THE LIFEBLOOD OF SEABASING: SUSTAINMENT THROUGH RAPID STRATEGIC AIRLIFT

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The future of Seabasing rests with the capability to rapidly re-supply and sustain forces from strategic distances. Sealift presents one way of accomplishing this sustainment; however, it is slow. The solution for rapid long-range sustainment of a Seabase must come in the form of aircraft capable of lifting massive weights over vast distances and delivering them directly to the structure. This thesis explores the primary research question: What are the long-range, heavy lift aircraft programs that could sustain Seabasing? The question is explored by using the Wisconsin 7-Step Problem-Solving Strategy: state the problem, determine the solution criteria, gather needed information, generate potential solutions, compare solutions and problem, select the solution, and prepare communications. Four concepts were identified (Lighter-than-Air, Wing-in-Ground, Advanced Theater Transport, and Seaplanes) as having the capabilities to support Seabasing. Due to the many factors associated with determining the best solution, a technique of performing a grid analysis with weighted criteria is used. The results indicate that the best types of aircraft suited to sustain a Seabase are ones that are large, joint in development and operation, can be utilized outside standard military applications, and are capable of carrying massive payloads great distances.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE LIFEBLOOD OF SEABASING: SUSTAINMENT THROUGH RAPID STRATEGIC AIRLIFT, MAJ Matthew T. Magness, 109 pages.

The future of Seabasing rests with the capability to rapidly re-supply and sustain forces from strategic distances. Sealift presents one way of accomplishing this sustainment; however, it is slow. The solution for rapid long-range sustainment of a Seabase must come in the form of aircraft capable of lifting massive weights over vast distances and delivering them directly to the structure. This thesis explores the primary research question: What are the long-range, heavy lift aircraft programs that could sustain Seabasing? The question is explored by using the Wisconsin 7-Step Problem-Solving Strategy: state the problem, determine the solution criteria, gather needed information, generate potential solutions, compare solutions and problem, select the solution, and prepare communications. Four concepts were identified (Lighter-than-Air, Wing-in-Ground, Advanced Theater Transport, and Seaplanes) as having the capabilities to support Seabasing. Due to the many factors associated with determining the best solution, a technique of performing a grid analysis with weighted criteria is used. The results indicate that the best types of aircraft suited to sustain a Seabase are ones that are large, joint in development and operation, can be utilized outside standard military applications, and are capable of carrying massive payloads great distances.

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ACRONYMS

ATT	Advanced Theater Transport
BCT	Brigade Combat Team
CONOPS	Concept of Operations
DoD	Department of Defense
HULA	Hybrid Ultra Large Aircraft
JFC	Joint Force Commander
LTA	Lighter-Than-Air
MAF	Mobility Air Forces
MOB	Mobile Operating Base
MPF	Maritime Pre-positioning Force
WIG	Wing-in-Ground

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CHAPTER 1

INTRODUCTION

General Introduction

The future of Seabasing rests with the capability to rapidly resupply and sustain forces from strategic distances. Future sustainment will come in two forms: airlift and sealift. This thesis will address airborne technologies capable of influencing the sustainment and support of a Seabase by incorporating them into a decision-making matrix. With the use of a structured decision-making process, a definitive solution on which aircraft is most suitable to sustain and support Seabasing will appear. Due to the long-lead times required for the development of new aircraft, the best option will most likely lie in aircraft that are large, joint in development, and capable of carrying extremely large payloads unsupported over vast distances.

Warfighting and threat response require a sophisticated logistic capability that can transport land forces and vast amounts of material over strategic distances to achieve national interests (Trottman 1997, 2). The requirement for a multi-mission aircraft with the ability to carry massive logistical loads, above 80,000 pounds, will significantly improve Seabase capabilities, by adding speed and flexibility to its logistical arsenal. Airborne concepts developed around speed, distance, and lift will enable a joint force commander (JFC) to deploy and employ forces within hours instead of days. This will lead to an increase in operational maneuver, mobility, and ultimately in strategic flexibility. Recently retired Vice Admiral Arthur Cebrowski, Director the Office of Force Transformation, highlighted the requirement for new airborne heavy lift assets. In an interview given to *Inside the Pentagon* on 5 August 2004, he accurately points out that

many defense officials complain they can see improvements in information technology; however, similar enhancements have not been made for moving people and objects. According to Vice Admiral Cebrowski, the US Defense Department is at the point that the movement of electrons has exceeded the movement of material. Succinctly put, transportation and battlefield mobility have become the "long pole in the tent," according to the Office of Force Transformation Director. Change needs to occur in battlefield mobility, capable of moving personnel and equipment vast distances rapidly. The solution may lie in previously developed and understood technologies that lost their appeal over time and were either terminated or phased out. The difficulty for Seabasing is its development inside a legacy force structure. Currently, naval planners seem eager to use Seabasing as a justification for the continued acquisition of platforms defined in the current program of record, such as, aircraft carriers, amphibs, and maritime pre-positioned vessel, and miss the full strategic implications of Seabasing (Hendrix 2003, 61). One avenue not being fully explored is the strategic capability provided to a Seabase by airborne assets. Airlift concepts have the capability of lifting and moving a massive amount of weight and can act as a force enabler for Seabasing. Unfortunately, the procurement process window of opportunity is closing. To blend airborne technology with Seabasing, which may take fifteen to twenty years, a timeline that a concept can meet must be established and must be viewed as a determining factor. Thus, if projecting a military force to a Seabase is to remain an option for US policy makers in the far term, defined in the *Seabasing Concepts of Operations (CONOPS)* as "beyond 2019," the lack of an airlift capable of supporting it must be addressed to allow the marrying up of

technologies that will enable a synergistic effect provided not only through sealift, but more importantly, airlift.

The Research Question

The purpose of the research is to provide a guide that will aid in determining which long-range heavy-lift aircraft programs could support and sustain "Seabasing" and make it a viable capability that supports Department of Defense (DoD) transformation. To make this determination, this thesis analyzes the blending of airlift with Seabasing, as well as the benefits of sustainment over strategic distances. Furthermore, this analysis is aided by considering where the US Navy, US Army, and US Air Force agree on Seabasing's transformational influence. And last, which type of long-range heavy-lift airborne programs could support the services' lift requirements.

The advantages of a Seabase in an area of denied access gives traction to this transformational concept and its supporting elements. "Transformation" is understood as a joint process that shapes the changing nature of military competition and cooperation through new combinations of concepts and capabilities (US Department of Defense 2003a, 3). Moreover, transformation is not the result of a one-time improvement, but of sustained and determined effort across a broad range of capabilities. Each capability has a starting and ending point and is at a different stage of development, but is focused on contributing to and improving the whole (US Department of the Air Force 2003b, 10). Additionally, transformation, in its simplistic form, is a time for developing new capabilities that maintain relevance with the *National Security Strategy*. Consequently, the so-called transformation wish lists tend to one of two extremes: a bigger, faster, better version of some platform already in use or something out of science fiction with timelines

for delivery that stretch all the way to 2032 (Saalfeld and Petrik 2001, 48). Is this wrong? Probably not, many ideas have been labeled transformational. Ideas originally introduced forty to sixty years ago are very much larger versions of their predecessors. Technologies, such as tilt-rotor aircraft, wing-in-ground (WIG) craft that fly 10 to 100 feet off the water, or the use of lighter-than-air (LTA) ships, were once considered science fiction, but are now being reengineered to better implement their capabilities. Furthermore, these second generation concepts, set in motion by political and economic forces, are a reaction to a change in threat perceived by the US.

There is little doubt that DoD is transforming itself. Today, in order to secure funding, an enabling technology, such as Seabasing must link itself to doctrine and organizations capable of using these transformational capabilities. With emerging joint warfighting trends of increased speed, precision, shared awareness, persistence, and employability, exploiting concepts through transformation is mandatory (US Department of the Navy 2003a, 1). Some may argue that an idea becomes transformational when it redefines either a principle of war, such as, maneuver, mass, or economy of force, or a service's tenets. What is basically being redefined under transformation is the development of a new global military model for the US. This model is designed for global power projection, with a premium on evolving to a leaner, more flexible and agile, global insertion force wrapped in an expeditionary mind-set (Laired 2002, 38). None more so than the US Navy where documents, such as the *Transformational Planning Guidance* and the *Naval Transformational Roadmap,* frame why the Navy is expanding its array of naval capabilities centered upon the development of Seabasing. These needs are fundamentally laid out in these documents and are based on providing greater

capabilities to the JFC in combination with the transformed capabilities from the other services to project power from the sea (US Department of the Navy 2003a, 1).

Understanding each service's requirement that pertains to long-range heavy-lift aircraft and how services envision employing long-range "enablers" to these platforms aids in identifying which aircraft are most suitable. Enablers, sometimes called "connectors," are programs inside the DoD acquisition process that link common programs to each other with the goal of obtaining a future or improved technology. Enablers are considered transformational, depending on how they are used. Long-range, heavy-lift programs enable Seabases to project power. The speed at which power can be built-up and then projected is an example of a transformational construct.

Currently, the *Naval Operating Concept (NOC) for Joint Operations* provides overarching guidance for developing future capabilities and forces. The *Naval Operating Concept* links Navy and Marine Corps visions and concepts with emerging Army, Air Force, and Joint Operational Concepts, and it describes the capabilities that an integrated Naval Force contributes to joint and multinational operations (US Department of the Navy 2003b, 1). The area circled in figure 1 depicts the focus of this thesis. The *Defense Science Board Task Force Report on Sea Basing* highlighted the requirement for "a long-range heavy-lift aircraft that can be based at sea with capability to support forces ashore and transport troops" (Schneider 2003, ix). However, the first priority of Seabasing is its ability to sustain itself. Sustainment will most likely come from great distances using both strategic airlift and high-speed surface vessels. Surface vessels will undoubtedly play a significant role in the logistical sustainment, but only aircraft will allow a JFC to respond rapidly over vast distances when a major regional conflict erupts. There is little

doubt that the JFC will want to respond promptly and decisively with sufficient combat power to either fight the aggression or to restore peace. How quickly this happens depends on the speed of maneuver over strategic distances.

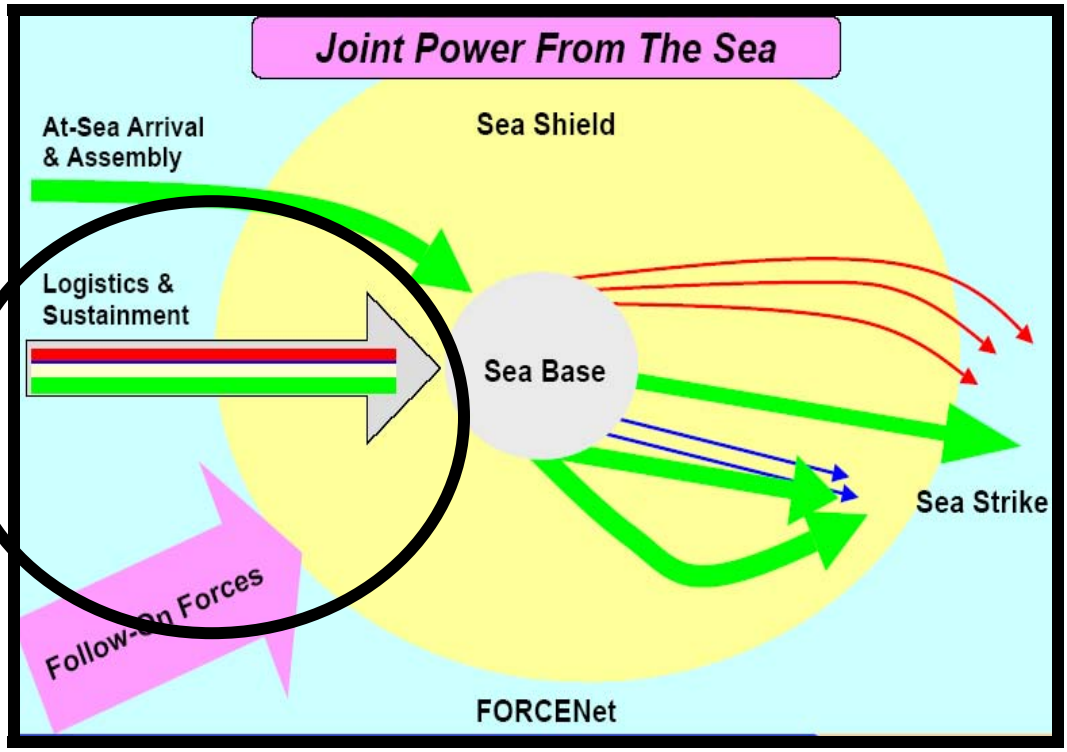

Figure 1. Area of Research Focus

Source: US Department of the Navy, *Seabasing Concept of Operations* (Draft), 11 March 2004, N75 OPNAV, Expeditionary Warfare Division, 2.

Background

Seabasing involves providing versatile sea-based platforms that can project US forces from any area of the world where a land-based option is not available. Airlift has the ability to augment sealift, as well as, move heavy equipment quickly to sustain a

Seabase. The challenge is learning to exploit airlift technology that currently exists while operating under the institutional political constraints an acquisition program creates.

Seabasing is a recognized transformational concept. As the availability of overseas bases declines, it is compelling, both militarily and politically, to reduce the vulnerability of US forces through expanded use of networked Seabases (Odedra, Hope, and Kennell 2004, 1). The Seabasing construct can exponentially exploit the principle of maneuver. In the past, it took thirty to forty-five days to move a Marine expeditionary brigade, of about 16,000 Marines, their equipment, and aircraft, from the US to a distant theater of operations. In the 1980s, that timeline was cut to approximately seventeen to twenty days, due in part to the creation of the maritime pre-positioning force (MPF) of sixteen ships based in Diego Garcia, Guam, Saipan, and the Mediterranean (Barnard 2004, 10). The Pentagon is currently looking to reduce this timeline from fourteen, with the ultimate goal that all services could conduct forcible entry operations with brigade-size forces over strategic distances in ten days. This timeline is being shaped by Secretary Rumsfeld's vision of the "10-30-30 strategy," which consists of the services seizing the initiative within ten days of a deployment order, defeat the enemy (or achieve objectives) within thirty days, then be ready for redeployment to a new battle somewhere else within another thirty days (Hawkins 2004, 10). Is this attainable? Absolutely, however, the window of time and distance is shrinking as technology improves. Enemies of the US will seek to mitigate developments made in capabilities that limit their maneuver. Therefore, when a concept, such as Seabasing, limits enemy movements, their only choice is to attempt to move faster in the hopes the US cannot.

> Seabasing was initially recognized in the 1970s as requiring the prepositioning of equipment in forward operating areas, hence three Squadrons (MPF) were developed and forward deployed in the event of conflict. However, this concept envisioned the existence of friendly ports to offload and join the equipment with ground troops that were transported from the US and other theaters. Changes around the world since the 1970s have forced planners to assume worst case and realize there will be future conflicts where absolutely no friendly bases will be available. The most likely point of entry in theater will be from the sea. (AMI Commentary 2003, 2)

Therefore, a versatile Seabase, through which US forces can surge from, unimpeded, is vital. Without the ability to rapidly move large forces to a Seabase and to sustain them at a rate required for their projected size, their capability will be limited. If the JFC has the luxury of massing forces on a Seabase prior to a crisis, risk can be easily negated through sealift. However, many crises develop on short notice, and future enemies will factor in how fast the US can respond in those situations. In order to prevail against these adversaries, the US will need a joint force capable of strategic access, as well as strategic and tactical lift systems robust enough to conduct and sustain multiple, simultaneous operations (Myers 2004, 12). Therefore, the US must retain its ability to operate unilaterally in the event of a conflict with no access to friendly or neutral air, sea, or land space available (AMI International Commentary 2003, 3). A lack of airborne assets for sustaining Seabasing may pose a significant strategic shortfall, limiting the US's ability to influence potential crises.

Missing in this development is long-range, heavy-lift airborne technologies that can exploit the vision of Seabasing. Finding the right connectors is one of the three top challenges for Deputy Chief of Naval Operations for Fleet Readiness and Logistics, Vice Admiral Moore, in bringing the Seabase concept alive (Cahlink 2004, 18). The lack of connectors--aircraft and ships--to ferry troops and supplies from the Seabase to tactical

units ashore is one of the biggest gaps in the Navy's Seabasing concept (Cahlink 2004, 18). However, this is only one-half the problem. Getting troops and equipment to the Seabase quickly, after assembly, is the crux that allows all other follow-on operations to occur. When sealift can take weeks, airlift provides an additional alternative to the JFC; therefore, it must be viewed as a critical enabler in force projection. Secondary to this, is the long-term sustainment of these forces operating from a Seabase. As humanitarian or combat operations commence from a Seabase, the rate of sustainment needed to allow for operations may exceed supplies available. Again, rapid strategic airlift to a Seabase can provide the solution that ensures success.

Both the Army and Air Force senior leadership have agreed that Seabasing is in their service's interest. However, a disconnect has developed among the services in determining long-range heavy-lift concepts that could interlock with Seabasing. Whereas, the Army is working with naval forces to develop joint seabasing technologies, including future MPF ships, high-speed ships, and other related operational concepts, the Air Force role in Seabasing remains undefined (Keeter 2004). This is due to the belief that the majority of forces and equipment needs to be moved by surface elements. Then why not also pursue strategic airlift for Seabasing? Part of the reason stems from the confusion on which service bears the responsibility for the next generation of airlift. The other is ensuring that each service's requirements for strategic airlift, based on the missions envisioned, can be balanced and satisfied under a joint program. Couple these two points to on-going individual acquisition programs, and effectively, any new long-range heavy-lift program is put on the "back burner." The research in this thesis will therefore define

criteria that may enable the best means to determine the type of airborne concept most suitable to all services.

Recent changes around the world have placed a higher emphasis on Seabasing. Conflicts in Afghanistan and Iraq highlighted the logistical problems the U.S now faces when it needs to conduct military operations close to uncooperative nations. Hostile groups intent on destroying the US and its interests are adjusting their tactics to react faster, and shape the battlefield before US or coalition forces arrive. These groups will attempt to determine a conflict's outcome within days in order to ensure the smallest of victories. The US's ability to project force from a Seabase will depend on the speed on which it can assemble. In the *Naval Transformational Roadmap,* the Seabasing concept depends on fielding new capabilities for at-sea arrival and assembly, selective offload, and reconstitution in order to support an Expeditionary Strike Force in forcible entry operations in any two or four critical regions within seven to fourteen days (US Department of the Navy 2003a, 62). If time is available to assemble forces, this concept will work. Whereas in the past, the US policy was more or less reactionary to global events. President Bush's doctrine of preemption has reshaped forces and technology to allow the exploitation of time in order to determine outcomes and their successes.

Potential Technologies

In 1907, a German prognosticator named Rodolf Martin published two books in which he proclaimed that Germany's future lay in the fleet of airships that could transfer entire armies of one-half million men to attack and conquer foreign lands. Like H. G. Wells, Martin saw airships vastly superior to airplanes as military vehicles, particularly

because they could carry much larger payloads. Little did they know the need to move Armies vast distances would still pose a problem to planners nearly a hundred years later.

The services are pursuing many technological improvements focused on moving and sustaining forces. Technology improvements, under constant pressure from the fiscal realities, involve both choices and tradeoffs of requirements. Many existing platforms, such as the V-22, are being improved under an acquisition construct called spiral development. While others, such as the 3-engine H-53, are viewed as an interim capability that will be overtaken by a future concept like the quad tilt-rotor. Seabasing will benefit from these technologies. Despite being limited in range, these technologies do exploit rapid-maneuver warfare. However, the Seabasing concept still lacks a set of requirements for long-range heavy-lift aircraft that support Army, Navy, and Marine Corps logistics. A reacting airborne logistical system, capable of supporting Seabasing over vast distances, could measure its response time in terms of hours from departure to arrival at the Seabase. As stated earlier, the *Defense Science Board Task Force Report on Sea Basing* highlighted the need for "a long-range heavy-lift aircraft [capable of carrying greater than 20 tons] that can be based at sea with capability to support forces ashore and transport troops." The report went on to say that a "meaningful participation by the Army and Air Force in forming a joint capability" is necessary (Schneider 2003, ix). This is most likely due to these two services being the primary user and operator.

In the future, the speed and capability to sustain and transport forces to a Seabase will come primarily from the air. New and improved technologies such as Advanced Theater Transport (ATT), WIG, LTA airships (also known as Hybrid Ultra Large Aircraft (HULA)) or a combination of several, have a chance to fill this void. Even an old

technology such as seaplanes could enhance a Seabase's logistical capacity by providing a useful resource to achieve force closure, through heavy-lift logistic sustainment (Odedra et al. 2004, 11). Many of these are still in the concept stage and will require dedicated involvement by Navy, Army, and Air Force budgets to achieve headway in development and design. Development, if started today, could align with the implementation of Seabasing in the far-term timeframe of beyond 2019 (US Department of the Navy 2003a, 62). Additionally, and most importantly, each one of these technologies has joint applications. Figure 2 depicts future concepts that could strategically sustain Seabasing.

Figure 2. Potential Technologies

Starting from top left (clockwise): Wing-In-Ground, Improved Lighter-Than-Air (LTA) airship, Advanced Theater Transport (ATT), New seaplanes. *Source*: Alexander, Brown, Jackson, O'Sullivan, Scott, Swanson, and Yoon 2004; Erwin 2000, 26; Huett 2003; Odedra, Hope, and Kennell 2004, 16.

Assumptions

There are six assumptions in this research and analysis. The first assumption of this author's research is the Seabasing will happen. Recent combat operations along with the incorporation of Seabasing into the naval vision have validated this requirement, as well as, the need to protect it. The concept will grow from an intermediate staging base sustainment operation to a strategic sustainment operation conducted from the US Furthermore, new technologies, such as the ability to selective offload, and integrated joint inventory that provide total asset transit awareness, will be integrated through spiral development programming. The second assumption is that Seabasing will grow from a networked strike force of carrier strike groups, surface action groups, and expeditionary strike groups supported by the MPF, in the near-term, to a self-propelled Mobile Operating Base (MOB) requiring a robust sustainment capability built around long-range heavy lift aircraft in the far-term (*Seabsing CONOPS* defines far-term as beyond 2019) (Kreisher 2004, 67). The MOB concept alone will require vast DoD expenditures, and the importance of Seabasing to the joint community will allow for its development. Therefore, as MOB concept matures, it will lose its naval centric development, and shape itself based on future platforms and joint requirements that allow it to operate in a maritime environment compounded by a lack of access to ports and airfields. The third assumption is the Navy will shift its focus from Sea Shield and Sea Strike, to Seabasing, as new technologies reduce its vulnerability, and begin to adequately fund development. The Navy Science and Technology will be geared toward the development of Seabasing structures and support vessels capable of handling large aircraft. This most likely will begin in 2008 (AMI International Commentary 2003, 2). This will leave the

responsibility of any development of long-range heavy-lift aircraft to either the Army or Air Force since they will be the primary users and operators. However, this hypothesis is based on the US Congress willingness to provide significant increases to the defense budgets. The fourth assumption is the DoD will only procure one type of new airlifter during the next twenty years due to the costs associated with the development of new technologies and weapon systems. This new airlifter will be a joint development program and have a joint budget, whereas funding inputs and responsibilities may not be equal due to sheer expense of the acquisition program. Furthermore, the DoD will create a joint program office to bring together available technologies much like other joint endeavors, such as the Joint Strike Fighter (Navy, Marine Corps, and Air Force) and V-22 (Marine Corps and Air Force). The fifth assumption is that long-range, heavy-lift aircraft will be developed in conjunction with smaller tactical aircraft required to support ship-to-shore maneuver. However, due to the significant amount of funding required for new weapon systems, it is conceivable that any procurement of aircraft will include a multifunction, multiroll capability, and most likely result in the acquisition of one system that can do it all. Additionally, any future airlift procurement program must entice civil involvement and investment to further champion its capabilities and utilization outside military applications. The final assumption is that the US will remain the preeminent power in both naval and aerial warfare. Naval dominance of the sea will continue well into the next century. Furthermore, air supremacy will become the standard during military operations. The need for very large transports that require protection en route to a Seabase will be minimal, nevertheless, depending on the locations and operations, required on a smaller scale.

Definitions

Long-Range Heavy-Lift Aircraft. In researching long-range heavy-lift aircraft for Seabasing a common definition for long-range heavy-lift aircraft has it capable of supporting forces ashore, organic intelligence, surveillance, and reconnaissance, acting as a loitering weapons platform and tanker, and transporting troops to the Seabase from the advanced base (most likely the US). The aircraft must be capable of lifting twenty-foot equivalent unit loads (loads that are 20 foot by 8 foot by 8 foot and can weigh up to 24,000 pounds) for distances of 300 miles. Furthermore, the aircraft should be resident on the Seabase and capable of ferrying troops to the Seabase, from the Seabase, and to the land battle area (Schneider 2003, 67). However, for this study, long-range heavy-lift aircraft are considered aircraft capable of operating at distances up 2,000 nautical miles and beyond, and have the capacity to carry a minimum of 40 short tons, which is the upper limit of the existing and developmental fixed-wing tactical transport capability represented by figure 3. (Note: The *Naval Transformation Roadmap* envisions the Seabase will be able to accept forces and material for sustainment directly from the Continental United States, from an advanced base no further that 2,000 nautical miles from the Seabase.)

Seabasing. Defined as a fully networked, rapidly deployable, and interoperable combination of amphibious task forces, carrier battle groups, MPF platforms, ships of the combat logistics force, “black-bottom” commercial shipping, emerging technologically advanced high-speed vessels, and other advanced lighterage that are able to provide continuous support, sustainment, and force protection to select expeditionary joint forces

without reliance on land bases within the Joint Operating Area and facilitate assured access and entry form the sea (Corbett and Goulding 2002, 34).

Transformation. Defined as "a process that shapes the changing nature of military competition and cooperation through new combinations of concepts, capabilities, people and organizations that exploit our nation's advantages and protect against our asymmetric vulnerabilities to sustain our strategic position, which helps underpin peace and stability in the world" (US Department of Defense 2003a, 3).

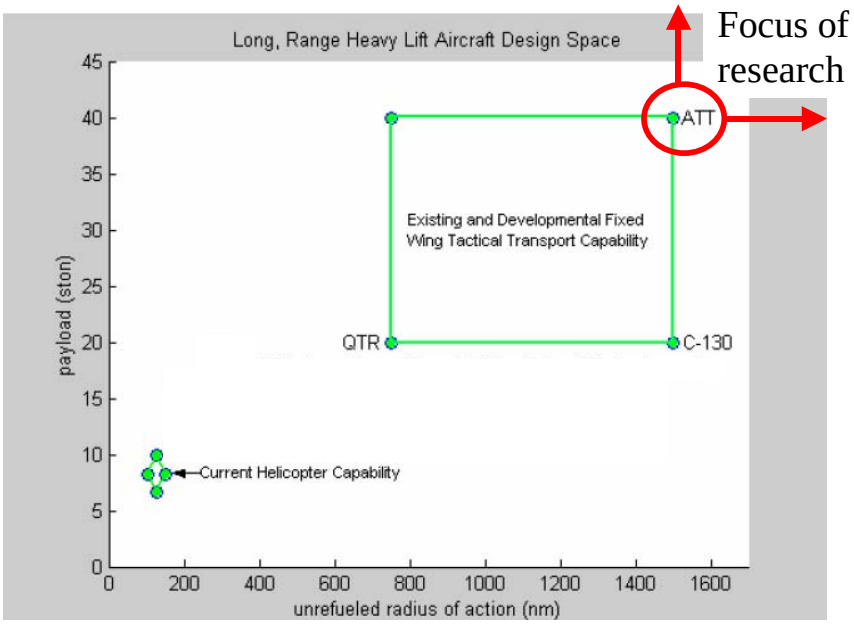

Figure 3. Graph of Long-Range Heavy-Lift Payload Requirements; Bottom Limit

Source: Chuck Calvano and Dave Olwell, *Expeditionary Warfare Final Report* (Naval Postgraduate School Integrated Project, 2002), XIV-11.

Limitations

The major constraint of this study is in researching technologies geared towards long-range heavy-lift. With the rising costs of operations and the maintenance of current

systems, a challenge exits in the procurement of and research in new systems. Furthermore, some airlift technologies may be classified. With many new concepts remaining just that, concepts, the amount of research into their applications and capabilities are limited or simply theoretical (unproven) and are more or less stalled in their evaluation, due to either lack of interest, or sponsorship. One such concept that is being reinvestigated is seaplanes. The Office of Naval Research is investigating the use of massive seaplanes; however, no significant investment in seaplane technology has been done for over forty years. Although, current technology suggests seaplane operations are possible, and may be simpler to integrate with the Seabase, the study is currently at a standstill due to funding.

Delimitations

The focus of this report is on the requirement for long-range heavy-lift aircraft to support Seabasing. Identified by the *Defense Science Board Task Force Report on Sea Basing* as a needed capability, this study focuses on potential technologies in the aviation arena that could have an effect on supporting this concept from the sustainment aspect (refer to figure 1). This study will not include other Naval Capability Pillars of Sea Strike, or Sea Shield. Additionally, capabilities able to rapidly supply or resupply a Seabase by other means, such as the high-speed vessel or heavy-lift loading craft air cushions, central to Seabasing sustainment, will not be included. These were thoroughly analyzed in the 2002 Naval Postgraduate School Integrated Project, *Expeditionary Warfare.* Furthermore, aircraft like the V-22, 3-engine H-53, or future transport rotorcraft required to position troops and equipment from the Seabase is not in scope of this research, due to their short-range and limited cargo carrying capability. Finally, this

research will not include any service budgets required to meet long-range heavy-lift technologies. As of now, the uniformed services have not clearly defined their requirements for long-range heavy-lift aircraft, making it difficult to analyze costs associated with procurement of untested concepts. Furthermore, any large-scale investment into aircraft already listed will most likely take on a civil-military partnership in its procurement, thereby spreading the responsibility and eventual acquisition of a heavy-lift program.

Significance of the Study

To make Seabasing a truly transformational capability, it is necessary to have sustained capacity to rapidly move forces and supplies to a Seabase when required. The logistic chain must be capable of responding swiftly and effectively to meet the demands of combat. As technologies develop and mature, the speed which sustainability will occur is from the air. Seabasing sustainment technologies should attempt to capture the requirements of all four services: Army, Navy, Air Force, and Marines. By using a structured analytical format to compare future long-range heavy-lift aircraft, a theoretical guide in the sustainment of Seabases can emerge. This guide could help programmers determine a set of evaluation criteria needed to meet the joint concept of Seabasing, as well as a list of priorities for acquisition of aircraft envisioned to sustain it.

Today, and in the future, the Achilles heel in any crisis will continue to be the deployment of forces. The *Defense Science Board Report on Sea Basing* has already identified this limiting factor. Speed, maneuver, and sustainment are becoming transparent on the battlefield. Aircraft movement across the Pacific is measured in hours, while sealift still measures its timeline in days. Opposing forces are recognizing the US's

capability to rapidly project power. Therefore, a change in enemy strategy will be to win before a strong enough force can reach the theater of operations. The Navy and Army have come to the same conclusion; long-range heavy-lift aircraft need to be developed.

> Future airlift vehicles--quad tilt-rotor, larger single rotor, fixed wing, HULA, or lighter than air cargo movers--are not alternatives to sea basing, but rather should represent the movement, mobility, and maneuver assets, which would integrate into and augment the seabase. Sea basing will depend upon mobility assets to assemble and close the force in the joint operations area. Given the capabilities of future air vehicles, the potential exists for lift to move the force from CONUS [Continental United States] directly to the Seabase or to the Seabase via an advanced base. (Schneider 2003, 64)

Unless the DoD has the "movers" to support and sustain long-range movement of forces and material, the Seabase will be limited in its duration in how long it can sustain a high operations tempo. Therefore it is reasonable to define responsibilities between the services. Whereas, the Air Force or the Army can be expected to be the lead service responsible for the airlift portion of a Seabase, the Navy and Marine Corps will lead in developing surface employment operations. However, despite the Air Force and Army's acknowledgment that it needs to happen, there is no proposed requirement to support it. On 14 June 2004, the Joint Requirements Oversight Council directed the development of five Joint Integrating Concepts, including Seabasing. A Joint Integrating Concept is a description of how a JFC ten to twenty years in the future will integrate capabilities to generate effects and achieve an objective (US Department of Defense 2005, 2). The Joint Integrating Concept will identify how each service supports Seabasing. How the services do it will depend on the current priority of programs now underway, and whether low cost, high gain research can be conducted into these areas. This research hopes to point

out the best direction in obtaining airlift capable of supporting a Seabase over strategic distances.

CHAPTER 2

LITERATURE REVIEW

The literature review began with addressing information related to the primary research question. What are the long-range, heavy-lift aircraft programs that could sustain Seabasing? Furthermore, the literature review included topics associated with three secondary research areas: (1) What are the services requirements for long-range airborne aircraft based on their transformational roadmaps? (2) What other studies or reports have been done that support long-range heavy-lift aircraft? and (3) What type of aircraft concepts currently being evaluated could support Seabasing? Subsequently, much of what is written on long-range heavy-lift aircraft and its ability to support Seabasing can be divided into three sections: The Roadmaps, The Studies, and The Concepts.

The first section, independently discusses the service's transformational roadmaps and whether services envisioned a particular aspect of Seabasing, as well as how they would support it, either directly or indirectly, through strategic sustainment from the US. The next section looks at the various studies or documents linking Seabasing, and long-range heavy-lift aircraft. The third section will look at the various aircraft concepts in development that could support strategic lift to a Seabase. This section will focus on four types of aircraft: WIG, LTA transports, Seaplanes, and ATT. Whether any of these concepts mature into a viable strategic lift platform for the US is unclear. However, this research is important because it shows the capability, and versatility required to support Seabasing.

Summary of Existing Literature

The current literature does address long-range heavy-lift aircraft. More specifically, the literature suggests that future airlift and associated technologies could easily be meshed with the Seabasing, and would meet a Seabase timeline for 2019 and beyond. Furthermore, the literature shows a need to expand and modernize the US's airlift fleet and its associated capabilities. Finally, the literature addresses past history of these aircraft and a reinvigoration of their concepts for future use in strategic lift over vast distances (greater than 2,000 miles).

The Roadmaps

The services transformational roadmaps set the stage for this research. They answer the "why" portion of needing versatility in long-range heavy-lift aircraft, and lay the foundation to investing in new technology or concepts. The roadmaps of the Navy, Army, Air Force, and Marine Corps provided information on how services intend to integrate Seabasing into to their doctrine along with their need for strategic lift. The point of this research is to show they are linked. Furthermore, both are also linked independently inside the DoD's transformation planning guidance in support of the critical operational goals described in the *2001 Quadrennial Defense Review Report* and the new joint operating and functional concepts currently being formulated. Speed and maneuver are associated through a common theme between the services that still must be determined, however, common ground does exist for a better, faster, and more versatile system to accomplish sustainment over strategic distances regardless of the location.

Long-range heavy-lift aircraft and Seabasing are strongly linked through the Navy's 2003 Transformational Roadmap. In the *Naval Transformation Roadmap 2003:*

Assured Access & Power Projection…From the Sea, the Navy clearly lays out how it intends to develop Seabasing and what actions need to occur in order to support it. Seabasing is supposed to develop as one of the interdependent Naval Capability Pillars; these include Sea Shield, Sea Strike, and FORCEnet, which is a construct that provides the capability to deliver comprehensive surveillance to support decision-making. As these pillars develop and gain synergy, they will increase the speed of response of forward deployed, pre-positioned, and surge forces giving military and National leadership more options earlier in a crisis or conflict (US Department of the Navy 2003a, 1). Immediately, the *Naval Transformation Roadmap* links itself with the need for swiftness. Under the section of Sea Base it adds: "effective power projection, however, depends on the joint force's ability to rapidly close, effectively employ, and reliably sustain forces" (US Department of the Navy 2003a, 57). It goes on to say, "to realize the full potential of Seabasing, new capabilities are required to enhance our ability for rapid force closure, at-sea arrival and assembly, selective offload, indefinite sustainment, and re-constitution and redeployment at sea of naval and joint forces" (US Department of the Navy 2003a, 57). Finally, as currently envisioned, the sea base will be able to accept forces and materiel for sustainment directly from US, from an advanced base no further than 2,000 nautical miles from the sea base, or from closer intermediate sites, with an anticipated throughput of 2,000 short tons per day (US Department of the Navy 2003a, 59). What the Navy has essentially laid out is a Seabasing vision based on speed and sustainment over vast distances. The Navy envisions making this link with the future use of High Speed Vessel technology. The document leaves undefined the speed required for an indefinite sustainment of a Seabase. Additionally, what if the timeline does not match the force

projection requirement, in other words, what happens if forces are needed in hours, instead of days? The relationship also needing consideration, simultaneously with high-speed vessels, is aircraft that can lift massive amounts of equipment and personnel and move them distances greater than 2,000 miles. This maybe the only way the Navy can reach its goal of simultaneously fielding three MPF Groups in three theaters.

The greatest emphasis for additional strategic lift comes from the Army. Under Focused Logistics in the *Army's Transformational Roadmap,* the Army states that sustainment operations must blend strategic and operational sustainment, and extend strategic sustainment flows beyond the shoreline to provide continuous sustainment for a wide range of stability operations tasks throughout the operational area. Alone, this statement in their roadmap subtly emphasizes the need for rapid resupply of forces. In the future, the Army intends to maximize critical airlift to move heavy, medium, and light force packages anywhere in the world rapidly. Furthermore, the Army requires a sustainment capability that is characterized by speed, adaptability, and flexibility. The roadmap correctly points out that sustainment flows need to be fully integrated within a national-to-theater-to-tactical continuum, from early stages through conflict termination, to support the deployment momentum needed to seize the initiative quickly, and maintain operational momentum to overwhelm the adversary (US Department of the Army 2003, 3-8). The Army is setting a priority on velocity over mass in their positioning of troops and equipment. Their argument and reasoning allows a future force to optimize its reachback operations, enhance force protection, and reduce logistical footprint in theater (US Department of the Army 2003, 3-8). What the Army's roadmap simply states is more lift is needed, but what it does not do is address the "how," leaving that answer to either

the Navy or Air Force. Nevertheless, the Army has outlined their need for lift that is fast and can carry large amounts of men and equipment.

In the *US Air Force Transformation Roadmap: Flight Plan*, the Air Force recognizes the need to assist and coordinate with other services and agencies to enable transformational capabilities. The Air Force has identified in its roadmap the need for quick, effective response to any crisis or contingency. When achieved this will mitigate instabilities and reduce an adversaries' time to mobilize potential threats, limiting casualties to US and allied forces. Given the rapid ability to deploy, replenish, sustain, and redeploy joint forces in minimum time allows for success throughout all phases of conflict. Furthermore, the Air Force links speed and versatility to a quick and effective military response that can mitigate instabilities harmful to the security interests of the US and its allies. Finally, the Air Force directly addresses Seabasing in its roadmap by identify the need to have integrated joint logistics support both to and from the Seabase. Again, the "why" is thoroughly addressed, and lays a solid foundation for future lift concepts in the broadest of terms. This will allow future logistical concepts to easily springboard off the services need for speed, range, and lift (2003, 16).

Another Air Force roadmap consulted was the *Air Mobility Master Plan 2004*. This roadmap lists several critical areas of concern for the future of airlift, and links Seabasing indirectly to future airlift concepts. Several key sub-chapters in the plan were: Access to Forward Bases or Ports will Remain Critical and Become Increasingly Risky, Mobility Air Forces (MAF) will be Required to Operate in Small Logistical Footprints, MAF Operations must Become Airfield Independent, MAF Successes Will Rely on Greater Commonality with the Commercial Sector, and MAF Operations Will be

Profoundly Impacted by Advances in Technology. Unfortunately, all the sections listed were written as points of concern and gave general statements with no specifics in how to meet these challenges. However, what it does show is the how significant the Air Force views this issue, and how it may impact operations in the future. As gains are made in the development of Seabasing, documents such as this will begin to integrate strategic airlift with a Seabase, allowing for the sustainment of Seabasing to develop within the Air Force.

The last roadmap reviewed was the *Marine Corps Transformation: Expeditionary Maneuver Warfare.* In their roadmap the Marine Corps focuses on how Seabasing can affect operational maneuver from the sea. The Marine Corps fully recognizes that Seabasing is the foundation of expeditionary maneuver warfare, however, their roadmap focuses on the Seabase to shore operation. They envision strategic lift as an enabler to move Marines from anywhere in the world to a theater staging base, then forward to a Seabase via intra-theater lift, such as high speed vessels or the MV-22. For the most part, the Marine Corps is ship-to-shore operations and any investment in technologies will reflect exactly those requirements. How the strategic aspect evolves will depend on the Navy or Air Force, and technologies they invest in. What the Marine Corps does not acknowledge is a possible use of a multicapable aircraft that can cover both strategic and tactical distances. Unfortunately, with their current investment in the MV-22, any shift in requirements would be too costly.

The roadmaps of all four services mirror the goals from the *Transformation Planning Guidance* put out in April 2003, which are a very broad "hand wave" that establishes the foundation for the services to grow, while providing enough flexibility to

adjust current systems to meet its guidance. The transformational roadmaps are a necessary and useful foundation for this research, so that when heavy airlift concepts are analyzed, a direct link can be made as to which particular technology the services should invest in to meet its transformational goals.

A supporting source to the transformational development of the DoD is the book by Douglas Macgregor. In his book *Transformation Under Fire,* Macgregor discusses how the Army needs to transform itself through the interaction of tactics, organization, technology, leadership, and culture. Macgregor makes two very important points in his book. First, JFC must become the executive agent for all matters pertaining to interoperability, including technology, force design, and joint operational concept development (Macgregor 2003, 29). Essentially, he says that the US must be joint in any procurement of technologies, and only the JFC that is backed up by the Secretary of Defense can impact funding to expensive programs (Macgregor 2003, 29). Second, transformation projects based on the premise of platform replacement alone leads to expensive ventures that stretch all the way to 2032 and divert attention from the far more important features of modern warfare: strategy, structure, and jointness (Macgregor 2003, 242). This ties directly to the on-going Joint Integrating Concept study directed by the Joint Requirements Oversight Council on Seabasing. The benefit of a Joint Integrating Concept is it narrowly focuses on the concept and distills joint operations concepts and JFC-derived capabilities into the fundamental tasks, conditions, and standards required to conduct a Capabilities-Based Assessment (US Department of Defense 2005, 2).

In contrast to what Macgregor states in his book, the fact that the Army is stuck with many legacy systems that were designed to defend against a fixed enemy like the

Soviet Union, makes it hard to transform quickly. Therefore, the ability to deploy rapidly will depend on moving sizable weights rapidly. However, the authors of "Airmechanization" argue that the transformation in the Army should focus on making a lighter force that have sufficient mobility, lethality and protection, then addresses how to move these forces with airlift (Grange, Liebert, and Jarnot 2001, 11). How this ultimately works with Seabasing will depend on movement characteristics of speed and overall load.

The Studies

The primary source that generated this research is the *Defense Science Board Task Force Report on Sea Basing*, August 2003. The results of the report laid out twelve issues needing to be addressed to make sea basing a reality. Long-range heavy-lift aircraft that can be based at sea with capability to support forces ashore and transport troops is one of these twelve items. However, the report made the assumption that an advanced base (also know as an intermediate staging base) within 2,000 miles of the Seabase would exist to facilitate the assembly and transportation of forces to the Seabase. The question is: What happens when an advanced base does not exist, or is beyond that 2,000-mile sustainment gap? The report goes on to say "as lift capabilities improve, a long term goal for sea basing may be the ability to operate independently in major littoral areas of strategic significance around the globe supported directly from the Continental United States . . . this improvement will reduce force closure time and increase seabase flexibility" (Schneider 2003, 22). Therefore, why not invest in the technologies to give Seabasing the flexibility and strategic linkage to sustain itself from the US? By eliminating the need for an intermediate staging base in the near term, the strategic significance of the Seabase becomes more valuable. This will ultimately reduce the need

to be dependant on host nations or governments in allowing the US access to its territory for follow-on operations.

A secondary source referenced was a recent draft copy of the *Sea Basing CONOPS* dated 11 March 2004. This *CONOPS* outlined the capabilities desired in a Seabase and followed an iterative process, called spiral development methodology, to ensure that the Seabase can fully support the other two naval capabilities of Sea Strike and Sea Shield. While the CONOPS was thorough in its development in how Seabasing will mature, it was clear that the Navy intended to sustain Seabasing through "continuous resupply enabled by responsive naval logistics." Although, strategic air was addressed in the movement of forces to an intermediate staging base, it was vague if the Navy envisioned using strategic airlift to support Seabasing directly, and gave very little specifics if and how these "connectors" should be acquired. This is significant, since a Seabase will carry a finite number of supplies, and rely heavily on sealift for sustainment. The argument remains, what option will a Seabase have for sustainment during contingency operations if sealift becomes unavailable, or is too slow because of long distances. In this case, airlift, becomes the only option. However, in retrospect, the *CONOPS* is still in draft form, and will most likely go through several rewrites, leaving the opening to add future lift concepts as they mature.

Another significant study came from the Naval Postgraduate School. Their 2002 Integrated Project, *Expeditionary Warfare Final Report* included a chapter dedicated to long-range heavy-lift aircraft. This chapter analyzed current platform capabilities, requirement drivers to support it, and potential mission profiles. However, much of their research was geared towards designing a conceptual aircraft that would operate in the

tactical realm from the Seabase-to-shore for up to 200 nautical miles. Nevertheless, the study provided excellent background information on existing technologies in long-range heavy-lift aircraft, but did not address the strategic distances that will ultimately require for heavy lift aircraft. For this particular information the best source was a report written for the Air Force, *Airlift 2025: The First with the Most*.

In the Air Force report, *Airlift 2025: The First with the Most,* long-range heavy-lift platforms were compared and evaluated based on technologically feasible concepts to meet the air mobility requirements posed by probable US national objectives in the year 2025. What is significant about this particular report from 1996 is the Air Force recognized that their current air mobility system would not support the air logistics requirements likely to be faced in 2025 (Fellows, Harner, Pickett, and Wood 1996, 1). The report stated the air mobility concepts proposed in the paper will allow the US to meet future national objectives. These concepts included transatmospheric, hypersonic, and supersonic vehicles, airships, WIG effect, very large aircraft, and unpowered and powered delivery systems using both manned and unmanned technologies. The report went on to identify two issues for airlift, one, getting personnel and material from their locations to the theater of operations in a timely fashion, and two, transferring personnel and material between the airlift platform and surface mediums (Fellows et al. 1996, 4). Both of these issues are now at the forefront of Seabasing today. While the report did not address Seabasing directly, several of the concepts the Air Force looked at in 1996 (airships and WIG, discussed later in the chapter), are now being evaluated for supporting a Seabase and have the capability to impact the logistical sustainment from strategic distances.

This was recently echoed by a Congressional Research Service Report for Congress on the "Potential Military Use of Airships and Aerostats" and suggested that airships with their very large payloads and long range can offer advantages to strategic airlift, and essentially carry a complete Army brigade directly from "the fort to the fight." overcoming logistic choke points and mitigating the effects of limited forward basing (Bolkcom 2004, 4). The Air Force's report further highlights many critical factors relevant today that link the concepts to the service's transformational roadmaps. The report alludes to factors such as speed, efficiency, interoperability, and responsiveness as all related to timeliness for delivering personnel and material exactly when and where the warfighter needs them. Nevertheless, the report is predicated on technology needed in the 2025 timeframe. It is the opinion of this author that this technology will be available sooner and meets the Seabasing's far-term timeline.

An additional Air Force Report, *USAF Transformational Flight Plan: FY03-07,* highlights the ATT as one of their "Transformational Programs," and considers the study of the ATT the "next step" in providing future mobility operations (US Department of the Air Force 2003b, 28). The Air Force, while recognizing the ATT is still in its conceptual stage, envisions an enhanced payload capacity, including oversized or outsized cargo; extended range; and include a super short take-off and landing or vertical take-off and landing capability. This document recognizes the need for mobility assets to have a short take-off and landing capability. Moreover, with the Air Force's recent purchase of the CV-22, a transformational concept, the next step should be how technology could enhance strategic lift. This research may show that concepts being evaluated for tactical lift may have joint roles when utilized for strategic lift.

Finally, a study conducted at the School of Advanced Military Studies at Fort Leavenworth, Kansas titled *Modern Airships: A Possible Solution for Rapid Force Projection of Army Forces* gives a positive assessment on the use of airships for the deployment of forces. The author, in a very thorough study, recommends that DoD allocate funding for the construction of an prototype airship (SkyCat 500 or 1000) for the purpose of finding out if these aircraft actually perform as modeling indicates. The research is centered on Army utilization in transporting brigade combat teams from their home-station directly to a location directed by the Combatant Commander, a point-to-point delivery system (Newbegin 2003, 3). The ability to negate an aerial port or seaport of debarkation is exactly what Seabasing needs. What the report does not mention is how DoD would integrate this new system into the services. Furthermore, it assumes the Air Force will be the primary service for implementing this new strategic transport.

A common theme in these reports and studies is the call for investment in new long-range heavy-lift technologies. Aircraft such as the C-130 and C-5, exceeding forty years of service, are at the end of their respective usefulness. The C-17, while new, cannot single handily accomplish all the US's strategic lift. Another more versatile airlifter is needed. Unfortunately, while the problem is recognized individually among the services, the responsibility for acquisition and development remains gray. Whether geared specifically for Seabasing, or not, the need to have a flexible system that is versatile will be the linchpin to investing in the appropriate airlift technology. Many factors, highlighted in the reports, will need to be weighed, specifically: speed, lifting capacity, offloading capability, and cost. The literary research continues to develop more questions. Questions such as, How do you align each services individual requirements

with one or two of these future technologies? Can the US afford more than one of these concepts? Can two be developed simultaneously with the current acquisition process? Should it be a separate service, or the primary services for strategic airlift, the Air Force, does the designing and buying? These types of questions will only grow. It is the assumption of this research that as Seabasing becomes reality responsibilities will take shape. This report remains focused on the concepts currently envisioned and whether they could strategically sustain a Seabase in the future, and not the ownership.

The Concepts

Many articles in periodicals and journals discuss the growing technologies of long-range heavy-lift aircraft. Other articles suggest that before a Seabase is designed, the US must define the capabilities to sustain it and the size of forces envisioned to operate off of its decks (Hendrix 2003, 62). The *Defense Science Board Task Force Report on Sea Basing* specifically calls for the development of an airborne transport for Seabases. Neither the Marine Corps nor Navy operates aircraft capable of carrying the loads required for a full-fledged concept. Articles suggest that a proper Seabase would need a transport that could haul more than 40,000 pounds for long ranges. Research has identified four concepts that could support Seabasing and will be the focus of this research: two land-based concepts and two sea-based concepts. The two land-based concepts are LTA and the ATT. The two sea-based concepts are WIG and future Seaplanes.

Land Based. In a report to Congress on the "Potential Military Use of Airships and Aerostats," author Christopher Bolkcom explains the capability to use airships in long-range airlift. He points out agencies like the Defense Advanced Research Projects

Agency have initiated an Advanced Technology Demonstration called “Walrus” that seeks to develop a hybrid airship capable of transporting up to 1,000 tons across international distances (Bolkcom 2004, 3). Furthermore, the Navy has initiated a similar project called HULA in May 2003. An added capability Bolkcom points out is airships and hybrids may be able to land on water, and prove valuable to the Navy’s sea basing concept (Bolkcom 2004, 4). The importance of this type of concept, like LTA or HULA, is its potential to negate many of the long-range, heavy lift aspects typically accomplished by sealift. Unfortunately, a limitation of airships is the vast amount of space they require to operate. The need for at least a 3,000-foot open landing space with appropriate personnel and handling equipment just to perform a vertical landing has not been fully analyzed. Whereas, a fully loaded LTA like the SkyCat 1000 (1,200 tons) would require an area 10,000 foot by 4,000 foot to operate (Newbegin 2003, C-6). Despite being able to carry seven times more then a C-5 aircraft, floor restrictions on the LTA limit cargo to lighter items such as helicopters, light vehicles, and sustainment stocks (Wass de Czege and Majchrzak 2002, 20). Nevertheless, several authors such as Woodgerd and Myers, along with the Air Force’s report, *Airlift 2025: The First with the Most* point out that airship technology could yield tremendous increases in overall capabilities with substantially decreased delivery times at a fraction of current per-mile costs for air cargo movement. Finally, and what seems the most significant step in obtaining any type of LTA technology, is the idea brought forth in Woodgerd’s article, “Fantasy or Prophesy? The Need for a New LTA Aerospace Capability,” of meshing military and commercial needs to boost the US aerospace industry ability to develop LTA. This idea is gaining more and more ground inside the Pentagon. The vision of the

US military tapping into a commercial airship fleet in a manner similar in how the DoD uses the Civil Reserve Air Fleet today is a viable option. The relevancy of this idea has merit considering that in a recent inspection of the traditional acquisition programs now underway, shows delays and cost increases of 40 percent being common (Woodgerd 2004, 3).

Writers also make the case about reintroducing older innovative concepts from history that were discarded due to varying circumstances of their times. These concepts were given a "second chance" after their value to military doctrine was redefined. Some examples are aerial refueling and gliders; more specific to this research is the airship. Airships proved most successful at strategic lift and long-range passenger transport. By the time they came into their own with these missions, airplanes were emerging as superior (Wilmoth 2000, 54). This suggestion adds to the on going debate whether airships have been fully analyzed and evaluated to the extent warranted, and this research will explore these further.

The other land-based concept is called the ATT. While little is known exactly what the ATT will look like, one thing is for sure, authors recognize the need, and the importance of modernizing the theater airlift fleet. Although, most of them focus on the tactical portion of an ATT concept, many concepts may have the range for strategic lift. The articles written on ATT concepts have pointed out that in order to support the Army's future Objective Force, the Air Force needs to look at other systems to improve their ability to deliver and support land forces. They further suggest that the Army and Air Force should not continue air mobility planning efforts without close coordination. This suggestion needs to be carried further and include Navy and Marine Corps

coordination, which will capture all the joint requirements for airlift and ultimately Seabasing.

Highlighting the need to modernize airlift was an Army Transformation war-game, called Vigilant Warriors 2001, conducted in April 2001. During the exercise the Army explored the challenges of multidimensional operations and operational maneuver from strategic distances. It featured the Army's Objective Force, the other services projected capabilities, and those of key allies, to include adversaries during that same time (Wass de Czege and Majchrzak 2002, 17). What it highlighted during the exercise was that Sealift had the capability, but was slow, and required days to load and unload. A lesson learned during the wargame was the capability to bypass fixed ports. Furthermore, future concepts, such as the ATT, played a critical part in the campaign's success (Wass de Czege and Majchrzak 2002, 19).

The ATT's heavy-lift capability is marginally acceptable for strategic sustainment, but sufficient for tactical requirements (see figure 4). Its ability to perform both strategic and tactical missions will add to its flexibility and make it a strong candidate for eventual acquisition. According to *Aviation Week and Space Technology*, Boeing intends to start development of their concept in 2011. This not only aligns with the beginning of the retirement for the Air Force's C-130 fleet, but could easily allow for an alignment with Seabasing in the future years (2015 and beyond).

As of now, only two US companies have proposed ATT designs. In May 2000, Boeing unveiled a concept called the "Super Frog," a four engine, tailless tilt-wing that can carry 40 tons at 410 knots, and land at speeds as low as 36 knots. Lockheed's version uses various flow control performance enhancers on its fixed-wing concept, and can only

carry one-half as much as Boeing's design. While both concepts can operate with the 30 ton payload set by the Army, landing and takeoff distances vary between the two. Boeing's concept can takeoff and land within 600 feet, while Lockheed's lands within the specified distance of 750 feet, it requires 1,200 feet for takeoff. Bell Helicopter's version, the quad-tilt rotor, remains a potential candidate, but is limited in the amount of weight it can carry, leaving it as a tactical (theater only) transport. Nevertheless, the Army remains the focus for any development of the ATT. Acknowledged by Gerry Janicki, Director of Strategic Development for Boeing's military aircraft division, "the Army is the focus . . . we want to design this aircraft so that cargo can be loaded and offloaded autonomously directly to the truck or to the ground without any extra equipment" (Erwin 2000, 27).

Sea based. A concept known as WIG is looking at being able to project 2.8 million pounds of cargo (17 M1 battle tanks) up to distance of 3,000 miles (Vizard 2003). Whereas, this concept operates from land, the need to operate from water is just as great. WIG offers a different aspect of strategic maneuver, which has inherently been a characteristic of the Navy and Air Force. In his research paper, "Wing in Ground Effect to the Rescue," David Trottman points out that WIG craft are capable of filling the niche between slow moving ships and fast but expensive airplanes (1997, 4). This is further echoed by the authors of "The Tyranny of time and distance: Bridging the Pacific." In this *Military Review* article, the suggestion is made that since the Army is the only service without strategic mobility, the WIG craft possible belong as part of the Army Aviation of the Transportation Corps (Grau and Kipp 2000, 80). This is a plausible idea, however, the last time the Army developed an aircraft for strategic proposes was World

War II. The cultural climate in the Army, which is focused on land maneuver warfare, will make it especially difficult for the Army to develop such a craft. However, it is very feasible for the Army to partner with either the Navy or Air Force in a joint acquisition program of a WIG craft. Regardless, the article did present an "out of the box" thinking, and reasoning of why WIG craft should be bought which is primarily its improved speed. With conventional hulled vessels, the term "fast" means an increase from 20 to 30 knots, where WIG aircraft could fly at a cruising speed of up to 400 knots at very low altitudes (less than 100 feet) over water, exploiting the aerodynamic benefits of "ground effect." An added benefit of WIG is the difficulty in detecting it with radar, adding to its survivability in strategic maneuver. The Army would need approximately 11 WIG craft, each designed to move 2,500 tons, to move a mechanized brigade with all its personnel (Grau and Kipp 2000, 79). WIG offers a viable alternative for a possible replacement of the Air Force's aging C-5 aircraft. Despite modernization programs to extend the life of the US's aging airlifters, the need to use a combination of airlift and sealift is required, and will continue to grow, as the nation's strategic strategy is executed from the continental US. This is exactly the point *Airlift 2025: The First with the Most* makes. Not only does it point to advantages with HULA but also WIG craft. The report states that developments in lightweight structures and materials have made it technologically feasible to construct a wingship capable of lifting 5,000 tons, although engines required to power it are still a long way off (Fellows et al. 1996, 25). Nevertheless, the report cited a Defense Advanced Research Projects Agency study that showed WIG craft could operate at un-refueled distances of 10,000 miles. What the 1996 report did not mention was the WIG's (nor airships) ability to sustain Seabasing.

Seaplanes are a relatively new concept envisioned to support Seabasing. It was recently proposed that seaplanes may be simpler to integrate with a Seabase. A study completed in September 2004, by the Office of Naval Research, found technical issues, including those related to integrating seaplanes within a Seabase, were better understood then originally thought. Issues such as rough water operations, mooring and beaching, and operating in high sea states could be negated through the use of technology. Why seaplanes? Just like airships, the seaplanes demise as a significant airlifter can be traced to a combination of operational, performance, and economic reasons after World War II. Nevertheless, it appears that seaplanes are getting a second chance, as doctrine is redefined to encompass Seabasing. As Gregory Wilmoth wrote in his article "False-Failed Innovation," "Only by analyzing requirements thoroughly and defining them objectively, unconstrained by narrow thinking about how traditionally military capabilities have been used, can a failed technology become a false-failed innovation" (2000, 57). Unfortunately, seaplanes, like the ATT are being linked to intermediate staging bases, while at the same time being mentioned along with WIG and airships, which both have strategic lift capabilities (Barnard 2003, 1). The research in this thesis hopes to show that seaplanes, like WIG, have capabilities to support Seabasing from vast distances.

CHAPTER 3

RESEARCH METHODOLOGY

To answer the primary research question: What are the long-range, heavy-lift aircraft programs that could sustain Seabasing? The Wisconsin 7-Step Problem Solving Strategy as outlined in *The Elements of Information Gathering, A Guide for Technical Communicators, Scientists, and Engineers,* by Donald E. Zimmerman and Michel Lynn Murasji (figure 4) is used. The author uses the same methodology to address the secondary research questions: (1) What are the services requirements for long-range airborne aircraft based on their transformational roadmaps? (2) What other studies or reports have been done that support long-range heavy lift aircraft? and (3) What type of aircraft concepts currently being evaluated could support Seabasing?

Step 1, stating the problem, involved formulating the question: What are the long-range, heavy-lift aircraft programs that could sustain Seabasing? After the problem was stated, four assumptions were made. The first assumption was that Seabasing could not sustain itself solely through sealift. The second assumption was that concepts already existed that could mesh with Seabasing. Third, any procurement of new strategic lift aircraft would need to meet all the services utilization requirements for the movement of material and personnel. And last, any acquisition of new aircraft would require joint funding, essentially giving each service a stake in ensuring its proper development and ultimate success, and most likely the acquisition of one concept.

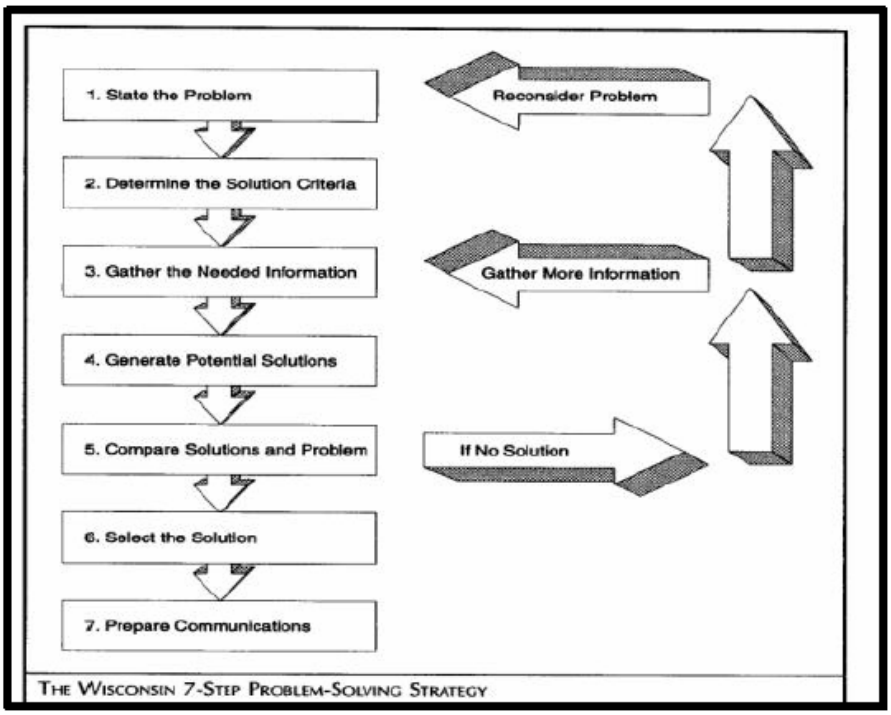

Figure 4. The Wisconsin 7-Step Problem-Solving Strategy

Source: Donald E. Zimmerman and Michel Lynn Muraski, *The Elements of Information Gathering: A Guide for Technical Communicators, Scientists, and Engineers* (Phoenix, AZ: Oryx Press, 1995), 12.

The next step, determining the solution criteria identified eight areas where potential solutions could be drawn from:

1. Is the solution technically feasible given current technology and projected developments in the next fifteen years? This “yes or no” criterion is a standard that, if a concept does not meet, then the concept is excluded outright. This criterion assesses what is already known about a concept and its technology to determine if it is feasible.

2. How well can the concept mesh with a future Seabase? The greater ability to operate in maritime conditions, the more it is preferred. Failure to meet this criteria is a standard that will exclude the concept outright.

3. How much is the concept considered transformational? The concepts ability to meet transformation roadmaps and capabilities consistent with the timelines in developing joint operating concepts for Seabasing is required. Therefore, the more associated a concept is to the DoD's *Transformation Planning Guidance*, the more it is preferred.

4. How well could the concept be applied in a joint manner? Jointness in today's systems also implies interoperability, and how it integrates with other service's equipment, communication, and logistical needs. The more potential a concept has for joint application (interoperability), the more it is the preferred.

5. How well does the concept perform? This criterion evaluates the areas of flexibility, speed, lift capacity, range, suitability, personnel requirements, survivability, and risk of a selected concept. Therefore, due to the complexity of this criterion a comparison, as well as an analysis within this criterion is performed and shown in tables 2 and 3. A stronger overall performance in these sub-criterions makes the concept more preferred.

6. How well can the concept be utilized outside military applications? The more a concept is useful in the civil sectors, essentially supporting a greater number of customers, the more it is preferred.

7. How versatile is the concept? The more different types of missions the concept can do in strategic and tactical environments the more it is preferred.

8. How small is its operational footprint? By not demanding a complex infrastructure at airports or seaports, thus mitigating costs and environmental concerns, the more it is preferred.

Once the solution criterion is determined, step 3, requires gathering needed information. Issues on long-range heavy-lift aircraft and whether it could support Seabasing are addressed. More specifically, service's transformational roadmaps are analyzed to find links to this capability in an attempt to lay the foundation for this research. Studies, reports, articles focusing on potential types of aircraft, and Seabasing logistics are reviewed. Finally, actual concepts envisioned by aircraft manufactures are included in this exploration. Some concepts were based on improving past technologies, while others envisioned experimentation with new technology. Nevertheless, all concepts meet the basic requirements of strategic sustainment.

All information gathered came from open sources (internet homepages, periodicals, official reports) and many times directed the reader to supporting information, other concepts, or reports. A comparison of each service's roadmaps revealed a common theme in need for new long-range heavy-lift aircraft. The research focused on the word "new" and exactly what capabilities are required that current airlift cannot provide. The effort revealed a desire for a joint force capable of massive, rapid and sustained logistical support over vast distances.

Research then shifted to studies and reports that focused on the sustainment for Seabasing, particularly, heavy-lift aircraft concepts capable of moving equipment and personnel vast distances. Moreover, the research addresses how services foresee these concepts being utilized within the logistical infrastructure. Reports of interest were ones

that particularly addressed a single concept, a logistical shortfall within a service, or a service's desire for improved lift.

Finally, as the case narrowed for using long-range heavy-lift aircraft to sustain a Seabase, two categories of aircraft were identified; land based (operates on land only), and sea based (operates on water only). Aircraft were selected because of their ability to operate with loads above 40,000 tons and at distances of beyond 2,000 nautical miles. Aircraft were also considered that were capable of operating with 40,000 tons, but not yet capable of flying beyond 2,000 nautical miles without refueling. From this, four different types of aircraft were selected.

Having completed the initial research, the following four possible solutions were considered.

1. LTA aircraft (Land Based/Sea Based). This concept involves the use of a large airship or potentially a type of hybrid air vehicle that uses lifting gas (helium) for all or most of its lift, has a payload far greater than conventional aircraft in terms of volume and weight, range in thousands of miles, speed significantly greater than surface ships, and does not require significant destination infrastructure (such as airports and seaports) (Woodgerd 2004).

2. ATT (Land Based). This concept is a four-engine, no tail, tilt-wing aircraft capable of landing and taking off from landing strips as short as 600 feet. The design being evaluated for this research is Boeing's "Super Frog" that can carry 40,000 tons, cruise up to 410 knots, and land at speeds as low as 36 knots. The concept would carry twice the load and operate in about three-quarters of a C-130J's required ramp space (Global Security 2002).

3. Wing-in-Ground (Sea Based/Land Based). This concept uses ground effect, a dense cushion of air that develops when an aircraft operates close to a surface. WIG craft can move heavy loads efficiently and rapidly. WIG craft, depending on the size, can fly in excess of 400 knots and carry over 1,500 tons. Depending on the development, this concept could have the capability to operate on water or land, expanding its versatility in operating with a Seabase.

4. Seaplanes (Sea Based). This concept uses today's technology improvements in payload, speed, and range, and couples them to logistics delivery, seakeeping (ability to operate in open seas), and amphibious operations for a larger, much improved seaplane that could sustain a Seabase.

Four potential solutions were generated in step 4 and step 5, comparing solutions and problem were performed. When each potential solution was compared to the problem's screening criteria, each solution proved feasible. Chapter 4 discusses each concept's capability when considered against the screening criteria.

Step 6, select the solution, was executed by first performing a paired comparison analysis on all the criteria to determine a weighted factor for order of importance. A paired comparison analysis is a technique used to determine the importance of a number of options relative to each other. Furthermore, a paired comparison aids in setting priorities where there are conflicting and competing demands on resources. The website, under the decision making page, provides an example of how to perform a paired comparison analysis (Decision Making Techniques 2004).

Table 1 outlines how each criterion is assessed against the other. How each criterion is graded is outlined at the end of the chapter. Grades are assessed based on

importance by comparing the vertical column against the horizontal column. Grading is then converted into a percentage of the total. Chapter 4 will discuss the weighted results and how they are applied in tables 3 and 4. Furthermore, due to the expanded nature of criterion 5 (step 2), table 2 compares its secondary criteria, which are also discussed in chapter 4. Results of each table are shown in appendix A and B, respectively.

Table 1. Paired Comparison of Main Criteria

		A	B	C	D	E	F	G
		Mesh with a future Seabase	Considered transformational	Joint Application	Concept Perfromance	Versatility of the Concept	Operational Footprint	Utilized outside military applications
A	Mesh with a future Seabase							
B	Considered transformational							
C	Joint Application							
D	Concept Perfromance							
E	Versatility of the Concept							
F	Operational Footprint							
G	Utilized outside military applications							

Table 2. Paired Comparison of Concept's Performance

		A	B	C	D	E	F	G	H
		Flexibility	Speed	Lift	Range	Suitability	Personnel Req.	Survivability	Risk
A	Flexibility								
B	Speed								
C	Lift								
D	Range								
E	Suitability								
F	Personnel Req.								
G	Survivability								
H	Risk								

After weighting each criterion, the next portion of step 6 was executed by comparing each aircraft concept against criteria established in step 2. The method used to evaluate concepts against the criteria is “grid analysis.” Grid analysis is a useful technique used for decision-making. It is most effective when you have a number of good alternatives and many factors to take into account. The Decision Making page at www.mindtools.com provides an example and instruction for performing a grid analysis using a weighted assessment. Whereby, the weight factor derived from the paired comparison is multiplied by the assessed grade for each criterion and totaled. The results of this analysis are detailed in chapter 4, and the recommended solution to the research problem is discussed in chapter 5, Conclusions and Recommendations.

To accurately assess the concepts, the sub-criteria of criterion 5 (step 2 of methodology) must first be evaluated. Table 3 outlines how this criterion is evaluated. The criterion of flexibility, speed, lift capability, range, suitability, personnel requirements, survivability, and risk are graded and totaled, then transposed as a graded value based on its percentage. Table 4 further outlines how potential concepts were assessed in accordance with the overall criteria stated in step 2. Results for these tables are shown in Appendix C and D.

The rows of tables 3 and 4 were filled out using ordinal measures. For each criterion, the order of capability is weighted, and converted to a percentage of the total. The following explanations specify each aspect of the solution criteria for both table 3 and 4.

Table 3. Grid Analysis of Concept Performance Criteria

		Potential Concepts			
Criteria	**Weighted Factor (Table 2)**	Lighter-Than-Air	Wing-in-Ground	Advanced Theater Transport	Seaplanes
Flexibility					
Speed					
Lift capability					
Range					
Suitability					
Personnel Requirements					
Survivability					
Risk					
TOTAL	**1.00**				

Table 4. Grid Analysis of Potential Concepts

		Potential Concepts			
Criteria	**Weight Factor (Table 1)**	Lighter-Than-Air	Wing-in-Ground	Advanced Theater Transport	Seaplanes
How well can the concept mesh with a future Seabase?					
How much is the concept considered transformational?					
How well could the concept be applied in a joint manner?					
How well does the concept perform? (from Table 3)					
How versatile is the concept?					
How small is its operational footprint?					
How well can the concept be utilized outside military applications?					
TOTAL	**1.00**				

Concept's Performance Criteria Explanation (table 3).

1. Flexibility. This criterion assesses how many different types of operating areas (land or water) could be serviced, as well as, how easily delivery destinations could be changed en route. If the concept requires large areas for pick-up and delivery (airfields), then the concept is considered less flexible than a concept that could operate within a restricted area (away from an airfield). Furthermore, the number of multiple areas serviced (ports and airfields), the greater means of flexibility of the concept. Finally, the greater ease of changing operating destinations resulted in better flexibility as aircraft with this capability can incorporate areas outside the set of planned support areas that, with little notice, may need to be changed based on the mission.

2. Speed. This criterion evaluates travel time required from actual origin to final destination. The greater potential to reduce the speed differential (motor pool to Seabase) the more it is preferred.

3. Lift capability. The logistical sustainment process involves critical commodities like fuel, munitions, parts, and personnel. The quicker the supplies are provided, the better. New concepts must also be assessed in how effectively it can augment in moving a brigade-size force. The ability to augment the Secretary of Defense's 10-30-30 strategy, as explained in chapter 1, along with its ability to move a brigade-size force is paramount. Therefore, for this criterion, the greater the lift capability of a single system, the more preferred the system.

4. Range. This criterion assesses the operational range in nautical miles that a concept fly to unsupported. The greater the distance, the more it is preferred.

5. Suitability. This criterion assesses whether the concept has the functionality and characteristics to perform in a maritime environment over extended periods of time, the more suited for operations over water, the more it is preferred.

6. Personnel requirements. This criterion assesses how many personnel would be required to support the system to make the concept perform, including personnel needed to sustain continued use of the concept. The fewer people required, the more preferred the process.

7. Survivability. Due to varying mission profiles and environments, airlift concepts are built to different thresholds of defensibility and survivability. Operations in any given environment will place different types of aircraft at different levels of risk. With the assumption that DoD will only acquire one long-range heavy-lift airborne platform, the more defendable and survivable a concept, the more it is preferred.

8. Risk. This criterion looks beyond the concepts technical feasibility, and analyzes the ability to be utilized not only with a Seabasing concept, but also in the areas of airspace (utilization, restrictions, and evaluation of hazards), air traffic control (procedures and clearances), operations (national or international), support services (communications, terminal facilities, and navigation), potential maintenance (repairs and inspections), and aircraft development (risk in development, design and test of aircraft and aircraft equipment). The easier a concept can fit into existing architecture, the greater potential for success, and ultimately for development; thus the more it is preferred.

Main criteria explanation (table 4).

1. How well can the concept mesh with a future Seabase? This criterion assesses the concepts ability to potentially fit in with the Seabasing logistical structure, and its

own ability to work next to (on water), or on its decks. This criterion is fundamental to the primary research question.

2. How much is the concept considered transformational? This criterion assesses the concepts ability to meet the *Transformational Planning Guidance's* Third Pillar and Fourth Pillar of "Concept Development and Experimentation" and "Developing Transformational Capabilities" respectively (US Department of Defense 2003a, 17-19).

3. How well can the concept be applied in a joint manner? This criterion assesses the concepts utilization across the joint spectrum, from operations, to maintenance. Furthermore, this criterion assesses the concepts potential to meet the interoperability goals laid out in the *Transformational Planning Guidance* (US Department of Defense 2003a, 16). The greater priority a concept places on interoperability the more it is preferred. Commonality in equipment, communications, and logistical systems are examples interoperability focuses. Therefore, the greater the concepts ability to have a common operating system the more it is preferred.

4. How well does the concept perform? Areas of flexibility, speed, lift capacity, range, suitability, personnel requirements, survivability, and risk are assessed and results are brought forward and multiplied against this criterion's weighted factor. An overall strong performance makes the concept more preferred.

5. How versatile is the concept? With the assumption that DoD will only acquire one long-range heavy-lift aircraft, this criterion assesses the strategic and tactical aspects of a concepts capability. The potential to provide strategic lift, then follow-on with a tactical deployment from a Seabase is very realistic and deserves analysis in this research. Therefore, the more versatile a concept, the more it is preferred.

6. How small is its operational footprint? This criterion addresses the operational footprint required to support each concept at an assembly area and at a forward operating base such as a Seabase. A smaller operational footprint enhances strategic options, is more sustainable, and limits exposure, and therefore, is more preferred.

7. How well can the concept be utilized outside military applications? This criterion assesses a concept potential to integrate with a commercial market. There are many markets that can benefit from the movement of large volumes of equipment, particularly developing countries with limited infrastructure. The more a concept's potential application to civil needs the more it is preferred.

Grading Criteria. The final portion of step 6 is to assess a grade to each criterion. First, in the paired comparison to determine importance (weighted factor) of each criterion, then during the grid analysis to determine the best concept. How each grade is applied, and the rationale behind it, is furthered discussed in chapter 4. Table 5 depicts the paired comparison grading criteria to be used in conjunction with tables 1 and 2. For tables 1 and 2, the grading compares the vertical column against the horizontal column. In table 6, a six point grading scale is used for the grid analysis of tables 3 and 4. The only exception is criterion 3. (How much is the concept considered transformational?) In assessing grades for this criterion, due to the complexity of how concepts are labeled as being transformational or not, a slight modification must be used. If three services show interest in the concept, then the concept rates an A, excellent, if two or more, a B, very good. Whereas, if one service is interested, and has the interest of a civilian contractor, that could form a Civil Reserve Air Fleet program, a grade of C, good, is given. If only

one service is interested, a grade of D, sufficient is assessed, and if none of the services show interest, a failing grade is levied. Grading results are shown in Appendixes.

The final step, step 7, was to prepare communication. The communication media chosen for this research is a thesis approved for public release

Table 5. Grading Criteria for Paired Comparison

Point Value	**Description**	**General, qualitative description of importance of criteria**
3	Very Improtant	Criterion is of much higher importance.
2	More Important	Criterion is of more importance.
1	Important	Criterion is marginally more important.
0	Equal Importance	No difference between criterions.

Table 6. Grading Criteria for Concepts

Grade	**Point Value**	**Description**	**General, qualitative description of valuation criteria**
A	5	Excellent	Concept meets criterion.
B	4	Very good	Concept meets criterion, lacks one or two features, impact on utilization; minimal.
C	3	Good	Concept meets criterion, lacks several features, impact on utilization.
D	2	Sufficient	Concept marginally meets criterion, lacks several features, requires additional development prior to acquiring, significant impact in utilization.
E	1	Insufficient	Concept barely meets criterion, requires major development in several areas, needs further assessment prior to acquiring.
F	0	Fail	Concept does not meet criterion.

Strengths and Weakness. The strengths of the Wisconsin 7-Step Problem-Solving Strategy provide a logical and fundamental framework to conduct research. Furthermore,

the process eliminates tendencies to select potential courses of action early in the process. If the process is followed systematically, the researcher should arrive at an outcome commendable of the research effort. Without a logical approach, a researcher could potentially produce results, but at great effort, and at a cost to the credibility of the research. This strategy reduces the chance of a viable course of action being discarded before a solution is fully developed, and continually focuses on gathering of information and comparing of solutions. Thus the process, by its design, increases the chance that a researcher will find an acceptable solution to the research question. Finally, by incorporating the paired comparison and grid analysis into the process, an agreeable solution should emerge.

A weakness of the methodology is that it does not take into account access to information or level of expertise of the researcher. Additionally, utilization of the process may require more steps than appear in figure 5. The methodology does not address the possibility of obtaining multiple solutions, which may require a researcher to take additional steps to gain further understanding of the information. Moreover, with the advantage of the internet, the researcher may be required to sift through an overabundance of information with multiple opposing views; calling for additional steps and time not alluded to in the process. Nevertheless, a systematic approach allows for the researcher's level of expertise and sophistication to increases throughout the process.

CHAPTER 4

ANALYSIS

This chapter presents analysis of the thesis to address the primary research question, what are the long-range, heavy-lift aircraft programs that could sustain Seabasing? Long-range heavy-lift aircraft for this research are again defined as aircraft capable of operating at distances up to 2,000 nautical miles and beyond, and have the capacity to carry a minimum of 40 short tons. The analysis includes the comparison of criterion against each other, along with the comparison of the four concepts against the solution criteria. Results are found in appendices A through D.

Paired Comparison of Main Criterion and Sub-Criterion

Main Criterion

Each of main criterion was compared against its others to determine a weighted factor to multiply against the criterion grades. The need for a weighted factor is significant in determining a potential solution, as well as, working out the importance of each to layout logically how a concept should develop to ultimately sustain a Seabase. Nevertheless, determining a weighted factor should by no means minimize the importance of the solution criteria. Table 7 shows the hierarchal results of each criterion based on the graded criteria in appendix A. Results of the paired comparison showed that very little separated the criterion in importance. In six out of seven categories the difference was one grade. However, one criterion did emerge as the most important. The criterion of “how well the concept is applied in a joint manner” highlights the need for new concepts to be joint in development and requirements before funding them. Joint applicability across a broad range of requirements will enable long-range heavy-lift

weapon systems to have a broad range of appeal among the services, and mitigate costs by defining a common set of requirements prior to development. The services most impacted by the development of long-range heavy-lift aircraft are the Army and the Marine Corps. Jointness also weighted slightly higher due to its other underlying factor of interoperability. Interoperability ensures an integrated architecture, and according to the *Transformational Planning Guidance,* should describe the relationship between the tasks and activities that generate effects on enemy forces and supporting operations, and can identify where operations intersect and overlap. Furthermore, the need for strategic aircraft to integrate within a deployable joint command and control process is significant in any future weapon system's development and must be considered.

Table 7. Results of Paired Comparison from Appendix A

Criteria	**Point Total**	**Weight Factor**
Concept applied in a joint manner	5	.278
Concept performance	3	.167
Concept utilized outside military applications	3	.167
Operational footprint	3	.167
Mesh with a future Seabase	2	.111
Considered transformational	1	.055
Versatility of the concept	1	.055
TOTAL	**18**	**1.00**

The next three criterions, all of equally weighted importance, were: performance of the concepts, having a small operational footprint, and the requirement to have utility outside the military construct. These three requirements, when compared to the other criteria, amounted to 50 percent of the total weight. The significance of each allows the establishment of a foundation that permits a concept to develop and ultimately support a

Seabase. The three equal criterions, coupled with joint application, makes up 78 percent of the weighted criteria and provides solid support to the remaining three criterion.

The next criterion is the need to mesh with a Seabase. One might presume that this criterion would have the highest weighted value considering the nature of research question; however, the need to establish a foundation that allows a strategic lift concept to mature in order to sustain a Seabase is unobtainable without first meeting the proceeding four criteria.

Finally, the least two important criteria were the versatility of the aircraft, and how much the concept is considered transformational. The need to operate in both strategic and tactical environments is important, but without first fulfilling the other criterion, a platform that was versatile still would not be acceptable. This resulted in the versatility obtaining the lowest weighting factor. Additionally, and what was surprising, was weighted value of how much a concept is considered transformational. However, on further review, the first five criteria make the concept, in its own right; transformational whether the DoD considers it so or not. Therefore, there is no need to have a higher weighted value next to this criterion. Nevertheless, the need to balance the *Transformational Planning Guidance* off of any new concepts prior to development or acquisition, in this author's analysis, is required, despite the lower weighted value.

Sub-Criterion

The next step in the analysis was comparing the concepts performance. This comparison established the relative importance of each performance measure. Eight measures, deemed essential, were compared and graded in importance to each other.

Table 8 shows the results, in hierarchal order, of each measure based on the Paired Comparison in appendix B. Results showed a significant dispersion between the criteria.

Table 8. Results of Paired Comparison from Appendix B

Criteria	Point Total	Weight Factor
Risk	17	.425
Flexibility	8	.20
Lift capability	5	.125
Range	4	.10
Speed	2	.05
Personnel Requirements	2	.05
Survivability	1	.025
Suitability	1	.025
TOTAL	**40**	**1.00**

The heaviest weighted criterion is risk. The paired comparison analysis weighted risk more than twice as much as the next criterion of flexibility. This is due to the technical magnitude of developing a massive concept that will seamlessly mesh with civil aerospace structures like international air traffic control, maintenance, and facility support operations. The technical feasibility of the concepts is more or less known, however, risk in development based on assured success, and whether it will work as it is envisioned must be evaluated. If enough understanding on how to develop the concept existed, then it stands the highest probability of succeeding, and therefore, being fully operational within the far-term timeframe. Furthermore, the need to align inside the aerospace structure without the development of additional architectures or constraints, such as procedures, facilities, and airspace, factors heavily in this comparison, and ultimately its large weight factor.

The criterion of flexibility was second because of a competing concept's requirement to serve in many different areas. Furthermore, the ability to incorporate areas outside the planned operating area, with little notice, gives a concept the ability to work in multiple environments. Flexibility, coupled with risk, account for 62.5 percent of the characteristics needed for a concept to augment in the sustainment of a Seabase. This analysis indicates priority of procurement that should be for a concept, which is already understood capable of operating in an established aeronautical structure, and can operate on any terrain over land or sea on short notice.

The remaining criterion of lift, range, speed, personnel requirements, survivability, and suitability round out the bottom third of factors, and differ as little as one point between them. This indicates a concept, once developed and capable of operating in an aerospace structure, as well as, flexible in its utilization must then ensure lift, and range before speed, personnel requirements, survivability, and suitability. Again, as stated earlier, all criterions must be considered, but to ensure a building block approach, the order that gives the greatest advantage and sets the priorities for success in long-range heavy-lift aircraft that support Seabasing are listed in tables 7 and 8.

Comparison of Identified Concepts Against Solution Criteria

To maintain a consistent analysis in conjunction with chapter 3, "Methodology," the criterions are discussed in order of how they were presented in the previous chapter. It is, therefore, imperative the reader understand the full analysis of the comparison by reading the entire text for the eight solution criterions.

Is the Solution Within the Engineering Realm of Possible in the Next 15 Years?

This “yes or no” criterion is the first wicket each of the four potential concepts was assessed against. No concept would be evaluated against the remaining solution criteria if it were not technically possible within the next fifteen years. Concepts evaluated but not meeting this criterion include the Quad Tilt Rotor and the Future Transport Rotorcraft.

Research on the four concepts indicates there is enough engineering knowledge to proceed with development on any of the four concepts. Then why has development not started? The answer lies in the differences between the services in requirements, ownership, and funding. Much of what is already known about LTA, WIG, ATT, and seaplane concepts are being tested by civilian companies both in and outside the US; companies such as, Boeing Aerospace (WIG and ATT), Advanced Technologies Group (LTA), Shin Meiwa of Japan, and Beriev of Russia for seaplanes. Funding and acquisition on the best course of action depends on DoD, and its desire for new long-range heavy-lift aircraft; a requirement that needs to be outlined sooner, rather than later.

How Well Can the Concept Mesh with a Future Seabase?

Assessing each concept against this criterion is fundamental to this research. Therefore, it is imperative that each concept meets the criterion, with a minimum grade of a C, good.

Each concept, met all criteria, with all the concepts rating a grade of B, very good. The lower grade for LTA, WIG, and seaplanes is because of their lack of ability to load and unload in high sea states; something the Navy is very aware of, and has already addressed in their *Sea Basing Concept of Operations* (US Department of the Navy 2004,

21). The transfer of payload at sea is one of the biggest issues facing any Seabase. Without this capability, operations are limited, and require the support of a system such as a large intermediate transfer station (Odedra et.al. 2004, 6). The intermediate transfer station reduces the torque on the ramps of the Seabase during cargo transfer in high sea states, providing a sheltered lee for the lighters, and allow for multiple lighters to receive cargo simultaneously (Odedra et al. 2004, 6).

The ATT, assessed a B, due to its need to operate from hard surfaced runways. Runways of sufficient length (longer and wider than an aircraft carrier) are required to launch and receive this concept. The ATT's capabilities, including its short takeoff and landing characteristic, can enhance a Seabase's functionality of utilizing it for either tactical or operational maneuver over strategic distances. If the DoD opts for this type of concept, which has the interest of the Army and Air Force, it will undoubtedly lead to the Navy's development of a MOB capable of launching and receiving the ATT from its decks. An assumption stated earlier by this author.

How Much Is the Concept Considered Transformational?

The *Transformational Planning Guidance's* third and forth pillars are sequential pillars that enable a transformational concept to develop and mature within the DoD acquisition process. The goal of these two pillars is to provide an incubation period for a joint concept by developing and experimenting with them, while being sensitive to changing requirements. The pillars further allow a non-linear way of attacking a concept that has potential for utilization across the three levels of war, strategic, operational, and tactical. Moreover, it allows for a receptive approach to a joint concept that may otherwise go unfunded due to competing priorities within each service. The pillars imply

a concept must first be joint in development to enter transformational experimentation and assessment programs. Participation of civilian companies should be encouraged, and would enhance a concepts utility outside the military construct. Civilian companies can also aid in experimentation and assessment, further offsetting the costs associated with development of new concepts. The difficulty lies in identifying concepts that could benefit from the programs stated in the pillars. Furthermore, the requirement for services to identify a single concept as meeting its needs is paramount to ensuring a successful development in the transformational arena.

The desire for rapid strategic deployability remains strong within the DoD, and more particularly the Army and Marine Corps as they begin to evaluate their transformational roadmaps. Research shows each concept could be transformational in its utilization. However, in assessing grades for this criterion, a concept is more likely to be developed, and fall under the *Transformational Planning Guidance* if two or more services participate in development. Therefore, to assess a grade against a concept, which may or may not be considered transformational, it must be evaluated on a common need for a particular concept within the services. Desire for a capability shared by multiple services makes a concept more likely for development and experimentation, and thereby considered more transformational in its design and approach.

Two performance characteristics, range and lift, are given the most focus in determining whether a concept could sustain a Seabase. LTA's range and lift have the interest of the Army and Marine Corps for the movement of their forces and therefore a B grade. Whereas, the ATT, also rated a B, because of requirement for the Air Force to

replace its aging C-130 fleet and the Army's need for airlift to continue to move its legacy systems into combat.

WIG met the criterion with a C, good. A plausible concept, confusion in its ground-effect technology on whether it is considered more ship then plane, has held off Navy and Air Force interests. Discussion of WIG technology in military journals and staff college papers has not yielded any official position by the two services. Touted as a possible replacement for the C-5 (Grange et al. 2001, 21), the Air Force put to rest all rumors, and recently began to upgrade the C-5's avionics and engines, indicating it is uninterested in replacing the aging aircraft in the future. However, WIG has caught the interest of the Army, and along with Boeing, included it in the Army's study of advanced mobility concepts in April 2003.

While the Navy did have a long relationship with seaplane designers, it lost interest in the 1950s when it discounted jet-powered seaplanes as a nuclear bomber platform (Grau and Kipp 2000, 79). Air Force interest in seaplanes is even less, as it keeps its focus on a potential land-based replacement for the C-130. However, seaplane utilization for Seabasing, highlighted by a report from the Naval Surface Warfare Center, Carderock Division, shows the Navy reinvestigating the use of seaplanes to support Seabasing. Due to lukewarm interest in seaplanes from only one service, a D grade is sufficient.

How Well Can the Concept Be Applied in a Joint Manner?

The difficulty in determining how a concept is applied in a joint manner is in the vision of each service, as well as where its primary operating environment will occur. In the past, if an aircraft operated over the water for extended periods of time and landed on

the water it belonged to the Navy. If the concept lands on hard surfaces, it most likely belongs to the Air Force. However, in today's expensive acquisition environment, any new concept undoubtedly must incorporate the needs of the other services. In the future, new programs must be justified along the lines of being multiservice capable prior to being considered for funding. The difficulty lies in determining which service is the lead service.

The two concepts that have the highest potential of developing a joint program and received an A grade of excellent are LTA and WIG. These two concepts have the ability to benefit all the services with their lifting capacity and range. Furthermore, the number of aircraft required for a sufficient fleet, capable of moving large brigades, is much smaller, potentially requiring these types of concepts to be joint from their onsets. Finally, these concepts have not been developed; therefore, requirements from each of the services can still be captured and incorporated, ensuring interoperability across the entire spectrum of operations and maintenance.

The other two concepts, ATT and seaplanes, both received Cs, good, as their grade. The difficulty for these concepts is to ensure jointness in their primary operating environments. Seaplanes, are inherently waterborne, whereas, ATT are hard surface. So the question arises who should be responsible for their development. Smaller lifting capacities and ranges, not including its in-flight refueling potential, make ATT and seaplanes more of a theater asset and less of a strategic one. Finally, ATT and seaplanes require a large fleet to support a Seabase, most likely requiring the development of several models and a split in ownership which impacts the roadmap each service

envisions to meet the interoperability goals stated in the *Transformational Planning Guidance*.

How Well Does the Concept Perform?

The results from appendix C indicate the best concept to be LTA or HULA. However, the difference between all four concepts is a mere grade, indicating all concepts could operate along side future sealift systems, and add a synergistic effect in moving forces and equipment. The concepts are discussed in order of their preference based on the summation of grade multiplied by weighted factor. Each criterion is discussed in order of highest to lowest grade.

It is important to highlight that any future long-range heavy-lift concept the DoD procures must fit into the Navy's Seabasing framework, and therefore compliment the acquisition of sealift platforms to the point if sea lanes were threatened, a fleet of future airborne connectors could continue to sustain a Seabase, or rotate units at a rate where impact to operations is minimal.

Lighter-than-Air. LTAs (including hybrid airships) two greatest attributes are lift capacity and range. With the ability to operate to distances of 10,000 nautical miles unrefueled and carry up to 1,100 tons, aircraft such as the SkyCat 1000 far exceed most airlift abilities and rated an A, excellent. However, to sustain a Seabase, a requirement for an LTA is the ability to vertically land and takeoff. This reduces an LTA concept's ability to lift, at most, 630 tons (Newbegin 2003, C-6). This reduction is not significant enough to change its grade. Using LTA concepts to maneuver and reposition brigade-sized forces on a grand scale will further allow the DoD to meet its strategy of 10-30-30, as explained

in chapter 1, of deploying within ten days, defeating an enemy in thirty days, then redeploy to be ready to fight in another thirty days.

A concept like the SkyCat 1000 would theoretically require a fleet of 21 aircraft, or 21 flights, to move an entire Brigade Combat Team (BCT), which has a unit weight of 12,840 short tons to a Seabase (Vick, Orletsky, Pirnie, and Jones 2002, 17). However, the Army intends to deploy a BCT with ammunition and other stocks sufficient for three days of combat, with additional stocks being flown in immediately after arriving at their forward operating location. Using this information, an initial deployable weight for a BCT is reduced to 2,500 short tons (Vick et al. 2002, 16). Therefore, a more accurate theoretical number of aircraft required to move a BCT for a short duration is four.

The LTA needs minor improvements in flexibility, suitability, and risk, and rates a B, very good against the criteria. Specifically, monster airships like the future SkyCat 1000, require massive operating areas for launching and recovery. Support facilities must also have the capability of loading and unloading at sea. Additionally, further enhancements, although good at this time, need to focus on speed and personnel support.

Currently, speed for LTA aircraft ranges between 50 to 100 knots. However, despite its slow speed, it rated a B, very good, due to its ability to pick up forces and equipment directly at areas of debarkation (port and base). This saves considerable time and costs by avoiding additional transfers associated when units and their equipment are forced to travel by rail or truck to get to their port of debarkation. LTA's responsiveness by reducing the logistical transfer of units strongly supports the 10-30-30 strategy. Moreover, it will only get better as speed increase and improvements are made with

aerodynamics; however, any significant gains will be marginal due to the large structure of the LTA.

Personnel requirements for LTA rate a D, sufficient. LTA, when operating at maximum weight, require vast operating areas to maneuver. Support for these aircraft requires a significant personnel structure capable of launching and receiving these massive airships. Personnel requirements for LTA will remain significant to ensure safe usage, timely movement control, and reduced risk.

Finally, LTA survivability, rates an E, insufficient, due to its lack of maneuverability stemming from its massive size. Developments in stealth and low observable technology make what is already a low-signature target, due to its composite structure, potentially more survivable (Fellows et al. 1996, 23). However, once identified, their size and lack of maneuverability become its shortfall. Any LTA concept must therefore operate under the auspices of air superiority, and out of range of enemy air defenses.

Wing-in-Ground. The next concept having the greatest potential to integrate with future sealift systems and sustain a Seabase is WIG. Like modern airships, WIG craft, through their design, are able to exploit lift capability and range.

In an analyzing the performance criteria, WIG craft rate an A, excellent, for lift and range. Current studies have WIG lifting capacity at 1,500 tons, and ranges of 10,000 nautical miles (Trottman 1997, 4), and make it a viable concept to augment sealift. However, using conservative estimates for WIG lifting capabilities, based on known performances of Russian WIG craft, 540 tons is used for this thesis (Trottman 1997, 3). Therefore, by using past capability performances, it would in theory require twenty-four

WIG craft to move an entire BCT. This number is reduced to ten aircraft if a water version of Boeing's "Pelican" is acquired, which is slated to carry up to 1,400 tons. Moreover, using RAND's study for a three-day deployment of a Stryker BCT, a deployment package could tentatively require only five WIG craft. The lifting capability associated with these aircraft, along with the low number of airframes need, especially if augmented with sealift will allow the DoD to reach its strategic goal of 10-30-30. However, this assumes WIG craft being able to land at a BCT's home station. More than likely units would have to travel by rail or road before loading adding considerably to the deployment timeline. As for range, the Defense Advanced Research Projects Agency calculated WIG craft as being capable of flying 10,000 nautical miles unrefueled in ground effect (Fellows et al. 1996, 24). This range is sufficient to support Seabasing operations anywhere in the world.

WIG's strongest attribute, along with lift, is speed. With its ability to reach 400 knots (Fellows et al. 1996, 24), although the Russian version was only capable of 310 knots, the WIG's speed enables the DoD to meet its future goal of 10-30-30, when deploying and redeploying forces. However, speed for WIG craft, despite being the fastest of the four concepts, rate only a B, very good. This is due to concerns over whether the US airspace restrictions, could support a large, very fast, low flying, long-range concept. Low flying airspace in the US is highly regulated and sanctioned. Therefore, when over land WIG craft will be required to operate at higher altitudes, out of ground effect, and thereby lose much of their fuel efficiency. Additionally, WIG craft will need to be placed closer to the coast to mitigate any low-fly restrictions imposed on it. Ultimately, this affects how forces and equipment are moved to the aircraft and

lengthens its motorpool to Seabase time. Regardless, once loaded, WIG's speed will significantly enhance its' ability to sustain a Seabase.

WIG's ability to operate from land and sea add to its flexibility, and rate a B, very good. WIG's requirement to operate close to flat areas in order to take advantage of ground effect does impinge on its flexibility. Furthermore, once inside a controlled environment, WIG craft will need to climb, due to airspace restrictions, mitigating its advantages of ground effect and reducing its range.

Suitability also rated a B, very good, due to concerns over its ability to operate in rough seas, as well as how to load and unload its cargo when positioned next to a Seabase. This can be mitigated with technology. Advances in frameworks to better distribute the loads will add to the crafts strength, and the use of submergible docks able to lift aircraft out of the water, could provide the stability during loading. However, until adequately addressed, this will remain a shortfall for any waterborne concept.

WIG's survivability is also a strength, and rate B, very good. Its ability to fly very low over the surface allows it to mesh with ground clutter making it stealthy in its approach to a Seabase or even an intermediate staging base. Moreover, WIG craft usually fly within 50 meters of the surface, and therefore in the blind zone of radar sweep and search (Grau and Kipp 2000, 79). However, once detected its ability to maneuver while close to the water is extremely limited.

Additional advantages of WIG craft include the need for fewer personnel to operate and maintain the aircraft. However, this is in direct correlation to the size of the WIG craft. Developments in lightweight structures and materials have made it technologically feasible to construct a WIG craft capable of lifting 5,000 tons, although

engines required to power it are still many years away (Trottman 1997, 4). Nevertheless, like the LTA, the larger the aircraft the more support it will require. Thereby, a rating of a C, good, was assessed.

For risk, WIG was given a C, good. WIG craft are technologically feasible, but the fleet size needed to support Seabasing is large, and requires facilities on both coasts of the US. Additional concerns stem from the maintenance requirements. The tremendous stresses, due to the speed on water hitting the airframe during takeoffs or landings (150 to 200 miles-per-hour), make the airframe more susceptible to cracks and therefore more frequent inspections would be necessary. Combine that with operating in a corrosive saltwater environment, and risk is further increased by costs associated with materials engineering.

Airspace restrictions, as well as its requirement to operate very close to the surface will impose further risk in development, and quite possibly have contributed to its lack of enthusiasm inside the DoD. The Soviet Union was the last country to experiment with WIG craft on large scales, since then manufactures have constructed a variety of smaller craft mainly for recreation flying. China is particularly interested in WIG technology due to its superb mobility, airworthiness, and ease of operation (Grau and Kipp 2000, 78). However, it is unknown if development has started on another craft like the massive Lun Ekranoplan, a Russian wing-in-ground craft from the 1960s.

ATT. The difference between ATT and the concept that rated the lowest for this criterion, seaplanes, is 0.075. Essentially, both are equal in their performance. However, out of all the criteria, risk hurt ATT most because its tilt-wing technology is still in development and the aircraft is experimental. Using history as an indicator, the

difficulties and developmental challenges discovered in tilt technology development for the tilt-rotor aircraft (V-22) will most likely recur when developing the larger ATT. The development of a concept such as ATT is possible, however acquisition and funding for this technology must start now to meet a target year of 2019.

The V-22 started its full-scale development in 1985, and is now just starting its operational evaluation, a timeline of twenty years. In retrospect, the V-22 was marred by several years of program funding turmoil and groundings caused by mishaps. For the ATT to avoid a similar history, funding must be committed to something as new as a tilt-wing design along with developmental assurances for a strict timeline would have to be in place to reduce the risk involved with acquiring this technology.

The highest grade of A, excellent, was awarded for ATT's survivability. Experts envision that ATT will incorporate many of today's advancements in missile defense and radar warning; furthermore, it will have the ability to utilize the upper airways to mitigate vulnerability to small arms fire. Finally, if the DoD procures only one concept to work inside Seabasing's infrastructure, as well as, have the ability to perform intra-theater missions, survivability will need to be very robust, no matter what the aircraft.

ATT's speed, and personnel requirements both rated B, very good. The ATT's speed, using Boeing's tilt-wing version, will be a little faster then today's C-130 aircraft which can cruise at 300 knots true airspeed. The ATT's commonality with other long-range aircraft such as the C-130, P-3, and C-17 allow it to operate within the familiar construct of international aviation. However, its tilt-wing technology will identify this concept as a unique aircraft, requiring specialized training.

Other areas of note for the ATT include: range, lift capacity, and flexibility. Where range received the lowest grade of E, insufficient, both lift capacity and flexibility were graded as Cs, good. The reason for range receiving a grade of E stemmed from the concepts requirement for in-flight refueling to go beyond 2,000 nautical miles. Lift capacity's grade was due to the concept being on the extreme low end for this study (see figure 3). The ATT's ability to aid in meeting the DoD's 10-30-30 objective is good, and has the highest potential out of the four concepts, because of its flexibility in operating in both tactical and strategic zones. However, a concept like ATT, requires a substantial fleet of over 400 aircraft, to move a BCT. Therefore, in the sustainment of a Seabase, ATT would be relegated to more of an augmentation role then that of a main effort airlift like LTA or WIG. Finally, ATT's flexibility grade resulted because it requires hard surface runways with a minimum length of 1,000 feet to operate. Congestion at a Seabase or airfield, limits this concepts option, and will require Seabases operating within range of friendly shore based airfields for emergency situations.

Seaplanes. Despite very little development of seaplanes during the last forty years, it has the potential to augment future sealift systems just as much as WIG craft could. All criterions graded a B, very good, with the exception of risk, lift capability, and range. If lift capacity were to improve, a higher grade could be given making seaplanes very competitive with LTA and WIG.

Seaplanes are very flexible because they have the capability of operating on land or water and are suitable for operations in the maritime environment. However, surface conditions for loading and unloading during maritime operations remain the limiting factor and must be mitigated through improved design. One such way is through the use

of submergible platforms or docks, however, this may add to the Seabase's infrastructure and be an associated cost with procuring seaplanes.

Speed, survivability, and personnel requirements also rate a B, very good. This is due to a seaplanes ability to operate at airfields (if outfitted with landing gear) or ports by directly picking up the customer, saving time, as well as incorporating many existing technologies in aerodynamics, electronic counter measures, and active missile defense systems. Much of the need for personnel requirements will mirror today's weapon systems in crew and support.

Risk rates a C, good. The seaplanes' ability to operate in the international airspace construct, and terminal environment are strong due to ground crew's and traffic controller's familiarity with its operation. However, maintenance intensive inspections incurred from landing and taking off on water resulted in much of its reduction in grade. Like WIG, large seaplanes will operate between 150 and 200 miles-per-hour (depending on weight and size) for these maneuvers. Hull inspections and corrosion from saltwater operations impose a material engineering problem as well as propulsion issues, which can drive up costs in operations. Light weight, very strong, composites along with new aerodynamic designs can offset some of these concerns. However, the structural stresses, imposed by very heavy loads, are hard to negate, and will impose on the overall aircraft development.

Seaplanes need significant improvement against two criteria, capacity and range. Currently, studies show target loads for future seaplanes at 30 tons with ranges out to 2,000 nautical miles (Odedra et al. 2004, 8). These graded F, fail, and D, sufficient, respectively for their inability to sufficiently move enough material without having a

sizable air fleet. Hypothetically, if seaplanes were to be used solely to move a BCT, with an assumed unit weight of 12,840 tons it would require 428 flights (Vick et al. 2002, 17). The seaplanes required could be reduced to eighty-four if only supporting a three-day package. This is highly unrealistic, since the goal is to be able to sustain a Seabase anywhere in the world from strategic distances. Furthermore, if lift capacity remained below the 40-ton level, it would restrict support to the 10-30-30 objective, and relegate the seaplanes role to a theater support aircraft. However, technology to develop seaplanes on a larger scale does exist, and could increase the lifting capacity and range of this concept.

The strategic capability of seaplanes is no doubt minimal, however, as technology allows for increases in weight, and capacity for fuel, so will its potential to support Seabases directly from the US. Until then, seaplane use to augment future sealift systems will remain marginally sufficient and will require in-flight refueling to reach the distances envisioned from the US. Nevertheless, the potential for seaplanes to support future sealift systems is valid and is worthy of continued study.

How Versatile Is the Concept?

A concept with multiple capabilities is fiscally and politically appealing. It is a simple relationship between numbers and money. The more a concept can do, the more money is saved by not having to invest in additional equipment or technology. Out of all the concepts, ATT is best suited to operate in both strategic and tactical environments. Receiving a grade of B, very good, ATT could easily move forces to a Seabase, then immediately deploy those forces forward. Its downgrade from excellent is based on the need for a large fleet to move forces to a Seabase as part of its strategic capability.

Limitations, stemming from the size of a Seabase (assuming a MOB configuration) will limit the amount of aircraft capable of operating from its decks. Therefore, a large fleet of ATT aircraft could be more of a hindrance to the flow of aircraft when operating in a restrictive environment while conducting employment and deployment operations. Nevertheless, the versatility of ATT to conduct operational maneuver from strategic and tactical distances is strong.

The next two concepts both received Cs, good, as their grades. WIG and seaplanes for the most part are watercraft. Both can follow on with tactical missions, large payload capacity coupled by their shallow drafts allow the use of beachheads to deploy forces (Trottman 1997, 3 and Odedra et al. 2004, 7). Operations on airfields will depend whether either are fitted with landing gear, however, this will impact the structure of the airframe, increasing its weight and ultimately its maneuverability. Their ability to conduct airdrop operations is also limited, however, if their procurement is pursued, it is likely they will be outfitted with some form of this capability. WIG's speed to move forces, as well as its low radar and infrared signatures is an advantage (Trottman 1997, 4). But its lack of maneuverability due to its size and closeness to the surface limits its tactical advantages when identified by hostile forces. Due to its structural requirement to operate on water seaplanes are limited tactically. Furthermore, strengthened hulls add extra weight to seaplanes, penalizing any aggressive maneuvering capability (Odedra et al. 2004, 2). The additional weight during tactical maneuvers places undue stresses on the wings. This potential stress limits seaplane's maneuverability when reacting to threats.

The least versatile concept is LTA and HULA, which received a grade of D, sufficient. The low grade is for a requirement to have a robust defensive system, or a

large support package to facilitate a tactical employment. Additionally, the mere size of LTA craft make it highly vulnerable to attack from surface-to-air weapons, and undoubtedly would be labeled a “high value target.” Furthermore, while the US is relatively unchallenged in air-to-air combat, a 1,000-ton airship with a brigade-worth of equipment is a lucrative target for enemy aircraft (Bolkcom 2004, 6), which may induce the risk and chance to shoot down one. Therefore, the DoD would ensure these assets were well protected with several defensive layers during tactical operations. However, the likelihood of this type of concept being utilized in the tactical environment is low which mitigates the risk involved.

How Small Is Its Operational Footprint?

The significance of this criterion is it has a direct correlation to the fiscal architecture required for the procurement of the concept. Essentially, the more autonomous the concept, the greater the savings to its logistical support structure, and the more favorable it is to the civilian sector which invariably is focused on the “bottom-line,” and will actually encourage investment. By not requiring a large reception package at its forward operating locations, or en route stops, a concept’s operational footprint can remain small. Thereby reducing other required support functions that almost always occur with large force packages. In turn, this allows flexible operations anywhere in the world. The concepts are discussed in order of their rating, best to worst.

The two concepts that rated the highest, and received excellent grades were seaplanes and ATT’s tilt-wing aircraft. With the addition of seaplanes [or ATTs] into a Seabase structure, operational and safety issues similar to those found at airfields are encountered (Odedra et al. 2004, 7). These types of aircraft are a familiar one for ground

crews, and most likely require very little additional training. Furthermore, the familiarity of a high-wing, turbo-prop driven airplane, like seaplanes and ATT is very much in line with other Naval and Air Force aircraft envisioned to be around in the year 2019. How this meshes with maintenance and other logistical support aspects will depend on the commonality of other DoD assets and the size of its design. Nevertheless, a familiar concept, with a common maintenance structure has the highest potential of succeeding, and therefore having the smallest operational footprint. Finally, if either concept is developed, an acquisition program to buy over 400 aircraft is required, more so for the ATT since it will replace the C-130 fleet (Shine 1988, 14). With the advantage of a large acquisition program, a vast logistical support base will enable worldwide flexibility in any theater of operations. By being able to use external equipment (power carts and forklifts) common to other airframes in the DoD, concepts such as seaplanes and ATTs are less vulnerable to operational pauses incurred by specialty equipment.

The other two concepts, WIG and LTA, received a very good rating. The operational footprint for this analysis is predicated on the amount of support each concept needs at an assembly area, or forward operating base. In theory, the larger the concept, the more support it will require in launching and receiving operations. However, this is not necessarily true. WIG's infrastructure requirements for and associated technology is substantially lower than for aircraft or ships (Grau and Kipp 2000, 76). Whereas, LTA based systems offer a small footprint and no demand for the complex infrastructure of airports and seaports with the attendant expense and environmental concerns (Woodgerd 2004a, 7). The advantage of both concepts is a reduction in "touches" of cargo, allowing the delivery of material outside the existing transportation bottlenecks and chokepoints,

reducing operational footprints of each. However, the concern associated with these two concepts is its questionable ability to load and unload massive amount of material efficiently and quickly, thereby keeping its footprint small. The logistical impacts associated with receiving vast amount of forces and equipment will put a strain on a Seabase's logistical system and possibly cause delays, thereby increasing its signature and overall operational footprint. Nevertheless, the goal remains to obtain operational maneuver from strategic distances (Costa 2004). The standard has already been set, according to retired Vice Admiral Cebrowski, former Director of Office of Force Transformation, "we have a commitment now to do a joint seabasing, which is going to cause us to put pressure on getting large aircraft on and off things at sea" (Costa 2004). The need is to do it quickly, efficiently, and safely while not impacting ongoing operations on the Seabase.

How Well Can the Concept Be Utilized Outside Military Applications?

The ability for a concept to be used outside military applications is highly desirable. When a concept remains solely a military technology, it tends to take longer to develop, and costs more to acquire and operate. Part of this is due to no coherent industry to promote and provide standards and advocacy for the technology, thereby limiting commercial demand, or markets other than the military. To reduce today's high-cost aircraft development, the military needs to form a partnership with aviation companies, especially when the technology can benefit the movement of goods and materials outside military applications. A partnership allows for either a larger aircraft buy, thereby reducing the cost-per-unit, or split costs predicated of a time-share usage. Furthermore, if the partnership is formed on the fact that money is saved by using a technology, the more

likely it will succeed. This analysis looks at each concept, in order of its assessed grade, to determine its usability outside military applications.

LTA rated the highest grade of excellent. The most significant factor attributing to this assessment was cost. A research monograph, *Modern Airships: A Possible Solution for Rapid Force Projection of Army Forces* analyzed a concept called SkyCat 1000, capable of operating at an expense of two and one-half times less then other CRAF aircraft like the MD-11, and 747-400F, and requiring only one sortie per their 11 to move 1,100 tons (Newbegin 2003, B-2). Therefore, applying the SkyCat 1000 model to other LTA concepts like the CL 160, the assumption is made that expenses associated with transporting forces and equipment with airships are lower than standard aviation. Furthermore, studies show that markets now exist that are more supportive than the once military dominated airship market of the 1930s (Woodgerd 2004a, 6). The global economy is larger, stronger, and more transparent now and could support fleets of airships and hybrids in commercial operation (Woodgard 2004a, 7). The use of airships to support industry from textiles, agriculture, mining, to humanitarian relief is endless. Some envision that the US government could subsidize the development of the LTA industry through a program much like today's Civil Reserve Air Fleet. An Army Transformation wargame, Vigilant Warrior 2001, made this exact assumption when it utilized ultra-large airships (LTAs) to lift assets over strategic distances (Wass de Czege and Majchrzak 2002, 19). There is no doubt that LTAs could fulfill a significant role in the civil industrial sector, and is the strongest candidate based on the monetary savings it could produce.

WIG, like LTA has the ability to move massive amount of material at a reduced cost. WIG's advantage over LTA aircraft is speed. However, WIG was assessed a grade of very good, due to its more limited commercial viability stemming from operating in the littoral regions only. WIG can operate over land; however, the commercial aviation restrictions associated with low flying routes in the US are immense. Restrictions would require WIG to operate at higher altitudes for safety, which would hurt its fuel-saving advantages that ground effect produces. Nevertheless, WIG craft, when operating over flat surfaces, can deliver large amounts of cargo with significantly less fuel consumption than aircraft, 50 percent more payload with 35 percent less fuel consumption than similar-sized aircraft and 75 percent less fuel than comparable-sized hydrofoil ferries (Grau and Kipp 2000, 75). With 70 percent of the world's surface being water, WIG's commercial application works well with the transoceanic need to move goods and materials quickly and economically. However, the limitations of WIG craft over ground are evident once it reaches shore and cargo must be moved inland.

For service outside of military applications seaplanes merit a grade of C, good. The popularity and demise of the seaplane, before and after World War II, as an important element of aviation is from a combination of operational, performance, and economic characteristics (Odedra et al. 2004, 3). It is these elements that are also holding it back from succeeding on a grand scale in the civil aviation sector. After World War II, commercial airlines stopped using seaplanes on long, over-water routes, and opted to pursue large, fast, highly efficient landplanes, with more reliable engines and all weather capabilities (Odedra et al. 2004, 3). Since then, seaplanes have suffered from the perception of being antiquated to the needs of aviation, as well as being economically

limited. Seaplanes can overcome this perception. The potential is there, but only if seaplanes are reintroduced on a larger scale, capable of lifting 40 tons to unrefueled distances of 3,000 nautical miles or more. Additionally, civilian companies may be more receptive to investment in a Civil Reserve Air Fleet role if it were subsidized by the DoD. Seaplanes the size of today's C-5 are hard to imagine, but it is this type of grand scale design that could break the mold of seaplanes as being more than a vintage flying boat used for leisure or small-scale commuter operations.

The ATT tilt-wing concept received a grade of E, insufficient. It would require major development prior to attracting civil investment. This is due to its experimental status of moving a primary flight control surface while in flight. Unlike the LTA or WIG where the technology has been known for over forty years, ATT concepts are an "out-of-the-box" development. Furthermore, the aviation commercial industry tends to stay on the sideline to see if a new "experimental" concept will work before it begins to invest in its application. Unfortunately, due to its fiscal resources, the DoD is the only source that has the means to develop new technologies. Civilian companies, even if costs were shared, do not have the capital to risk in supporting a new aviation program. The sure bet is to secure DoD funding, and then market a non-military version if it succeeds. Unfortunately, to entice outside investment on any type of ATT concept requires a significant understanding of the technology, as well as, risk reduction to ensure success. This steady and secure approach requires a large amount of time and money, something that civilian side cannot afford since success for the company rides on producing a profit.

Summary of Analysis

Results of the grid analysis, after multiplying a criterion's weight factor by its grade (Appendix D), have LTA and WIG within 0.216 points of each other, while ATT and seaplanes were much closer, 0.156 points. The grid analysis further shows LTA and WIG, large concepts, were separated by over three-quarters of a point from ATT and seaplanes, smaller concepts. Therefore, concepts that are large, joint in use, require very little support, and have the attention of the civilian industry, based on the stated criteria, can adequately sustain a Seabase. The ideal concept is an airship with its large payload and even greater range, followed by WIG craft, seaplanes, and ATTs. Results are discussed further in the next chapter, Conclusions and Recommendations.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This research project was conducted to answer the research question: What are the long-range, heavy-lift aircraft programs that could sustain Seabasing? The Research identified four concepts capable of sustaining a Seabase, selected and weighted the criteria, then used a grid analysis to determine the best airborne concept for sustainment of a Seabase. Having reviewed literature, conducted research, and analyzed several concepts, the best type of aircraft suited to sustain a Seabase are ones that are large, joint in development, require very little support, have the potential to be utilized by the civilian industry, and capable of carrying extremely large payloads great distances. This chapter presents conclusions drawn from examining four very different concepts as well as putting forth recommendations for future research efforts.

Conclusions

Lighter-Than-Air. Based on the grid analysis, this concept is the most promising alternative. Modern airships are gaining momentum among transformational proponents, as a way to project forces and equipment efficiently and rapidly. The ability to influence US foreign policy through strategic maneuver is compounded by the effects brought forth by airlift and Seabasing. As Seabasing becomes the next great power projection platform, the type of support LTA aircraft bring will not only enable Seabasing's success, but also increase its vitality as a instrument capable of affecting global events. The ability for a Seabase to continue operations will undoubtedly be linked to how fast sustainment occurs. LTA's capability of avoiding chokepoints by bypassing intermediate staging facilities between the US and a Seabase will save considerable time and is one of its

strongest selling points for its eventual development. New LTA squadrons, jointly developed, could begin experimenting with doctrine and training that can ensure a seamless transition to Seabasing when the time comes. Additionally, new airship squadrons built around a civil reserve air fleet type format and used outside standard military roles in the areas of moving industrial cargo or supporting humanitarian relief efforts will become an asset in US economic policy as well as US foreign policy. The success or failure of this concept will depend on DoD's investment in it.

The advantages of LTA make it an attractive alternative both economically and logistically for Seabase sustainment. While this research did not look at costs associated in developing this concept, it is widely understood in the aviation industry that costs to operate LTA in a "fuel cost per ton-mile" capacity is roughly one-third less than a C-5, and six times less than a Boeing 747 (Newbegin 2003, B-2). The recent reintroduction of futuristic airships has sparked a research program in the DoD called Walrus, which is an advanced technology demonstration program. Under the guidance of the Defense Advanced Research Projects Agency an intercontinental airship capable of rapidly transporting forces and equipment to a war zone will be developed (Daniel 2004). The three-phase study set to begin in June 2005 and conclude with a full-scale vehicle sometime after 2007 will look at mission utility and CONOPS of LTAs. Whether or not the study includes looking at LTA utilization within a Seabase, much of what will be learned will directly relate to Seabasing sustainment.

WIG. WIG craft finished second among the four concepts evaluated. WIG craft with its massive lifting capacity, long-range flying capability, and tremendous speed is very appealing for the sustainment of a Seabase. However, its role as a predominately

coastal-based aircraft will undoubtedly affect its deployment timelines. Furthermore, WIG's primary advantage of using ground effect to lift cargo and maintain fuel efficiency diminishes once it maneuvers inland to pick-up its cargo since air traffic control will likely require WIG craft to climb in order to be identified by radar. Once inland, WIG will not only compete with civil aviation requirements and regulations, but more importantly may lose its cost and lift benefit associated with flying low. Therefore, forces and equipment will most likely be moved to port and loaded before the advantages of WIG could be realized.

WIG's chances of being developed are small, but its speed alone may keep it at the forefront of potential concepts that will enable rapid sustainment of a Seabase. Knowledge about WIG's benefits is well known. Experimentation and study have been going on since the 1960s. Unfortunately, its development and experimentation has recently centered on small recreational craft. The last large WIG craft, operated by the Russians, ceased operations in 1987 and little has been done since then to further its understanding and feasibility as a large cargo aircraft. WIG craft can give the US the ability to respond quickly, decisively and with sufficient strength to fight anywhere in the world. However, its potential for use outside military applications, due to its distinctiveness as a military concept is minimal.

Seaplanes. The use of seaplanes for the sustainment of a Seabase finished a distant third in the grid analysis. The ability for this concept to reach beyond its shadow cast in the 1930s is one of its shortcomings. Whether due to its boat-like appearance, or its lack of interest by services, other than the Navy, seaplanes will continue to be slow in development. New studies investigating its use, the introduction of lighter weight

composites, and improved engines have all contributed to its reemergence as a viable option. However, the immense fleet size that would be required to work inside a Seabase sustainment construct, as well as a requirement to support the DoD's new 10-30-30 strategy make it a large scale, multiyear, acquisition program. Unfortunately, appetites within the DoD for large programs, in the face of declining defense dollars are being curtailed. Therefore, investment in seaplanes for strategic sustainment is unlikely, but potentially worthwhile for a tactical enabler of a Seabase.

ATT. The concept analyzed as having the least potential to sustain a Seabase was the ATT. Due to its experimental status and uncertain developmental timeline, it stands the least chance of sustaining a Seabase. Additionally, the ATT program must have some civil interest in order to survive beyond its military application, but its tilt-technology weakens this possibility. The advantages it gains by changing its aerodynamic structure with the movement of an entire flight control surface is weakened by requiring a time consuming and expensive testing program that could take years.

As with any new technology cost overruns are likely and may delay the ATT in its long-term development. Furthermore, any long-term investment geared toward a specific type of aircraft, despite it having both strategic and tactical qualities, may extend well beyond the year 2020, reducing any benefit to a Seabase in the early years. Finally, a long-term development program like the ATT, that requires a substantial fleet size and runways for its operation, would also require a Seabase to become a MOB sooner. While many assume that a Seabase would eventually develop such a capability, the timeline for a MOB is unclear and expected to extend well into the future. Additionally, any procurement of ATT aircraft would force a Seabase to have a minimum runway of 1,500

feet. This will most likely mandate additional costs early in the development to ensure ATT's use and effectiveness. Current budgets would not allow Seabasing to develop around experimental technology; to do so would jeopardize the entire development.

Recommendation

The viability of airborne sustainment for Seabasing will depend on speed and range. The two most promising concepts are LTA and WIG. Modern airships can provide the transport capability much sought after in the DoD to rapidly transport forces and equipment. Currently the DoD is using the Defense Advanced Research Projects Agency to further understand the benefits of LTA by conducting a three-phase study beginning in June 2005. WIG aircraft, which will most likely be tied to coastal operations because of its ground effect operations, is a concept worthy of additional study. WIG craft, while capable of carrying loads slightly less (depending on size) than LTA, has the ability to rapidly sustain a Seabase during contingency operations. Once proven in principle, the flexibility, speed, and range of large airborne vehicles like LTA or WIG will sell themselves and ultimately reshape the DoD logistical infrastructure into a force capable of operational maneuver over strategic distances. Therefore, by ensuring their application inside a Seabase construct, LTA and WIG's use out side military channels should also be researched.

Success of either concept for use outside military applications will depend on the DoD. If the Defense Advanced Research Projects Agency's multiyear study is successful, the DoD should capitalize on it by initiating the first step that will bring in civilian companies to form a civil reserve air fleet organization. To expect the aviation industry to make the first move is shortsighted. Which service or services bear responsibility for

acquiring LTA is as important as the locations and sizes of squadrons to include the maintaining and crewing of these concepts. To capitalize on the massive lifting capability provided by LTA would require a minimum of three squadrons. Locations for LTA must include one on each coast, as well as one regionally located in the center of the US to have the greatest flexibility and versatility. However, WIG's locations will most likely be coastal and require up to four squadrons (two on each coast) to take advantage of the efficiency and lifting characteristic associated with flying in ground effect. Coastal placements of either concept will further its ability to work internationally as well as domestically.

Sizes of squadrons must be based on the movement of an Army's BCT. Furthermore, whether a BCT deploys for thirty days, or just three days, the Army must first determine potential force packages and global sustainment possibilities (this also applies to the Marine Corps). These packages must be balanced against the Navy's growing Seabase construct and its ability to handle large amounts of men and material at sea. Tradeoffs will occur, however any shortfalls need to be identified early in development to allow work-a-rounds to mature into doctrine.

According to the Navy's transformational roadmap, full Seabase development is approximately fifteen years away. However, the decisions to ensure parallel development and success of programs like LTA or WIG must begin in the next two years. If not, failure to capitalize on these emerging capabilities will not only extend deployment timelines for forces and equipment, but minimize the force projection a Seabase can provide.

APPENDIX A

PAIRED COMPARISON OF MAIN CRITERIA

		A	B	C	D	E	F	G
		Mesh with a future Seabase	Considered transforma-tional	Joint Application	Concept Perfromance	versatility of the concept	Operational footprint	Utilized outside military applications
A	Mesh with a future Seabase		A1	C1	Zero	E1	A1	Zero
B	Considered transforma-tional			Zero	Zero	Zero	B1	G2
C	Joint Application				C1	C1	C2	Zero
D	Concept Perfromance					D2	Zero	D1
E	Versatility of the Concept						F2	G1
F	Operational footprint							F1
G	Utilized outside military applications							

APPENDIX B

PAIRED COMPARISON OF CONCEPT'S PERFORMANCE

		A	B	C	D	E	F	G	H
		Flexibility	Speed	Lift	Range	Suitability	Personnel Req.	Survivability	Risk
A	Flexibility		A2	A2	A1	A2	Zero	A1	H2
B	Speed			C1	D1	E1	B1	B1	H3
C	Lift				Zero	C1	C2	C1	H2
D	Range					D1	Zero	D2	H2
E	Suitability						F1	G1	H3
F	Personnel Req.							F1	H2
G	Survivability								H3
H	Risk								

APPENDIX C

GRID ANALYSIS OF PERFORMANCE CRITERIA

		Potential Concepts			
Criteria	**Weighted Factor (Table 2)**	Lighter-Than-Air (Grade x wt.)	Wing-in-Ground (Grade x wt.)	Advanced Theater Transport (Grade x wt.)	Seaplanes (Grade x wt.)
Flexibility	.200	B (0.800)	B (0.800)	C (0.600)	B (0.800)
Speed	.050	B (0.200)	B (0.200)	B (0.200)	B (0.200)
Lift capability	.125	A (0.625)	A (0.625)	C (0.375)	F (0.000)
Range	.100	A (0.500)	A (0.500)	E (0.100)	D (0.200)
Suitability	.025	B (0.100)	B (0.100)	C (0.075)	B (0.100)
Personnel Requirements	.050	D (0.100)	C (0.150)	B (0.200)	B (0.200)
Survivability	.025	E (0.025)	B (0.100)	A (0.125)	B (0.100)
Risk	.425	B (1.700)	C (1.275)	C (1.275)	C (1.275)
TOTAL (sum)	**1.00**	**4.05**	**3.75**	**2.95**	**2.875**

APPENDIX D

GRID ANALYSIS OF POTENTIAL CONCEPTS

		Potential Concepts			
Criteria	**Weight Factor (Table 1)**	Lighter-Than-Air (Grade x wt.)	Wing-in-Ground (Grade x wt.)	Advanced Theater Transport (Grade x wt.)	Seaplanes (Grade x wt.)
How well can the concept mesh with a future Seabase?	.111	B (0.444)	B (0.444)	B (0.444)	B (0.444)
How much is the concept considered transformational?	.055	B (0.220)	C (0.165)	B (0.220)	D (0.110)
How well could the concept be applied in a joint manner?	.278	A (1.390)	A (1.390)	C (0.834)	C (0.834)
How well does the concept perform? (Grade forwarded from Appendix C)	.167	4.05 (0.676)	3.75 (0.626)	2.95 (0.493)	2.875 (0.480)
How versatile is the concept?	.055	D (0.110)	C (0.165)	B (0.220)	C (0.165)
How small is its operational footprint?	.167	B (0.668)	B (0.668)	A (0.835)	A (0.835)
How well can the concept be utilized outside military applications?	.167	A (0.835)	B (0.668)	E (0.167)	C (0.501)
TOTAL (sum)	**1.00**	**4.343**	**4.126**	**3.213**	**3.369**

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