime operations, then emergency operations, and finally war-time operations.

PEACETIME

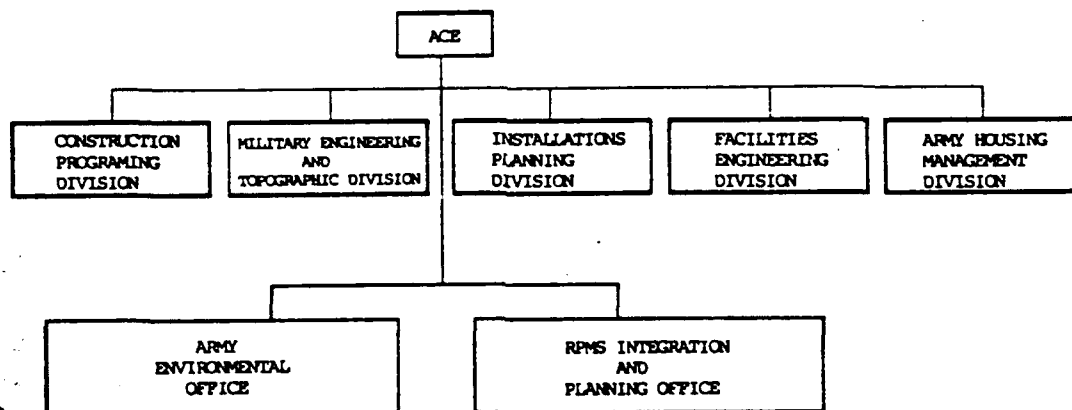
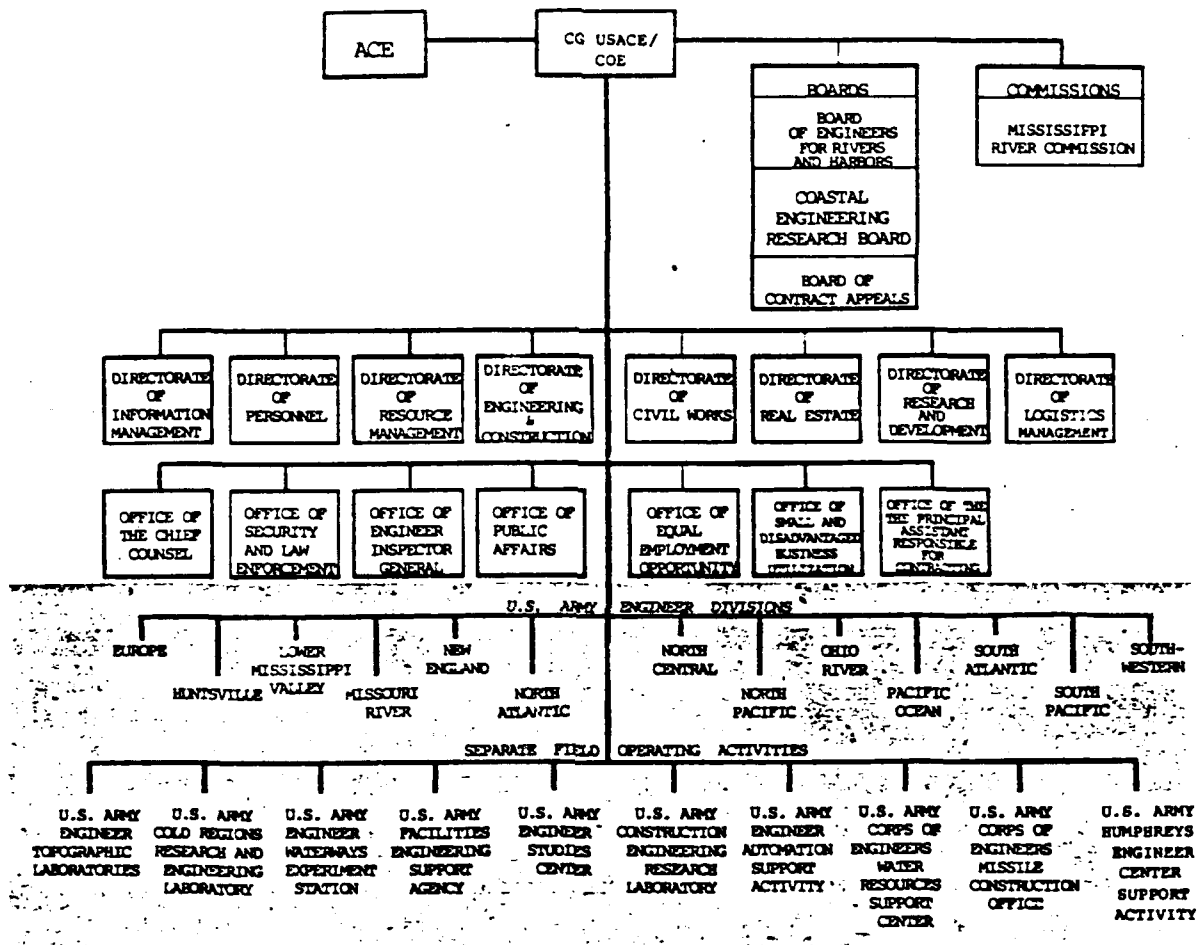
USACE is the primary construction organization for the US Army. Its missions are.

- * Manage and execute engineering, construction and real estate programs for the Army and Air Force
- * Perform research and development in support of above programs
- * Provide specialized engineer and technical support to.
 - Facility Engineers
 - Staff Engineers
 - Unit commanders of Army engineer organizations
- * Provide specialized assistance to theatre commanders in base development planning for contingency operations
- * Manage and execute Civil Works Programs
- * Perform R&D in systems, specialized equipment, procedures and techniques relevant to engineer support of combat operations³

Over the years, the USACE organization has evolved from an organization which executed most of its work in-house, to one which

primarily plays a management role. Approximately 85 percent of the design work and virtually all of the construction is executed through contracts with civilian designers and builders. Figure 4.3 illustrates the USACE organization.⁴

Figure 4.3 ARMY CORPS OF ENGINEERS, PEACETIME ORGANIZATION



The Corps also shares responsibility with the Navy and Air Force to provide overseas engineering and construction support. Responsibility is divided on an area basis as follows.

ARMY

Panama
Honduras, El Salvador and Costa Rica
Canada, excluding Newfoundland
Greenland
Europe and Turkey, excluding Spain, Portugal, Italy and Greece
Israel
Middle East, including Saudi Arabia
Egypt and Sudan
Liberia, Nigeria, Niger and Gabon
Southern Asia from Iran to Burma
Japan, Korea, Taiwan
Marshall Islands

NAVY

Atlantic Ocean Area
Carribean Sea Area
Newfoundland and Iceland
Greece, Italy, Spain and Portugal, the Azores
Morocco, Algeria, Libya, Tunisia
Guinea, Senagal
Djibouti, Somalia, Kenya
Indian Ocean Area
Republic of the Phillipines
Southeast Asia
Australia, New Zealand
Pacific Ocean area, excluding the Marshall Islands.

Air Force

British Isles

Countries that are not designated will be assigned by the SEC DEF when the requirement occurs.⁵

Within the Continental US (CONUS), the Army and Navy generally use their own engineer commands unless the use of the other service will increase efficiency or cost effectiveness. The Air Force normally uses the services of USACE for managing the design and construction of their projects.⁶

Emergency Operations

USACE also plays an important role in the preparedness, response, recovery, and mitigation aspects of natural disasters -- particularly flooding and coastal emergencies. The decentralized organization is ideal for providing timely technical advice and quick construction in support of state and local authorities.⁷

Wartime Operations

The USACE wartime mobilization mission is to "provide engineering and real estate services to the Army and the nation and accomplish the execution planning for the engineer manpower,

resources and facilities required to achieve installation capability to accomodate the mobilization and deployment missions." 8

USACE is responsible for expanding and taking the actions necessary to accomplish the wartime engineering requirements as directed by The Department of the Army or higher authority. Its major functions include.

- * Military Engineering and Construction needed to support full mobilization, early identification of required resources
- * Civil Works projects that are essential to national defense and mobilization
- * Real Estate aquisition and disposal for DOD and other federal agencies
- * R&D for the quick solution of engineer related problems

USACE has also issued the following planning guidance to assist its personnel. First, plans will be prepared to provide engineer resources in the manner most supportive of the entire mobilization effort. Second, new construction will be limited only to the minimum essential requirements, and temporary shelters will be used whenever feasible. Thirld, reactivated facilities will be rehabilitated only to provide basic operational needs, ensuring the most economical

use of resources, and giving priority to those items essential to permit occupancy. Fourth, whenever possible, activated facilities and buildings will be connected to existing utility systems. Fifth, peacetime real estate functions will be continued during mobilization until the Federal Government enacts emergency legislation. Finally, USACE will assist installations in meeting their facility requirements.⁹

USACE support for Overseas Theatre construction will be described under "Overseas Theaters".

4.1.4 The Navy

Like USACE, the Navy's Civil Engineer Corps (formerly called the Bureau of Docks and Yards, and recently named the Naval Facilities Engineering Command, or NAVFAC) has the mission of executing the Navy's military design and construction program around the world. Organized similar to USACE, construction is delivered by Engineering Field Divisions and Public Works Centers. Additionally, Officers in Charge of Construction (OICC'S) are designated for special projects, such as the Trident Submarine Base at Kings Bay, Georgia,

and for overseas missions in the theatres of operation. For example, in the European Theatre, the NAVFAC OICC executes DOD's peacetime construction program in the Navy's designated countries and serves as the Regional Wartime Construction Manager (RWCM) for the commander in Chief, US Navy Europe during wartime.

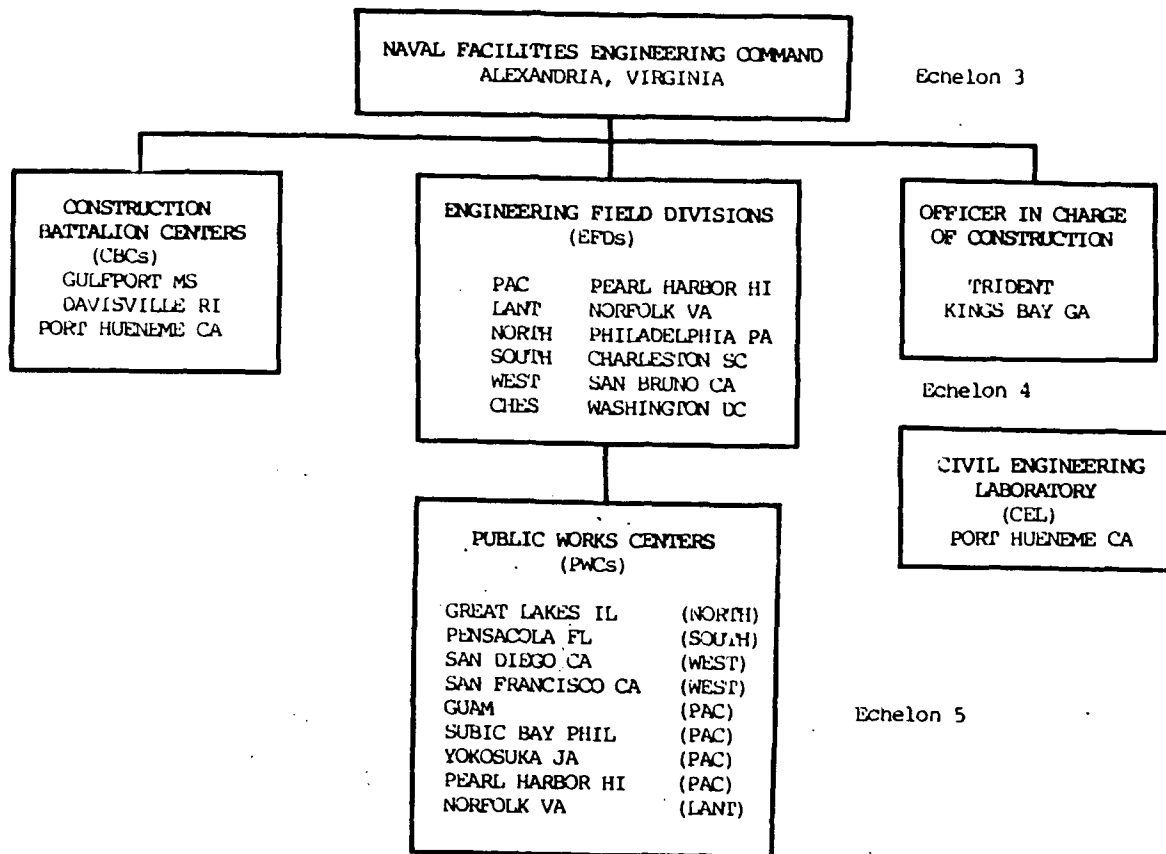
NAVFAC also has an R&D lab located in Port Hueneme, California. The Naval Civil Engineering Lab's work is applications oriented, and tries to anticipate construction requirements where technological problems must be resolved.

The Construction Battalion Centers focus on the Navy's construction troops -- the Seabees -- which support the Navy around the world. The Construction Battalions consist of both active duty and reserve troops. The Centers provide technical advice and training to the Naval Construction Force, and also maintain war reserve stocks for the Reserve Seabee Battalions.

The NAVFAC organization is illustrated in Figure 4.4.¹⁰

Like the Army, the Navy's Logistics Staff has a construction branch which plans the construction component of logistical support for Naval Forces in operations around the world.

Figure 4.4 NAVAL FACILITIES ENGINEERING COMMAND



4.1.5 Air Force (AF)

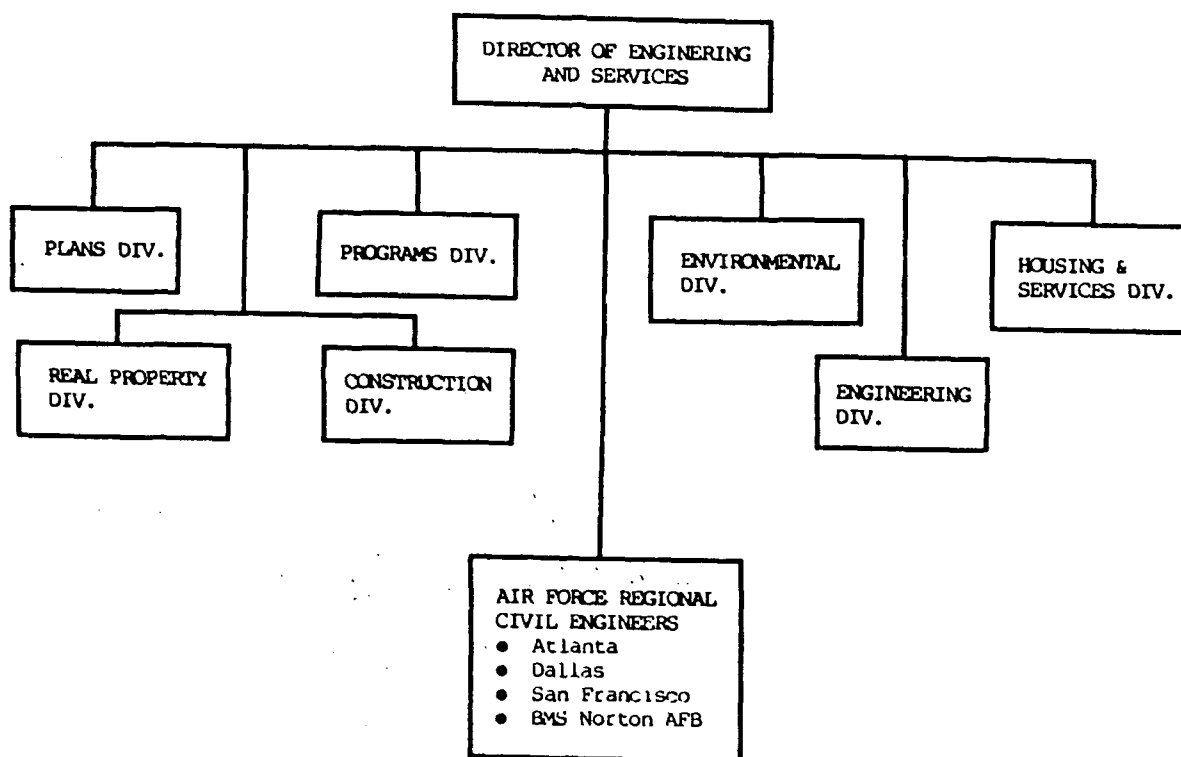
Although the majority of the AF's construction program is managed by either the Army or Navy, the US Air Force Directorate of Engineering and Services (AFDES) is responsible for the planning, design and construction of those projects which can be managed more efficiently and cost-effectively by the AF. Such projects must be approved by the DOD.

Like USACE and NAVFAC, the AFDES provides technical advice to the AF Regional Civil Engineers in the field who manage the design and construction of AF military family housing, and to the AF Base Civil Engineers who maintain AF bases around the world.

The AF also executes its DOD construction mission in the British Isles through the Commander in Chief, US Air Force Europe (CINC USAFE). The USAFE Deputy Chief of Staff for Engineering and Services, serves as the Regional Wartime Construction Manager during war, and as the principal construction executive in peacetime. The AFDES organization is depicted in Figure 4.5.¹¹

The AF also has engineer construction troops which provide construction support for AF combat operations around the world.

Figure 4.5 AIR FORCE ENGINEERING AND SERVICES



4.1.6 Theatre Commands

There are major unified commands which are responsible for the US's most crucial geographic areas of interest around the globe. They are the European Command (EUCOM), which is commanded by an Army General, The Central Command (CENTCOM), commanded by a Marine Corps General, The Pacific Command (PACOM), commanded by a Navy Admiral, the Southern Command (SOCOM), commanded by an Army General, the Atlantic Command (LANTCOM), commanded by a Navy Admiral, and the Readiness Command (REDCOM), commanded by an Army General. Table 4.1 lists each command's geographic area.

TABLE 4.1 THEATRE COMMANDS

EUROPEAN COMMAND: Europe, Turkey, parts of Africa

CENTRAL COMMAND: Southern Asia (from Iran to Burma), Indian Ocean area, parts of eastern Africa

PACIFIC COMMAND: Eastern Asia, Pacific Ocean area

SOUTHERN COMMAND: Central and South America

ATLANTIC COMMAND: Atlantic Ocean area, excluding the above-named areas

READINESS COMMAND: Continental US

During peacetime, construction is executed on a regional basis with the Army, Navy and Air Force each having geographic areas of responsibility as described in Section 4.1.3. For example, USACE's European Division (EUD) supports the EUCOM's construction program within those areas for which the Army has been designated the DOD construction agent.

During wartime, the situation is different. Construction planning then becomes part of the Joint Operations Planning System (JOPS). Under JOPS, a Civil Engineering Support Plan (CESP) will be part of the Logistics Annex to each Operations Plan (OPLAN). The CESP should reflect all base development construction, and assumed war damage repair construction on a time-phased basis.

In Europe, for example, USAFE has been designated as EUCOM's theatre wartime construction manager, and is therefore responsible for maintaining the CESP. USAFE must integrate construction requirements into the CESP in accordance with the needs of the Army, Navy, and Air Force within the European Theatre.¹²

The European Theatre is divided into three wartime construction management regions, (the UK, Central/Northern Europe, and the

Mediterranean), and the service component commanders have been designated as Regional Wartime Construction Managers (RWCM) for planning and executing construction in the countries listed below.

<u>COMPONENT</u>	<u>AREA</u>
<u>CINC, US Army Europe</u> (note. USACE's European Division shifts from USACE to USAREUR)	Norway, Denmark, West Germany The Netherlands, Belgium, Luxembourg, France
<u>CINC, US Navy Europe</u>	Portugal, Spain, Italy, Greece Turkey, Morocco, Algeria, Tunisia, Libya, and Mediterranean Islands.
<u>CINC, US Air Force Europe</u>	United Kingdom and the Republic of Ireland

Combat engineering support will be the responsibility of the engineer troops of the Army, Navy and Air Force. Most of these combat support troops will not be available to perform major military construction, since they will be in short supply and crucially needed on the battlefield.

Planners envision two possible strategic scenarios, each utilizing different methods to satisfy construction requirements. The

two scenarios are.

* A Short Duration War (less than six months) Facility requirements will be met by using existing facilities, military equipment, expedient construction, and the erection of deployable structures. Operating and Maintenance funds will be used as much as possible, and Military Construction programming and new construction contracting will normally not be required.

* Sustained Operations (longer than six months) When the situation requires facility construction of the type and scope normally funded by Congress through the Military Construction programs, then these requirements will be integrated into the CESP. These facilities will be built to temporary standards.

Based on the input of the three component commanders, the CINC Europe will develop a CESP for each contingency.¹³

The theatre wartime construction management plans for the other theatres are organized along the same principles as that described for the European Theatre.

4.2 How the Military Addresses Its Construction Needs

This section will discuss how the military plans to address their construction demands as described in Chapter 3, using the delivery system described in the previous section.

4.2.1 Deterrence

In general, this work emphasizes permanence, durability and the same economic principles as civilian construction. As described in the previous section, each service is responsible for managing its own peacetime construction program, along with its overseas geographic area of responsibility.

New construction is generally managed by the USACE districts or the NAVFAC public works centers. More than 85 percent of the design work is contracted out to private industry, and virtually all of the construction is performed by private contractors. (In certain circumstances, usually overseas, engineer construction troops actually build projects that are within the capabilities of their technical expertise and construction equipment.)

Most military construction projects are competitively bid, and

the "lowest responsive, responsible bidder" normally gets the job. Foreign and domestic contractors bid on these projects, and the military tries to maximize their construction dollar. Unfortunately, like other buyers of construction, the military has found that its construction dollar does not go as far as it used to. If and when the military wants a new facility in peacetime, it must simply pay for it.

Maintenance and repair of existing facilities is one of the military's most challenging and serious peacetime missions. This program is funded by the military's "Operating and Maintenance" budget and normally consumes more than the new construction program.¹⁴

Like new construction, repair and maintenance funding is allocated from the Congress, through the DOD to the services, then through the service's major commands down to the installation level where the facility or base engineer actually manages the work. Like new construction, most of the repair and maintenance work is contracted out to private industry.

For reasons described in Section 3.8.1, the military has been unable to satisfactorily meet this demand. Like the infrastructure

renewal crisis everywhere, the construction industry is unable to satisfy this demand in an economically acceptable way.

Unsatisfied with the response of private industry, the military is funding a substantial R&D program to develop new and better ways of managing and repairing their facilities, and to design new facilities in ways that prolong the facility life cycle and minimize maintenance and repair requirements. All of this work is performed with the intent of "stretching the military's construction dollar".¹⁵

4.2.2 Mobilization

Mobilization construction requirements will emphasize speed and expedient standards. These temporary facilities must be built when and where they are needed, and the normal peacetime standards of permanence, durability, and economics will not apply.

Mobilization construction requirements will be supplied by the US construction industry. Since the civilian construction industry is geared to make a profit in the private sector, where mobilization construction standards are rarely if ever seen, the military has had to develop the technology and planning necessary to meet this demand.

This will be discussed at greater length in subsequent sections.

USACE and NAVFAC are organized geographically. Their regional offices are responsible for identifying construction requirements for their area of responsibility during peacetime, determining when they must be initiated, who should execute them, and how they can best be accomplished.¹⁶

USACE and NAVFAC work with the facilities engineers at installations within their area of responsibility in developing mobilization construction plans. These plans are developed to support a full mobilization as a prelude to total mobilization. Full mobilization planning applies available resources against facilities requirements as expeditiously as possible. Shortfalls can and should be identified and a realistic assessment of mobilization capability can be determined. Shortfalls should be overcome by initiating peacetime military construction procedures.¹⁷

Total mobilization expands the Active Forces beyond the size of the force structure seen in full mobilization, which includes all of the active and reserve forces. It draws on all national resources required to equip and sustain the expanded forces. *Presently,*

there is no approved Total Mobilization Plan. Thus, engineering and construction plans cannot be fully determined until the Total Mobilization Plan -- addressing manpower and industrial capacities and requirements -- is developed.

Since total mobilization capacities and requirements are not fully known, it is impossible to accurately forecast the construction requirements. Yet, military construction and engineering must keep pace with the total mobilization effort.¹⁸

These difficulties will be further compounded because most design firms and construction contractors are unfamiliar with mobilization design and construction standards as well as the requirements and tasks that they might be asked to accomplish. Regional capabilities have not yet been evaluated, nor are adequate plans in place for mobilizing the industry.

Currently, the Society of American Military Engineers (SAME) is working with the military to involve the construction industry in a mobilization awareness and preparedness program. Their plan, called "Operation Fast Start", calls upon regional SAME posts to define general construction requirements for all emergencies, to inventory

all construction and design capabilities within the region, and to involve members of the construction industry in the planning process.¹⁹

Certainly a valuable and important step, this is no substitute for a formal program between the military and the US construction industry. The military could use Operation Fast Start as a model to develop their own comprehensive program to identify construction capabilities and prepare firms in peacetime for the work they will be required to perform during mobilization. Such a process would unleash the tremendous ingenuity and creativity of America's construction industry. This would then help the military to identify and troubleshoot potential manpower, legal, and resource shortfalls before a crisis occurs.

Currently, the military construction delivery system is better prepared for a mobilization than ever before in our history, but there is much more that can and should be done in peacetime. More and better planning would go a long way in alleviating the chaos and confusion that will otherwise undoubtedly prevail if the US must again mobilize for war. Since the military will rely almost

exclusively on the US construction industry, it is incumbent upon the military to develop the technology, planning and organization needed for mobilization requirements during peacetime.

It is also in the best interests of the construction industry to cooperate and get interested in the military's mobilization construction planning. First, since the construction industry, along with the rest of the nation, will depend upon the military for their very survival, it is in their own self-interest to do everything they can to make the mobilization a success and their survival a reality. Second, since military construction will dominate the industry during wartime, advanced cooperation will be the best way to help assure wartime revenue. Finally, as citizens and businesses, they should be willing to put something back into an American system from which they have gained enormous benefits.

4.2.3 Conventional Strategy

Construction support to overseas theatres of operation will be absolutely critical. As described in Chapter 3, US strategy depends upon the rapid deployment of forces and materiel from the US. The

Soviets realize this and will attempt to destroy the key transportation links that are required in the deployment.

The construction delivery system which will respond to the construction demand will consist of US and Allied engineer troops, and the host nations' construction industries.

The Regional Wartime Construction Managers are in the process of identifying probable construction requirements. They will then match the requirements against their own troop construction capabilities. The construction capability shortfall is then presented to the appropriate host nation. The host nation is supposed to consolidate the construction requirements and identify the appropriate capabilities to execute the tasks. This represents only the US engineer effort, however. The big problem is that "***no central body assesses the facility capabilities and shortfalls under the combined US, Allied, and individual nation responsibilities***"²⁰

Military facilities requirements have been undergoing intense scrutiny and planning by the responsible military RWCM's. For example, the AF has greatly improved the survivability and

sustainability of critical air bases under a program called "Air Base Survivability." The Navy and the Army have also initiated similar planning efforts. Although these efforts represent a significant step in the right direction, the broader issues concerning the defense and recovery of host nations' civil facilities have received considerably less attention and effort.²¹

Responsibility for civil facilities such as airports, ports, and railroads -- although militarily crucial -- belong to the individual nations, and are not currently part of the overall military planning process. Recovery operations will depend upon the host nation's construction industry. Although highly capable, private contractors will be greatly handicapped when forced to deal with unexploded ordnance, chemical or biological contamination, and terrorist attack, while under intense time pressure to re-open the facility which is critical to the war effort.²²

The current construction delivery system, which must be able to provide strategically vital facilities, is inadequate. Without a comprehensive analysis of requirements, the need for new technology has not been adequately addressed. Planning for the construction or

repair of vital facilities within a theatre is an extremely complex and difficult issue which crosses the responsibility and authority lines of nations, allied military forces, and individual US services. The entire delivery system needs to be thoroughly and continuously examined at all levels, since its success or failure could lead to victory or defeat.²³

4.2.4 Conventional Tactics

"Today's combat engineers are the weakest link in the battlefield combined arms team,"²⁴ said Major General RS Kem, former commander of the Army Engineer School, and currently the Chief Engineer Staff Officer for the US Army, Europe. This problem is slowly being corrected as the military fields better combat engineer equipment, but much remains to be done in the areas of integrated training, the need for still better equipment, especially for clearing minefields and crossing rivers, and new technologies for rapidly executing the military's unique wartime construction requirements.

The delivery system is organized along individual service lines, with each service responsible for providing its own engineer troop

support, as required. The engineer forces generally function at three different echelons of the battlefield. Divisional combat engineers are organically part of the combat divisions and actually fight the war with the infantry and armor. Corps level engineers provide additional heavy engineer support to the divisions, and also perform construction support in the corp's rear area. Theatre level engineers generally execute construction requirements in the theatre rear area as directed by the RWCM.

Theoretically, the US has a balanced structure, with sufficient engineer forces to support the combat arms. In reality, however, while about two-thirds of the military's combat power is on active duty, approximately two-thirds of the engineer forces are in the reserve component. This force imbalance will be exacerbated because the engineer and construction reserve troops are generally equipped with very old and outmoded equipment.

Until these reserve forces are activated and deployed to the theatre of operations, the theatre commander will be grossly short of the needed engineer and construction troops. This problem will be further complicated, since these same reserve engineer forces are the

ones who must maintain and repair the critical facilities needed to ensure the timely reinforcement of US combat forces.

The conventional tactical demand for construction will be provided almost exclusively by US engineer forces. The debate over how the military should organize itself in terms of active duty versus reserve engineer troops has been the subject of intense debate and scrutiny since the Vietnam War. The individual services, which actually man and equip the forces, tend to favor pushing much of the engineer support into the reserves to make more room for active duty combat units. The theatre commanders on the other hand, are more concerned with ensuring that they have adequate engineer forces on active duty, so that they will actually be in the theatre of operations when needed.

4.2.5 Low Intensity Conflict

Small War

If we enter a small war, construction demand will initially be satisfied by existing facilities and quickly deployable structures erected by US engineer forces.

If the conflict is short (less than six months), virtually all of the required construction will be provided by active duty military engineer troops. If the conflict is sustained beyond six months however, the situation will be different. As seen in Vietnam, the shortage of active duty engineer forces can cause a massive shortfall in the construction delivery system. If the President chooses not to mobilize the Reserves, the construction capability shortfall would have to be made up through the use of either host nation construction support (which is highly unlikely if the nation is either remote and under-developed, or hostile to the US), or private US contractors.

In the short war scenario, there could be serious problems, particularly in the areas of logistics over the shore operations, and in attaining required building materials. Planning for such contingencies is conducted on a case-by-case basis and the actual requirements and shortfalls are classified.

In the sustained war scenario, we could expect to see requirements and problems similar to those in Vietnam. Even if the Reserves are mobilized, there would probably still be a role for private contractors, since troop construction units have limited

expertise, especially in the construction of technically complex systems and vertical structures. For such contingencies, contractors have been contacted and advanced planning has been conducted.

Terrorism

The construction demand needed to respond to the terrorist threat will be met in several different ways. During peacetime, the military will contract the work out to private industry to design and construct the needed facilities. This is currently being done, and within budgetary constraints, the construction industry is responding adequately to the need.

During wartime, this process will be stepped up and engineer troops will also be given construction missions to help protect military facilities against potential terrorist attacks. Once hostilities begin, this mission will be a high priority and must be executed quickly. Given all of the other construction demands, there could be temporary shortfalls in which the delivery system cannot respond to all demands within the desired time. This represents yet another fertile area for the development and application of new

construction technology.

4.2.6 Total/Nuclear War

Assuming that a nuclear war will evolve from a conventional war, all recovery work will be executed by private industry. The decentralized nature of both the US construction industry and the military's construction management system, will allow recovery work to proceed as quickly as possible, with or without centralized direction or planning. Depending upon the extent of the attack, recovery operations will proceed in a manner similar to recovery from natural disasters, with state and local governments managing the effort. Military construction organizations, like the Corps of Engineers, will assist state and local authorities.

All civil defense construction that is put in place prior to a nuclear war will also be executed by private industry. Like the demand for other new construction, the industry will respond to the appropriate financial incentives, albeit slowly, expensively, and with relatively obsolete technology.

4.2.7 New Areas

The new military construction requirements discussed in Chapter 3 will ultimately be satisfied by the private construction industry. In the short term however, military construction R&D programs are devoting significant resources and efforts to solving these new challenges. New demands for construction must be solved by a team effort involving both private and military efforts.

Table 4.2 depicts how the military construction delivery system will address the military's construction demand.

TABLE 4.2 CONSTRUCTION DEMAND/SUPPLIER

<u>CONSTR DEMAND</u>	<u>CONSTR SUPPLIER</u>		
	<u>US Constr Industry*</u>	<u>Engineer Troops</u>	<u>Host Nation Constr Industry</u>
Deterrence	X		
Mobilization	X		
Conventional Strategy		X	X
Conventional Tactics		X	
LIC. -Short War		X	maybe
-Long War	maybe	X	"
-Terrorism	X	X	"
Nuclear War	X		
New Areas	X		

* Or, a more competitive foreign supplier.

"X" denotes the supplier.

4.3 Assessment of the Delivery System

This section will assess the consistency and responsiveness of the construction delivery system, and will identify shortcomings and inconsistencies in its responsiveness to the demand. In assessing the delivery system, I will analyze the role of two different groups -- the military, and the construction industry.

4.3.1 The Military

The military depends heavily upon the US construction industry to satisfy its demand for a massive and diverse construction program. This increasing reliance upon the private construction industry has paralleled a decline in the military's ability to design and execute its construction requirements in-house. Since WWII, both the USACE and NAVFAC have evolved from agencies which actually designed and built many of the military's projects into primarily construction management organizations. Unfortunately, the military's increased reliance upon the US construction industry has occurred during the same period that many contractors have also gotten out of the business of actually building, and into construction management. I

will address this dilemma further in the next section.

Decentralization of authority and responsibility is one of the great strengths of both the military construction management system, and of the US construction industry. It allows people in the field to do their job and accomplish the mission without undue micro management. Unfortunately, the lack of centralized information management regarding the demand for and supply of construction is also a potential wartime weakness.

Important and appropriate steps have been taken to meet the new construction requirements of the 1980's. Efforts have focussed on identifying construction requirements, capabilities and shortfalls. Most of this work has been accomplished by the individual services' construction agencies and the theatre commands. The problem is that most of these efforts have not been consolidated, coordinated or evaluated at the DOD or JCS levels. Additionally, the lack of a comprehensive, national mobilization plan has delayed major efforts in construction planning.

There are two major problems which plague the unified field commands. First is the challenge of host nation construction support

for essential military construction. Second is the dilemma in which the unified commanders find themselves dependent upon the individual services to man, equip, and train the forces which make up their commands.

Presently, host nation construction support is a major question mark. There exists a wealth of potential capability, however planning and coordination must be accomplished during peacetime in order to assure viability during war. Currently, host nation support represents a major shortcoming of the military's construction delivery system.

Many of the engineering and construction related shortfalls that currently exist within the unified commands have been known and identified for some time now. The theatre commanders who are actually in charge of planning, fighting, and winning our wars provide input to the Pentagon and the services who determine how the military budget will be allocated. Unfortunately, the dynamics of the budgeting and procurement processes are such that many of the theatre commanders' logistical support requirements have been systematically neglected in favor of other items such as new weapons systems. As a result, our engineer troop capabilities are

inadequate in terms of troop strength, equipment and construction capabilities.

Lacking a unified and consistent effort at the top, the efforts by subordinate elements have not resulted in a construction delivery system that will be consistent and responsive to the wartime demand.

There is much room and need for improvement in the construction delivery system, particularly in the areas of organization, planning, resources and technology. The military must take the initiative and become the leader and the catalyst for change. It is incumbent upon the military to get its planning and organization in order while simultaneously investing in new construction technology, and working closely with the private sector.

4.3.2 The Construction Industry

Although it is the nation's largest industry, construction has few of the typical characteristics of other industrial giants such as the automobile or petrochemical industries. Composed of more than 1.2 million firms, there are no General Motors or EXXONs. More than

half of the firms operate on a local basis, use no mass production, and are so small that they have no payroll. Unlike other industries, "they work seasonally and changeameleon-like in response to demand. For a given project, an ad hoc team may assemble consisting of workers, contractors, designers, developers, investors, suppliers, and representatives of any of seventy labor organizations and countless regulatory agencies. When the job is done, the crew disbands."²⁵

One of the most critical components of the US economy, construction employs nearly six million workers, performs more than \$300 billion of work each year, and has historically accounted for 55 to 65 percent of the nation's capital investment, and 8 to 10 percent of the GNP.²⁶

Construction's true importance to the economy is not determined by its size, but rather by the impact and function of its products.²⁷ The industry affects the daily lives of everyone, as it builds and repairs the structures needed for shelter, public health, water supply, irrigation, transportation, power, education and manufacturing plants. Indeed, construction plays a vital role in promoting our commercial and national identity, in enhancing our

national defense, and in improving our health and quality of life.²⁸

Additionally, the construction industry has been one of the largest foreign exchange earners in the US economy as our contractors have dominated the international market for decades.

For various reasons, US construction productivity has declined in the past fifteen years. According to the Business Roundtable, "by every common consensus and every available measure, the US no longer gets its money's worth in construction."²⁹ Among other factors, stagnant technology in the US construction industry has enabled technologically superior foreign competitors to outperform their US rivals. Given the dependence of both the military and the national economy upon the US construction industry, this decline has had a serious negative impact.

Due to the complexity of the problems and its own pluralistic nature, the construction industry has been unable to solve its most serious and basic problems.

Chapter 4 Endnotes

1. DOD wiring diagram is from the **US Government Manual**, p. 836. This diagram was a handout in Class 17.460, Defense Politics, at MIT.
2. US Army Corps of Engineers, **Construction and Engineering in Mobilization and War, Answer Pamphlet**, (Carlisle, PA: Ketron, 1987), pp 14-15.
3. US Army Corps of Engineers, **Construction and Engineering in Mobilization and War, TACSIT**, (Carlisle, PA: Ketron, 1987), Figure 4, p 2.
4. USACE, **TACSIT**, p 3.
5. USACE, **Answer Pamphlet**, pp 9-10.
6. USACE, **Answer Pamphlet**, p 7.
7. USACE, **TACSIT**, p 5.
8. USACE, **TACSIT**, Figure 20, p 6.
9. USACE, **TACSIT**, Figure 20, p 6.
10. USACE, **Answer Pamphlet**, pp 10-12.
11. USACE, **Answer Pamphlet**, pp 12-14.
12. USACE, **Answer Pamphlet**, p 18.
13. USACE, **Answer Pamphlet**, pp 32-33.
14. Edward N. Luttwak, **The Pentagon and the Art of War**, (NY: Simon and Schuster, 1985), p 213. As referenced by Luttwak, this information was taken from the **Report to the Secretary of Defense to the Congress on the FY 1985 Budget, FY 1986 Authorization Request and FY 1985-89 Defense Programs**, February 1, 1984, Chart II.D.1, p 102.
15. M. Dallam, Captain, US Navy, Office of the Assistant Secretary of Defense, in a speech entitled "Presentation to the Construction Industry Institute Annual Meeting", 7 August 1986.
16. USACE, **Answer Pamphlet**, p35.

17. USACE, **Answer Pamphlet**, p 36.
18. USACE, **Answer Pamphlet**, p 70.
19. USACE, **Answer Pamphlet**, p40.
20. Richard J. McAfee, Lieutenant Commander, US Navy, "Facilities and the Maritime Strategy Volume I. A Strategic Imperative", (Newport, RI: Naval War College, 1987), p 9.
21. McAfee, pp 9-10.
22. McAfee, p 10.
23. McAfee, p12.
24. Michael Herman, "Integrated Combined Arms Training for Engineers", **The Military Engineer**, September-October, 1987, p.548.
25. Fred Moavenzadeh, "Construction's High Technology Revolution," **Technology Review**, October, 1985, p. 32.
26. Moavenzadeh, p. 32.
27. Julian E. Lange and Daniel Quinn Mills, **The Construction Industry** (Lexington, MA: DC Heath and Co., 1979), p. 1.
28. **Proposal For An Engineering Research Center For Construction**, submitted to the National Science Foundation (MIT, Center for Construction Research and Education, September, 1984), p. 1-7.
29. **More Construction for the Money**, (the Business Roundtable, January, 1983), p. 11.

CHAPTER 5 GAP BETWEEN REQUIREMENTS AND CAPABILITIES

This chapter will discuss and analyze construction technology and the issue of foreign dependency in military construction

5.1 The Need for New Construction Technology

This section will examine the gap between construction requirements and existing construction technology; construction R&D; and what the military is doing in this area.

5.1.1 The Construction Technology Gap

In general, the public is no longer as willing to invest in its infrastructure as it was twenty years ago. The main reason is that the public feels that they no longer getting their money's worth when it comes to construction. The public is unhappy with the construction industry because they feel that the price is too high and the quality too low.¹

In general, it takes longer and costs more today, to build the same project, than it did twenty years ago. Although the reasons for this sad state of affairs are many and complex, one factor seems to consistently stand out above all the others. ***We are being held captive by obsolete construction technology***. Since the buyer has no real alternative to the status quo, he must either pay dearly, or not invest at all. A dynamic industry would have improved this

situation by investing in new technology.²

Like the industry it supports, construction R&D is a difficult topic to quantify. Data is sketchy and imprecise. With the exception of materials and equipment manufacturers (ie. Dupont and Caterpillar), almost no one performs construction related R&D. In fact, the industry as a whole, including owners, contractors, architect-engineer firms, and until relatively recently, academia, have generally been disinterested in, or resistant toward research and new technology. The "free rider" problem and the fragmented nature of the industry, with each sector more concerned with its own preservation than with overall advances is primarily responsible for this inertia. Yet, even when promising new technology exists, the industry will fail to adopt it. "Institutional barriers" block the spread of new technology from its origin to where it can cut costs and enhance productivity. Such barriers include: restrictive building codes and technical standards; labor agreements and craft jurisdictional issues; liability and other legal considerations; lack of incentives; counterproductive contractual relationships and government regulation; industrial inertia; and communication problems.³ The reasons for these problems are complex and worthy of a separate paper, but the point is that this indifference toward research, and resistance to adopt new technological innovation, have led to a construction technology gap, and are major factors in the rapidly rising costs of construction.

5.1.2 Construction R&D

According to the Federal Committee on Construction Productivity, many of these other productivity problems might not be present if more construction R&D had been performed.⁴ The committee says that "construction contractors spent \$28 million on R&D in 1974, which represents about \$54 million in 1984 dollars. Although this is not an insignificant amount of money, it is minuscule for the size of the industry, and it does not invalidate the conclusion by many that construction contractors spend almost nothing on R&D."⁵ The study goes on to say that "although the construction industry itself does little R&D, it uses and benefits from R&D performed by other industries (mostly manufacturing). For example, in 1974 the construction industry benefited from approximately \$432 million in R&D expenditures from 33 other industries . . . In 1984 dollars, these expenditures total more than \$838 million."⁶ Furthermore, the study could not determine the amount invested in R&D by corporate construction users, but was "certain . . . that the amount is small in comparison to the construction expenditures of large corporations" and "that such projects usually deal with problems concerning specific facilities rather than broad issues of concern to the construction industry. Thus, such R&D probably has little impact on construction productivity." ⁷

Table 5.1
ESTIMATE of TOTAL ANNUAL R&D EXPENDITURES⁸
and PERCENTAGE of TOTAL
(millions of 1984 dollars)

Construction contractors (general and specialty)	\$54 m / 4.4%
Manufacturers of construction products and equipment	\$838 m / 68.5%
Federal agencies (both consumers and nonconsumers of construction) ...	<u>\$220 m</u> / 18%
SUBTOTAL	\$1,112 m
All others (valued at 10% of subtotal) ...	<u>\$111 m</u> / 9%
TOTAL	\$1,223 m
Construction put in place	\$312,900 m
R&D as a Percent	0.39%

Compared to other mature industries, construction R&D expenditures, as both a percentage of total sales, and dollars per industry worker, are proportionally the lowest.

Table 5.2
R&D as a PERCENT of SALES /
R&D DOLLARS PER WORKER⁹

Construction	.39% / \$142
Tobacco	4% / \$267
Steel	.5% / \$740
Fuel	7% / \$3,110
Textiles & Apparel	.8% / \$571
Food & Beverage	9% / \$1,015
Containers	.9% / \$877
Paper	1.0% / \$1,261
Appliances	1.4% / \$1,231
Automotive	1.7% / \$1,498
Oil Service & Supply	2.9% / \$2,348

Compared to its R&D expenditures in other fields, and to its total construction expenditures of about \$44 billion per year, the Federal Government's investment in construction R&D of about \$220 million per year, is not large.

Table 5.3

FEDERAL R&D INVESTMENTS¹⁰
(in billions of 1984 dollars)

Construction	\$.22 b
Education, training, employment, social services	.20
Agriculture	.76
Natural resources, environment	.96
Transportation	1.04
General science	1.68
Space	2.30
Energy	2.58
Health related	4.78
Defense	29.29

As a percentage of
Federal investment
in construction .50%

Table 5.4
FEDERAL CONSTRUCTION-RELATED R&D ESTIMATES¹¹, 1984
(in millions of 1984 dollars)

CONSTRUCTION PROCURING AGENCIES:

DOD	\$79.7 m *
Dept of Energy	32.2
All others	<u>7.4</u>
SUBTOTAL	119.3

OTHER AGENCIES:

NSF	29.1
EPA	22.0
UMTA	17.8
FAA	8.1
NBS	6.7
USGS	4.6
FHWA**	2.5
All others	<u>10.0</u>
SUBTOTAL	100.8

TOTAL	220.1
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* This includes only that funding allocated to "construction labs" of the military's construction agents (ie. USACE, NAVFAC and AFDES) under the military's Research, Development, Test and Evaluation (RDT&E) budget; it does not include R&D allocated to such non-construction agencies as the Army Materiel Command, who also performs wartime construction R&D; or the applied construction R&D to solve specific problems that is funded by other military commands out of their own mission support funds; when these other sources of funding are included, the total exceeds \$250 million.

** plus \$30 million transferred to states

Finally, although accurate data was not available, there is evidence that the US's low level of construction R&D is lagging behind some important international competitors, most notably Japan.¹²

5.1.3 Military Construction R&D

As the nation's largest owner and buyer of construction, and for reasons explained earlier in this paper, the military has always been concerned with construction research and technology. More recently, however, the military has become concerned with the industry's declining productivity. As an owner, they want to receive the maximum possible construction for their dollar. Due to the general apathy throughout the industry, and in order to help themselves, the military has embarked on a substantial and significant construction R&D program. Like trying to determine construction R&D expenditures in the civilian sector, it is very difficult to measure and distinguish how much of the military's R&D is spent on construction. For example, some of the Corps of Engineer's research is not really construction research, while a considerable portion of the Army Materiel

Command's research -- particularly at the Ft. Belvoir R&D Center -- is construction related research. There is no clean breakout, and any figures on the subject are estimates.

Currently, there are six major military laboratories devoted to construction R&D -- four in the Army, and one each in the Navy and the Air Force. These labs spend approximately \$250 million per year on construction-related research. The purpose of this research is "to stretch the military construction dollar in order to keep the DOD physical plant up to the standard required for national security needs"¹³ and to enhance the warfighting capability of US forces.

In order to satisfy new mission and weapons requirements, and replace obsolete facilities, the military needs to invest considerably more in its facilities than it has and currently does. The philosophy behind the construction R&D program is to help correct this shortfall through improved technology.¹⁴ The military sees construction as an important and relatively fertile industry, where the infusion of a relatively small amount of R&D money will reap a substantial return on investment. Construction experts feel that such a program could easily cut construction costs by one percent or more, and provide at

least a ten to one return on investment.¹⁵ Such a reduction would save hundreds of million of dollars in construction costs each year. This money could then be used for any number of other purposes. In both absolute and relative terms, this contribution is significant.²⁸ As a percentage of construction investment, it is roughly 100 times greater than the industry average. (Note, although DOD's construction R&D program represents less than one percent of the total military R&D budget, it would be large enough to rank in the top one-hundred R&D programs in corporate America.)¹⁷

Most of this R&D is applied research designed to solve specific technical problems encountered by the military. Yet, successful implementation requires that the contractors adopt the new technology and use it. Although many important government officials feel that the private sector must assume responsibility for construction R&D,¹⁸ the industry has not done it in the past, and shows no indication that it will do so in the future.

One of the most significant and far reaching aspects of DOD's construction R&D program are two \$15 million grants -- one to MIT, and the other to the University of Illinois -- to conduct basic

research in advanced construction technology. These are the largest grants for basic construction research ever seen in the US. Part of DOD's University Research Initiative, these grants have enabled the nation's top construction departments to purchase essential experimental equipment, to provide fellowships, thereby attracting top-notch American students to do basic research in construction, and to do what they feel needs to be done without excessive and oftentimes stifling oversight from the sponsor.¹⁹ Construction is an important part of the military's long range plan to enhance science and technology in America.²⁰ For this investment, the military expects world class research, interaction between the universities and military labs, so the military and academia make each other aware of their problems and solutions, and leverage -- to serve as a catalyst for R&D investment from other governmental agencies, states, private industry and other sources.²¹

In FY 1986, DOD spent \$33.3 billion on Research, Development , Test, and Evaluation (RDT&E). Of this total, not more than \$250 million was devoted to construction related RDT&E, or .75 percent. Approximately two-thirds of this \$250 million are allocated to

combat engineering and wartime construction technology, or about one-half of one percent of the total RDT&E budget, while the remainder is spent on peacetime construction applications, under the title of Base Support. When Mission Support funds from Civil Works R&D are included, the total R&D figure increases. However, when the DOD actually allocates its RDT&E funds, it spends less than one percent on construction -- both peacetime and wartime applications.²²

Table 5.5
DOD's BUDGET FOR RESEARCH, DEVELOPMENT, TEST AND
EVALUATION²³ (in millions of dollars)

<u>BY COMPONENT</u>	<u>FY 86</u>	<u>FY 87</u>
Army	4,577.3 / 13.6%	4,711.6 / 13.0%
Navy	9,520.9 / 28.3%	9,352.9 / 25.8%
Air Force	13,151.0 / 39.1%	15,388.8 / 42.5%
Other Defense	<u>6,416.9 / 19.0%</u>	<u>6,798.7 / 18.7%</u>
TOTAL	33,676.1	36,252.0
<u>BY PERFORMER</u>		
Industry	24,186.6 / 71.8%	25,443.9 / 70.2%
Government In-house	8,031.7 / 23.9%	9,058.3 / 25.0%
Federal Contract		
Research Centers	688.1 / 2.0%	875.2 / 2.4%
Universities	<u>789.7 / 2.3%</u>	<u>884.6 / 2.4%</u>
TOTAL	33,676.1	36,252.0

These figures are quite revealing. The Army, which receives only thirteen percent of the RDT&E budget, accounts for more than half of all of the military's construction R&D. The Navy and the Air Force, who together receive more than sixty-five percent of the RDT&E budget, account for less than half of all military construction R&D.

This phenomenon can be partially explained by three factors. First, the Army has the most people and therefore the majority of the facilities and installations. Second, due to its ground combat role, the Army has the majority of the troop construction units. Finally, with the Corps of Engineers and its historic role of construction and engineering leadership, the Army tends to assume the leadership role in this area.

The military should be commended for allocating far more than the industry average to construction R&D. However it is difficult to understand why DOD allocates less than one-half of a percent of its RDT&E budget to a technical procurement item (peacetime construction) that consumes more than seven percent of its total budget, and that is held hostage by the obsolete technology of the US

construction industry. In virtually every other technical area, the military has served as the catalyst for radical technical advances through its R&D program. Yet, in construction, the military has taken what is for them an uncharacteristically passive role in correcting a technological problem which adversely affects their readiness and consumes a disproportionate share of their resources.

The same can be said of DOD's funding for wartime construction and combat engineering capabilities, which I will discuss in the next section.

5.1.4 Need for New Wartime Construction Technology

Although wartime construction capabilities are at least as important today as in the past, they have not kept pace with the rapid technological improvements in the weapons systems which they must support. In other words, the technological gap between military construction capabilities and everything else continues to widen.

The unique nature of wartime construction requirements, as described in Chapter 3, offers a clear and distinct role for construction technology that is quite different from civilian or

peacetime construction. Currently, wartime construction capabilities still cannot solve many of the same engineering and construction challenges that were "war stoppers" as long ago as WWII.²⁴ For example, the US military still has not developed and fielded reliable mine clearing equipment. In WWII and Vietnam, enemy mines were one of the greatest obstacles to US tactical mobility and success, yet we still have not solved this problem. Marine Corps Commandant General Alfred Grey calls our inability to rapidly clear minefields and cross rivers "a disgrace". He questions the logic of fielding new, high speed, high-tech tanks when we still cannot solve such basic engineering challenges as the two listed above.²⁵ The Air Force and the Navy have also developed and fielded exotic new aircraft and ships, without solving the basic problem of rapidly repairing and constructing essential facilities.

Funding for new construction technology lags the development of new weapons and military doctrine. For example, after the Army adopted its new doctrine of rapid, maneuver warfare, and fielded its new family of tanks, it began to realize that the lack of combat engineering capabilities would be a major constraint. Similarly, the

Navy and Air Force are only recently becoming concerned with the facilities requirements needed to make their strategies successful. To their credit, the military is beginning to devote more attention and resources to these challenges.

Yet, wartime construction technology has improved only marginally since WWII, while most other types of military technology have improved by at least an order of magnitude. This technology gap has created a capabilities shortfall that could lead to a potentially disastrous situation. The inability to perform essential construction tasks when and where they are needed might someday be analagous to the US Navy's recent debacle in the Persian Gulf, in which the world's most powerful fleet was unable to clear mines that were manufactured prior to WWI, and laid by a third-rate navy.

Wartime construction capability may be the US military's "achilles heel." If not adequately addressed, it could easily become a major constraint on the military's ability to accomplish its mission in the next conflict. In a conventional war, the ability to rapidly repair the war-damaged infrastructure or construct new facilities will undoubtedly be a major problem in implementing our strategy. In

a low intensity conflict, our construction capabilities may well dictate what kind of forces we can employ. If we choose to deploy heavy forces, our current construction capabilities would put us in a situation analogous to the early days of Vietnam. Or, if we deploy light forces, we lose the inherent advantage and technological edge that gives US forces the superior mobility and firepower which makes them a decisive and dominant fighting force. Either way, this lack of construction capability forces us to give up much of our technological edge and military advantage.

5.2 Foreign Dependency

Both civilian and military defense officials, from the President and Congress to the Secretary of Defense and the JCS are extremely concerned with the US military's increasing reliance on foreign sources of materials, components and end items. Numerous studies and research have been done and are continuing on these issues. If the US must enter a period of "surge production" or mobilization, a cutoff of foreign sources would cause serious disruption of major weapon systems. Of particular concern is the growing foreign

dependency in the electronics technology necessary to produce advanced weapons systems. Although the studies indicate an awareness of the problem, it is not being addressed in any effective or systematic way, either by correction or accomodation. A combination of economic forces and conflicting US policy goals appear responsible for the current situation.²⁶

US military power relies upon the strength of the defense industrial base, which depends upon a healthy civilian industrial base. Military and civilian requirements are satisfied by the same industries, which rely upon the same input factors such as management, manpower, technology and capital. Thus, military production is built upon the same foundation as the nation's ability to produce consumer and industrial goods.²⁷

The fact is that the military has relied upon foreign materials since WWII. This problem has been acknowledged, studied and addressed through the "Strategic and Critical Materials Stockpiling Program." The Defense Production Act of 1950 provides the President with the authority to stockpile those materials seen as critical to the national defense. The President also has the authority to delegate this

power to the Director of the Federal Emergency Management Agency, on to the Secretary of Commerce, who in turn delegates the power to the Office of Industrial Resources Administration.²⁸

According to this plan, there are certain "controlled materials" which are the key to effective mobilization. These materials are steel, copper, aluminum and nickel alloys.²⁹ Additionally, the following defense programs are prioritized, and materials crucial to their success stockpiled.³⁰

Priority A: aircraft, missiles; ships; tanks/automotive; weapons; ammunition; electronics; communication equipment

Priority B: military **building supplies**; production equipment

Priority C: DOD **construction**; maintenance, repairs and operating supplies for DOD **facilities**; controlled materials for defense industrial supply center; miscellaneous.

The new concern however, is the dependence upon foreign manufactured goods and technology, as opposed to the traditional concern about raw materials. The most recent authoritative analysis on the vulnerability of the US industrial base describes the purchase of foreign goods as both an opportunity and a potential problem.

It is an opportunity in that it provides access to foreign

technology. It is a potential problem in three ways. First, since the flow of foreign goods is less reliable than domestic sources, continuous and surge production could be vulnerable. Second, domestic production capacity is reduced. Finally, domestic technology may be retarded.³¹

Defense planners attempt to deal with the vulnerability issue by analyzing and prioritizing the problem as follows: "Not everything that is sourced abroad, nor indeed everything for which the US has a foreign dependency, is a foreign *vulnerability*. There are important differences between these categories . . . If foreign vulnerabilities are a subset of all the items sourced abroad, the initial effort must be on identifying the vulnerabilities. Given the large number of items that are sourced abroad, and the growing interdependence of the world economy, it is clear that the key to successfully dealing with foreign vulnerability is not identifying and eliminating all foreign sources, or even all foreign dependencies, but identifying and eliminating those dependencies that are indeed identified as vulnerabilities."³²

The following definitions apply.³³

* FOREIGN SOURCE -- any source of supply, manufacture, or

technology outside the United States or Canada (Mexico might also be included).

* FOREIGN DEPENDENCE -- any "foreign source" for which there is no immediately available alternative source within the US or Canada (or Mexico).

* FOREIGN VULNERABILITY -- any "foreign dependence" whose lack of reliability and substitutability jeopardizes national security by precluding the production, or significantly reducing the capability, of a critical weapons system.

In terms of construction, the US military depends upon foreign sources, however there are immediately available alternative sources within the US, and Canada (and Mexico). In a worst case scenario in which all domestic capability to produce construction materials and equipment ceased to exist, top military industrial analysts are confident that US manufacturers have the capability to quickly begin domestic production of these items. If planning for the unlikely event that all US, Canadian and Mexican sources dried up, the military would determine how long it would take to renew domestic production, and would purchase a buffer stock of critical materials,

components and equipment to tide us over until domestic production was once again under way.³⁴ Since WWII, the DOD has followed exactly this procedure for a number of industrial areas.

Other options in dealing with the foreign dependency issue are to ignore the problem and simply buy the required goods and services at the lowest prices on the world market. This would be unwise and imprudent. A second option would be to buy strictly from American sources. This would be economically unwise and would deny us access to the latest foreign technology. Furthermore, since the necessary conditions -- a large scale conventional war with the USSR and a total cutoff from foreign producers -- are both extremely low probability events, it would be unwise to pay such a high economic price to guard against such a low probability event. Stockpiling, along with some further policy options which I will recommend in Chapter 5, appears to be a prudent and adequate solution.³⁵

In gross terms, the \$350 billion-per-year construction industry should have no problem providing the resources and manpower needed to execute a \$140 billion wartime mobilization construction program, which is only forty percent of their normal

output. Furthermore, the "difference" of \$210 billion can be used to fund other military industrial requirements. In the event of a military production surge or mobilization, certain peacetime civilian production must be displaced. Since construction and other durable goods expenditures are among the easiest to postpone, both residential and commercial construction will be drastically curtailed in order to free up scarce resources for both military construction and other industrial requirements. This is depicted below.³⁶

Table 5.6
1985 WARTIME VERSUS PEACETIME CONSTRUCTION SCENARIO
(in billions of \$)

	<u>Peacetime</u>	<u>Wartime</u>	<u>Difference</u>
Residential Construction	190	40	150
Business Construction	<u>160</u>	<u>100</u>	<u>60</u>
TOTAL	350	140	210

Some construction analysts feel that the US construction industry's declining productivity and lack of investment in new technology will result in foreign firms someday dominating the US construction market. They cite the fact that foreign contractors have

increased their US domestic market share from less than \$3 billion in 1980 to almost \$10 billion in 1986.³⁷

As discussed above, the military implications of such a scenario are serious. Lack of a viable domestic construction industry could lead to a major shortcoming in the military's construction delivery system, not to mention the potential adverse affects on the nation's economy. It is strategically vital that our domestic construction industry be capable of producing the materials and equipment needed to build. Additionally, it is crucial that our contractors maintain some capability to actually build things, and not become managers whose only skill is maximizing profits.

The military's most recent authoritative studies conclude that the US construction industry has the gross capacity to meet the military demand, and will not be hurt in any significant way by foreign dependence upon materials, equipment or technology.

5.2.1 Materials

The three basic construction materials are steel, cement and lumber. US imports of these items increased dramatically during the

early 1980's due to a declining world market and an over-valued dollar. Recently, this trend has begun to reverse as US materials become more competitive as a result of the falling dollar.

In 1984, foreign steel accounted for 30 percent of total US steel consumption. By 1986, this figure had dipped to less than 25 percent.³⁸ For military planners, it is significant that the US steel industry is operating at only 60 percent capacity. This means that domestic sources could more than compensate for any cut-off of imported steel.³⁹ Furthermore, most of our steel imports are from military and political allies such as Japan (25 to 30 percent)⁴⁰, Canada (12 percent)⁴¹ and Korea.

In 1982, imported cement accounted for 4.5 percent of total US cement consumption. By 1985, this figure had increased to 16 percent. The highest percentage of this imported cement is from Mexico,⁴² which, along with Canada, can be considered a reliable source during a crisis. Other sources are Columbia, France, Greece, Japan, Korea, Spain and Venezuela.⁴³ Military planners do not foresee any problem with the US cement industry expanding production in an emergency.

In 1976 the US imported 22 percent of its softwood lumber. In

1986 it imported 33 percent. Virtually all of this lumber is imported from Canada. In fact, 80 percent of all Canadian lumber is exported to the US.⁴⁴ Since Canada is considered a reliable source in a crisis, this is not viewed as a problem.

5.2.2 Construction Equipment (CE)

In real terms the value of US shipments of CE peaked in 1978 and has declined each year since then. In 1981, exports of CE reached \$6.3 billion in nominal terms, but dropped to \$2.4 billion in 1983. This was due to world-wide recession, which reduced demand, and the high value of the dollar. Additionally, two important domestic producers--International Harvester and Bucyrus Erie--have left the industry in recent years.⁴⁵

In 1963, the US imported about 10 percent its total CE. But, nearly three-quarters of these imports came from close allies. Japan--31%, Canada--18%, UK--9%, West Germany--15%. Thus, we are not a big importer of CE to begin with; we possess the indigenous technological capability to produce CE, and our imports are mostly from our close military allies.⁴⁶

Military planners also look at the tremendous excess capacity in the US CE industry. In 1982, our domestic industry operated at less than 50 percent capacity, while world-wide, the industry operated at only 28 percent. During the same year, capacity utilization for the durable goods industry as a whole was at 70 percent. The principle reasons for this under-utilization of CE plants were the cyclical nature of the construction industry, and the overly optimistic export predictions in the 1970's, which led to too many firms and too much capacity.⁴⁷

The CE industry's R&D expenditures did not suffer with their decline in sales. Caterpillar's R&D rose from 3.8 percent of sales in 1979 to 6.3 percent in 1983; Deere's rose to 5.4 percent in 1983, and Ingersoll-Rand's rose to 4.6 percent in 1983. (Note, these figures are for the company as a whole--not just CE.) During the same period, R&D expenditures for all durable goods industries is estimated at 2.9 percent. But, the CE industry's R&D budgets were actually fixed at a time when sales went down, and are not indicative of permanently increased R&D funding.⁴⁸

Table 5.7
MAJOR US CONSTRUCTION MACHINERY PRODUCERS
R&D EXPENDITURES, 1979 TO '83⁴⁹
(in millions of nominal dollars)

	1979	1980	1981	1982	1983
Caterpillar	283	326	363	376	340
Dresser Industries	21	21	24	24	26
Deere	n/a	n/a	240	242	212
Ingersoll-Rand	93	112	129	114	103

CE is a mature industry that changes slowly. Its main R&D thrust in the past twenty years has been on developing higher horse power, more sophisticated transmissions, hydraulics and electronics. The industry's R&D has been incremental in nature and has tended to concentrate on: achieving higher efficiency in tractor speed and traction; reducing friction; increasing engine efficiency; redesigning engines and transmissions to lower maintenance costs, ease servicing, and reduce down-time. Computers and microprocessing are being introduced to increase efficiency and reduce operator fatigue. The industry has also been working on safety innovations. Unfortunately no dramatic, revolutionary changes have occurred. Robots and automation have received little attention because

construction is seen as too diverse and requiring too many on-site decisions for such technology to be feasible.⁵⁰

5.2.3 Technology

In recent years, the US construction industry has lagged behind in the development and adoption of new construction technology. This is especially apparent in comparison to the Japanese and some European nations. Yet, all of this advanced construction technology is well within the technical ability of the US industry to develop and utilize. As previously discussed, the failure to develop and implement new construction technology is due primarily to organizational issues.

For these reasons, the military does not view America's poor performance regarding new construction technology with major concern, when analyzing the foreign dependency issue.

5.2.4 Summary Of Foreign Dependency

At this point, most military construction and industrial experts

do not feel that foreign dependency is much of an issue with construction. They feel that although the industry has been going through some hard times, it is still a dynamic, flexible and responsive industry that can and will overcome its difficulties and re-assert itself in world and domestic construction markets. Even though there is a gap between the military's construction requirements and capabilities, foreign dependency is not seen as the problem.

LTG Heiberg, the Chief of Engineers, believes that in the short term, foreign dependence will not pose a problem in construction. Over the long term however, he thinks that the shortage of American engineers and scientists could cause a serious erosion in America's technological and industrial base. This in turn would have a direct, negative impact upon construction.⁵¹

Chapter 5 Endnotes

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2. Moavenzadeh, 20 January 1988.

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5. **Construction Productivity**, p. 32.
6. **Construction Productivity**, p. 34.
7. **Construction Productivity**, p. 36.
8. **Construction Productivity**, p. 41, and David Haviland, **Testimony before the Subcommittee on Science, Research and Technology, Committee on Science, Space and Technology, US House of Representatives**, June 4, 1987, Exhibit 8.
9. **Construction Productivity**, p. 41, and **Testimony**, Exhibit 8.
10. **Construction Productivity**, p. 42, and **Testimony**, Exhibit 12.
11. **Construction Productivity**, p. 38, and **Testimony**, Exhibit 11.
12. **Construction Productivity**, p. 42.
13. Captain M. Dallam, Director of Construction Office of the Assistant Secretary of Defense, "Presentation to the Construction Industry Institute Annual Meeting", August 7, 1986, p. 3,4.
14. Dallam, p. 4.
15. Business Roundtable.
16. Fred Moavenzadeh, interview on March 11, 1987.

17. This assertion is made based on a comparison from **Technical Insights, Annual Report on Research and Development**, 1982, p. 158.

18. "Building Research Abandoned," **ENR**, February 10, 1983, p. 25,26.

19. Fred Moavenzadeh at the Army Research Office/Program for Advanced Construction Technology (ARO/PACT) Conference, held at MIT on April 22, 1987.

20. Dr. Joseph Sattler, Deputy Assistant Secretary of the Army for Research, Development and Acquisition, interview on April 22, 1987.

21. Sattler.

22. These figures are extrapolated from the following sources. **Construction Productivity**, p. 63, the Corps of Engineers' R&D breakdown as provided by the Public Affairs Officer at CERL, **ARMY Research, Development and Acquisition**, July/August 1986, p. 10, CPT Dallam, presentation to the Construction Industry Institute on August 7, 1986, and **Defense 87**, September/October 1987, p. 23.

23. **Defense 87**, p. 23.

24. LTC Stu Kincaid, USACE R&D, interview on 4 December 1987.

25. General Alfred Gray, Commandant, US Marine Corps and member, JCS, in a speech to the SAME in Washington DC on 9 September 1987.

26. Roderick L. Vawter of the Mobilization Concepts Development Center, **US Industrial Base Dependence/Vulnerability, Phase I, Survey of Literature**, (Washington DC: National Defense University, December, 1986), p. iii, iv.

27. Vawter, p. vi.

28. Department of Commerce, Office of Industrial Resources Administration, **Defense Priorities and Allocations System**, October 1984, p. 7.

29. DOC, **Defense Priorities**, p. 4.

30. DOC, **Defense Priorities**, p. 30.

31. Martin Libicki, Jack Nunn and Bill Taylor of the Mobilization Concepts Development Center, **US Industrial Base Dependence/Vulnerability, Phase II - Analysis**, (Washington DC: National Defense University, November 1987), p. iii.

32. Libicki, p. iii, iv, v

33. Libicki, p. 4.

34. Libicki, p. v.

35. Libicki, p. x.

36. Libicki, p. 65.

37. "Foreigners Step up US Invasion", **ENR**, November 27, 1987, p. 12, 13.

38. "Foreigners Step up US Invasion", p. 31.

39. "Foreigners Step up US Invasion", p. 31.

40. "Foreigners Step up US Invasion", p. 31.

41. "Foreigners Step up US Invasion", p.29.

42. "Foreigners Step up US Invasion", p.33.

43. "Foreigners Step up US Invasion", p. 32.

44. "Foreigners Step up US Invasion", p. 31, 32.
45. US Department of Commerce, International Trade Administration,
A Competitive Assessment of the US Construction Equipment Industry, (Washington DC, February, 1985), p. 1,2.
46. DOC, **A Competitive Assessment of the US Construction Equipment Industry**, p. 18.
47. DOC, **A Competitive Assessment of the US Construction Equipment Industry**, p. 57,58.
48. DOC, **A Competitive Assessment of the US Construction Equipment Industry**, p. 56.
49. DOC, **A Competitive Assessment of the US Construction Equipment Industry**, p. 57.
50. DOC, **A Competitive Assessment of the US Construction Equipment Industry**, p. 3, 56, 57.
51. LTG E.R. Heiberg, Chief of Engineers, in a speech at MIT on 8 December 1987.

CHAPTER 6 SUMMARY, RECOMMENDATIONS & CONCLUSIONS

In this chapter I will first summarize the preceeding information and analysis. Next, I will offer recommendations and policies to help improve the current construction delivery system. Finally, I will conclude with some thoughts on the importance of implementing these recommendations.

6.1 Summary

My purpose in this thesis has been to develop a current understanding of the role of construction in American national defense, military construction requirements, and the military's construction delivery system. In Chapter 2, I provided a historical analysis of construction's generic military role, and its role in American defense.

In Chapter 3, I analyzed the different roles that construction plays in modern American warfare. These roles are critical along the entire spectrum of potential conflict -- from fighting terrorism and small wars to deterring war, at every level of military action -- from tactical to strategic, and from providing crucial logistical

support to actually enhancing the combat power of the combined arms war-fighting team. Finally, I analyzed the unique nature of wartime construction, which emphasizes speed and mobility over permanence and economics.

The military's demand for construction will be immense. Although exact, quantifiable requirements are impossible to predict, WWII and Vietnam offer good order of magnitude approximations for what we might face in similar types of conflict. Construction will be at least as crucial today as it was in WWII and Vietnam. Because of the diminished time-space dimension of military operations and the increase in technological developments at all levels, time constraints will be tighter and more critical than in past wars. Due to the heightened importance of speed and maneuverability, as called for in US military doctrine, construction will play an even more important role than in the past.

In Chapter 4, I analyzed the military's "Construction Delivery System". I assessed how the military plans to respond to the construction demand identified in Chapter 3, and how the delivery system has evolved to meet today's demand. I then identified

inconsistencies and shortcomings in the military's ability to deliver the required construction when and where it is needed.

In Chapter 5, I analyzed the gap between construction requirements and capabilities. Specifically, I examined R&D and the issue of foreign dependence. I shall now offer my recommendations for improving the current situation.

6.2 Recommendations

Before starting this section, it is important to frame my analysis in the proper context. Without a doubt, the US military is currently at its highest state of peacetime preparedness in its history. The quality and quantity of US forces, to include both equipment and people, are at the best and highest levels ever seen in peacetime. This praise, however well deserved, must also be placed in context. We are living in a dangerous world in which armed aggression against our vital national interests are a distinct possibility. We must be militarily prepared.

It is also important to note that many dedicated professionals have devoted themselves to improving our current construction

delivery system. They have worked long and hard to develop and implement many positive and important changes which have significantly improved our ability to deliver the required construction when and where it will be needed. As a result, the military construction delivery system is better organized and prepared to serve the nation today than ever before during peacetime.

Yet, there is plenty of room for improvement. There remains much that can and should be done. My recommendations will be directed towards three different groups -- the Government, the military, and the US construction industry. I will also make recommendations for further research.

6.2.1 The Federal Government

In order to improve the construction delivery system, the Federal Government should take the following steps.

- * Take the lead in promoting construction innovation, productivity and competitiveness. The Federal Government alone buys approximately 15 percent of the new construction built in the US each year. They are by far the largest consumer of construction in the

nation. They are in the unique position of being able to manipulate construction producers. Given this advantage, they should coordinate governmental construction procurement, and develop a policy which will give the construction industry incentives to overcome their most serious deficiencies. Currently, each governmental agency must comply with the Federal Acquisition Regulations, but is otherwise on its own.

- * Coordinate the nation's construction R&D effort at the federal level. Currently, the efforts are scattered among the Department of Transportation, Housing and Urban Development, DOD, the National Bureau of Standards, and others.¹ The initiative for this will probably have to come from Congress, since the operational agencies are always under pressure to cut their budgets, and are therefore unwilling to justify construction R&D funds that are not directly part of their missions.²

- * Reexamine laws that hurt the US construction industry in the international construction market, and consider legislation that would help the industry. For example, Congress should examine double taxation on income earned abroad, the Foreign Corrupt Practices Act,

and the Anti-Boycott provisions of the Export Administration Regulations.³ They should also look at how the Japanese Government ties its foreign aid program to their domestic construction industry, thereby enhancing the industry's competitive position in the international market.⁴

* Enhance wartime construction capability by ensuring that a national Total Mobilization Plan is developed. This plan must define the roles and missions of all the various governmental agencies, and coordinate across all functional areas to include requirements for industrial production, logistics, personnel, training and operations. This plan should be time phased, and ultimately managed with a knowledge-based expert system. Without such a plan, it is impossible for military construction planners to develop accurate and meaningful construction mobilization plans.

Additionally, they could require all architects, suppliers and contractors who do governmental work in peacetime to agree to support the government in the event of a national emergency. They should be required to provide an inventory of their capabilities, to include personnel, equipment, materials, and dollar volume of work

done by type and location. This agreement could be made a part of the pre-bid qualification procedure, and the information could be consolidated in a national construction data base available to military planners. Such a program could use the already existing "Operation Fast Start", developed by the Society of American Military Engineers, as a model, or even piggy-back on it.

Under the Constitution, Congress is responsible for raising and supporting armies and for organizing, arming and disciplining the militia. Since mobilization construction is a pre-requisite for these other activities, Congress should be concerned with it. Yet, no one in Congress is in charge of overseeing this vital activity. The Small Business and Commerce Committees oversee the construction industry. The Armed Services Committees oversee military construction, and the Public Works Committees oversee civil works construction. Congressional oversight and inquiry is needed *before the fact* if we are to avoid the fiascos of the two previous world wars. Congress should get involved and require that mobilization construction plans be open for public inspection. Such a policy would improve our plans, increase our national security, and increase the

deterrent power of our military forces.⁵

* Develop long-term policies to deal with America's declining international competitiveness, particularly in the area of scientific and engineering education. Some experts see the declining pool of American engineers and scientists as the greatest threat to the long-term health of the US construction industry.

6.2.2 The Military

As the key player in this nation's defense policy, there is much that the military can and should do to improve the inconsistencies in the current construction delivery system. As a pre-fix, I would like to congratulate the JCS for planning and organizing two mobilization exercises in FY 88. These exercises will involve all major DOD agencies and commands, as well as the private industrial sector, to include construction firms. This represents an important step in the right direction, yet more should be done.

* The military should balance total construction requirements against total construction capabilities, in terms of personnel, equipment, materials and technology. They should then allocate the

resources needed to bridge the gap between requirements and capabilities.

- * Should look at devoting increased resources to R&D for unique wartime construction requirements. As discussed in Chapter 5, there is a technological gap between wartime construction requirements and capabilities.

- * Should develop incentives and contracting procedures which enhance innovation and improve productivity on peacetime construction projects. They should also work with government and industry to develop a coordinated policy to help improve the competitiveness of the US construction industry. Such programs have already been initiated by the Army under the direction of the Army Research Office and the Corps of Engineers' Construction Engineering Research Lab, yet the entire military ought to be brought into such a program.

- * Should increase technology transfer efforts to get military-developed construction technology into use in the private sector.

- * Military engineers should articulate their concerns so that

combat commanders and civilian officials at the Pentagon understand and appreciate the implications of engineering and construction shortfalls on combat power and the ability of US forces to deter, and if necessary win this nation's wars. Engineers must educate the rest of the military on engineering and construction related matters. This is a fundamental part of resolving the inconsistencies and shortfalls in our current construction delivery system.

* Military engineers should become better salesmen of their programs. In the past, engineers have tended to be too "engineerish". Like good engineers, they have been their own harshest critics. They have analyzed and scrutinized their proposals and systems to such a degree that historically, engineer and construction items have not fared well in the budget allocation process. For example, it has taken nearly 40 years since the need was identified in WWII, to begin fielding the Armored Combat Earthmover (a piece of earthmoving equipment which can keep pace with tanks and offers protection for the operator against small arms fire and schrapnel.) Worse, an effective system to clear enemy minefields still has not been fielded. Although prototypes have been successfully developed and

tested, and foreign military forces have successfully deployed such systems, the US military still finds itself in the precarious predicament of being unable to adequately counter the threat of enemy mines.

* The military should make the industrial base a key part of US national security strategy by raising "Industrial Strategy" to the same level of importance as military strategy and tactics. This would ensure that construction industry issues would be dealt with at an appropriate level. The advantage of this approach is that it "places emphasis on the area of greatest US relative strength--its industrial power-- so this advantage should be maximized." ⁷

* Should manage foreign dependency in a focused, effective way and ensure that the defense implications of America's eroding technological and industrial base -- including construction -- are considered in national policies.⁸ DOD should develop policies that lower the risks of foreign dependency, yet take advantage of the benefits of an increased scientific and industrial base within the free world.⁹

6.2.3 The Construction Industry

As the executor of a large portion of the military's construction requirements, the construction industry ought to implement the following recommendations.

- * Should become more receptive to innovation and new technology.

- * Should take a more active role in supporting, developing priorities for, and funding construction R&D.

- * Should place greater emphasis on management education and training.

- * Should work to overcome institutional barriers which constrain the adoption of new construction technology, and overcome the internal disputes among contractors, labor and suppliers and the divisive factionalism that has prevented progress.

- * Should be more receptive to military construction requirements, realizing both the industry's crucial role in national defense, as well as the potential benefits of increased industry-military cooperation. Professional organizations like the Associated General Contractors (AGC), should encourage and promote

such cooperation and interaction.

— Individual firms should come on line and declare that they are willing to execute military construction during a national emergency. As a practical matter, they should get involved with "Operation Fast Start", and present the local chapter of the Society of American Military Engineers with data on their capabilities. They should then ask questions like: What work will I most likely be called upon to execute? Where will my work be? What will happen to the members of my workforce when the Reserves are mobilized, or the draft started? Will I be relieved from environmental and legal restrictions? Can I terminate ongoing contracts without being sued? What will the construction standards be? To whom shall I report? These and hundreds of other questions and potential problems should then surface and solutions devised during peacetime. **Now** is the time to discover inconsistencies and shortcomings -- not when the emergency is at hand and time is critical.

6.2.4 Civilian Benefits of Wartime Construction R&D

The military has very important, wartime construction

requirements that its delivery system will not be able to accommodate. Due to the unique nature of wartime construction requirements, traditional construction methods and materials will not be adequate. In many cases, existing construction technology is simply unable to accomplish the given wartime requirements, when and where they are needed. Many of these problems have been with us since WWII, and are still considered "war stoppers" today. These wartime construction requirements simply have not received adequate attention or resources.

Normally, when the military has a technical problem, they define their performance specifications and then fund the R&D program to meet the specs. Although critics may argue that the military consumes too many of our nation's resources, or has funded the wrong programs, or that the spinoff to the private sector has not been as substantial as claimed, they have not been able to fault the military on their outstanding success rate and ability to solve technical problems. Military R&D has led to revolutionary technological advances in such diverse areas as material science, aircraft, missiles, munitions, engines, medicine, clothing and more. In

many areas the military has been the nation's technological and R&D leader, and has led the way to revolutionary breakthroughs in the private sector through either spin-offs or direct applications.

Had the military addressed its construction needs from WWII to today with resources and attention commensurate with their importance, and in the same fashion that it has addressed its other technological problems, I am confident that they could have achieved revolutionary technological breakthroughs. One can only speculate as to the number and degree of breakthroughs that the military would have achieved, and how many of them would have led to similar improvements in the private construction industry and throughout the economy.

In almost every technical field, there have been revolutionary advances and several orders of magnitude in improvements since WWII. Examples include the revolution in aircraft technology from propellers to jet engines, communications, electronics, medicine, agriculture, weapons systems and many more. However, when we look at construction, there have only been incremental improvements during the same period (a few percentage points). For a variety of

Industrial, organizational and political reasons, the level of construction R&D funding and technological improvements is less than that of any other US industry.

Congress and the military have been reluctant to fund construction R&D because US construction contractors have alienated themselves by their continual bickering about Labor. Yet, these unique wartime military construction needs represent a golden opportunity in which everyone -- military and civilians alike -- would benefit. Furthermore, no other group has the resources and organizational ability to bring about radical technological improvements in construction like the military.

A significant military construction R&D program aimed at solving wartime construction requirements could produce revolutionary breakthroughs that would spinoff and lead to quantum improvements in the construction industry. Radical construction technology developed for military needs could have a direct application in such areas as public and low cost housing, infrastructure rehabilitation, and hazardous waste processing. Because of the likelihood of spin-offs, the military might also find

more friends in the private sector and the government, as opposed to other R&D projects, which do not offer such tangible benefits to the civilian economy.

If the military devotes the resources needed to solve its own construction problems, radical advances in construction technology would probably lead to quantum improvements in civilian construction as well. This would have a positive impact on the US economy, since US economic growth has traditionally been directly related to infrastructure development (i.e. roads, railroads, canals, etc.). It would also help to rectify the impending economic crisis that will result from thirty to forty years of consistent neglect for the nation's capital stock. Specific benefits might include: higher employment, increased economic health, and a higher level of public and societal welfare. One economist claims that every \$1.00 the public spends on infrastructure leads to \$1.50 in private economic gains.¹⁰

Given this area where the needs of the military, the civilian economy, and the construction industry dovetail so nicely, and where important benefits will accrue to all, why hasn't a greater effort been

made to address wartime construction requirements? I believe it is due to benign neglect.

A dedicated R&D program to solve the unique technological challenges of the military's wartime construction requirements would greatly enhance both the credibility of its deterrent and its actual war-fighting capabilities. Additionally, such a program would probably lead to technological spin-offs which would greatly benefit both the civilian economy and the construction industry. In considering such an R&D program, the potential benefits to the civilian economy should be afforded adequate consideration.

As military historian Paul M. Kennedy says, "It is not an exaggeration to claim that major, long-lasting wars between great-power coalitions have always been won, in the modern age, by the side with the largest economic staying power and productive resources. Without a flourishing and efficient economic base . . . a nation's military power lacks long-term credibility. Politicians and strategists . . . today might do well to concentrate rather more upon the often subtle relationships between military strength and economic strength--and to wonder whether, in some instances,

front-line military and naval forces are the best measure of a nation's real power."¹¹

Given its important role in driving the nation's economy and in maintaining the national infrastructure, construction ought to be considered in this light. Dedicated military construction R&D efforts offer the unique opportunity to realize significant gains for all parties -- the military, the civilian economy and the construction industry.¹²

6.3 Recommendations for Further Research

My first recommendation is that further research be conducted on the results and consequences of the US military's construction planning and capabilities (or lack thereof) on past performances. Detailed analysis of causes and effects should be studied so that policy makers have a clear understanding, supported by historical documentation, of the possible results of their decisions. When Congressmen and top Pentagon officials are provided undeniable evidence of construction's crucial importance, they may be more likely to make it a higher priority and give it the commensurate

attention and funding.

My second recommendation is for further research to be conducted on the role of construction in each of the various levels of potential conflict, from deterrence through total war. A more detailed and thorough understanding of the costs and benefits of adequate construction planning and capabilities on the conduct of war is essential for military planners to make optimal decisions.

Significant study and effort is needed to identify and determine what construction capabilities are needed -- when, where, and at what rate. Currently, the military does not have this information, save for certain specific contingency scenarios that have received significant attention. As previously discussed, this information should be collected, then consolidated at the highest levels, and compared to the capabilities that are available. Currently, shortfalls cannot be adequately identified and analyzed, since we do not yet know what the requirements are.

My third recommendation is for further research on the military's construction delivery system. Its organization, and how it addresses its construction needs should be studied in terms of the

following specifics.

- * Resource allocation and the budgeting process. The system should be thoroughly analyzed to determine why construction planning and capabilities are systematically underfunded in favor of other programs, despite the protests of the Theatre CINCs. Once causes are determined, specific solutions should be developed.

- * Military reliance on the construction industry. DOD should further analyze its dependence upon the private US construction industry, and determine what impact the recent decline in productivity and competitiveness will have upon the ability of the military to accomplish its missions, and what the future holds.

- * A Military-Industrial Policy for Construction. Based upon the results and findings of the above-named recommendation, DOD should then study possible solutions to deal with the problem, if it is determined that one exists. Analysis of various alternatives such as government funded R&D programs, strategic stockpiling, subsidies, tariffs and other economic options to help the US Construction Industry should be studied.

Finally, the relationship between national economic strength

and military power needs more study.

6.4 Conclusions

"If any officer a couple of years ago had said, 'I want \$15,000,000 to lay out possible camps,' I submit that they would have made short shrift of him. Why, they would have said that it was fanciful. They would have wanted that officer looked into as to his ability and capacity."¹³

- Under Secretary of War Robert Patterson
before Senate investigating committee
1941

Certainly, the US has come a very long way in its military construction delivery system since WWII. We are better prepared than ever before to support a large, modern force that must be capable of performing military missions around the globe. Because we are better prepared than in the past, and war seems to be a distant notion, it is easy to procrastinate our duty to be militarily prepared. With the urgent rush of daily activities, it is indeed difficult to put hypothetical wartime planning very high on our priority lists.

Yet, if we are to avoid repeating the mistakes of the past, that is exactly what we must do. For when the war tocsin sounds, and the

fog, friction and chaos of war abound, it will be too late to undo the years of neglect.

Military construction experts estimate that every dollar invested in prior construction planning will save seven dollars of waste. Such budgeting is not only cost effective, it is essential to ensure a credible national strategy.¹⁴

Harry Truman said, "There is nothing new in the world except the history you do not know." Our challenge is to learn from the past so that we can avoid reliving the same bitter experiences.¹⁵

This nation has the ability and resources to do what is needed to correct the shortcomings and inconsistencies in its military construction delivery system. What is not so obvious is whether or not our leaders -- governmental, military and industrial -- have the will and foresight to act. I hope that they do.

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