

Future Carrier vs. Super Carrier: New Issues and Technologies

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EXECUTIVE SUMMARY

Title: Future Carrier vs. Super Carrier: New Issues and Technologies

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Thesis: New technologies and emerging issues such as the Joint Strike Fighter and the shift to a littoral navy threaten the future of the super carrier.

Discussion: Since the carrier's inception, heated arguments have been waged as to the size and capabilities of future carriers. This paper explores whether the era of the super carrier—a large aircraft carrier that is superior in size, capability and status—is coming to a close by examining the United States' need for large carriers. An examination of; the development of the carrier, threats, costs, emerging technology and capabilities will show that future carriers will remain large despite affordability.

The carrier has evolved to support the air wing. Aircraft have provided the major source for change to the carrier. Successful development of Short Takeoff and Vertical Landing (STOVL) aircraft will expand the capabilities of the air wing and require new capabilities from the carrier. Conventional Takeoff and Landing (CTOL) aircraft have perpetuated the legacy of the super carrier. Integrated air wings of STOVL and CTOL aircraft will allow interoperability between Joint forces and coalition forces.

Emerging technologies such as electro mechanical aircraft launching system (EMALS), unmanned aerial vehicles (UAV) and unmanned combat aerial vehicles (UCAV) will enable cost reductions in manpower and modify hull design. Measuring the total operating costs (TOC) will make estimating budgets for the new carriers more efficient and help achieve long-term goals by making it easier to remain on budget avoiding cost overruns.

While other naval powers operate with smaller carriers, the U.S. is the only naval power that has the capacity and resources to operate super carriers. The capability of the carrier and its air wing are the key issues that must be addressed when discussing the next super carrier. Ultimately, the size of the carrier is dictated by capabilities required to carry out its mission, the core functions of the Navy and total operating costs.

Conclusions: Tomorrow's carrier design must be centered on the functions of the Navy and the capabilities required to support those functions. While the U.S. Navy is currently focused on the littorals, the advent of sea basing and emerging threats demand that blue water capabilities may receive less emphasis, but not be ignored. CVN-76 and CVN-77 will become the bridge in the transition to CVNX2, the follow on generation of aircraft carriers for 2018 and beyond. The option of transitioning to smaller carriers will limit our capability as a superpower. Large carriers will ensure the national interests of the

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United States are secure. The super carrier remains the vehicle with the capabilities required by our nation to support troops on land, maintain a forward presence and ensure command of the seas.

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Future Carrier vs. Super Carrier: New Issues and Technologies

“A navy built around these ships [carriers] will not carry us into the emerging era of warfare any better than did the USS Arizona in to WWII.Building more large carriers today and expecting them to be useful into mid century is to be blind to reality.”¹

-Admiral Stansfield Turner USN (Ret.)

Introduction

The development of Expeditionary Warfare, the requirement for Joint platforms and the change in world events has threatened the future of the current Nimitz class carriers. In order to survive and remain relevant to future operations, the carrier must evolve. Emerging technology, changing threats and new aircraft will enable the carrier to adapt and remain relevant in the future.

The aircraft carrier has undergone dramatic changes in the past eighty-five years. Aircraft carriers have grown in size to accommodate aircraft and their capabilities. The ship and its aircraft have adapted over time into a remarkable platform that projects power and dominates the world’s oceans. Throughout its history, the carrier has engaged in decisive battles contributing to the United States’ rise as sole remaining superpower. Today, in an era of military transformation, the size of the carrier is questioned. Is it too big? Can we build them smaller and still accomplish the mission? Can the United States afford to continue to build Nimitz class aircraft carriers? Is a Joint platform required in order to maintain relevance in future military operations?

This paper will determine if the era of super carriers—a large aircraft carrier that is superior in size, capability and status like those contained in the United States Navy’s Nimitz class carriers—is ending by examining the United States’ need for large carriers. An

examination of: the development of the carrier, threats, costs, emerging technology, and capabilities, will show that the aircraft carrier of the future will be large, yet affordable. The capability of the carrier and its air wing are the key issues that must be addressed when discussing the next super carrier.

Functions of the Navy

The drive toward a littoral navy marginalizes the need for a blue water navy to protect global shipping and sea lines of communication.² Focusing solely on the littorals, while economical, is not prudent given the potential threats in the world. Admiral Chase listed the following main functions of the Navy.³

1. *For coastal defense*
2. *For commerce raiding*
3. *For enforcing respect for U.S. interests especially trade and shipping*
4. *An instrument of foreign policy*
5. *For commanding the seas*
6. *For direct support of land operations*
7. *For projecting force inland from the sea*
8. *An integral and important component of the strategic deterrent power of the United States*
9. *A means to implement social reforms*

While all nine functions described by Admiral Chase are important and have maintained relevance over the decades, the three most important functions are; commanding the seas, direct support of land operations and projecting force inland from the sea.⁴ Command of the seas requires a blue water navy able to keep vital sea-lanes of communication open, free from aggressors. The carrier is one of several tools that the navy needs to directly support land

¹ Stansfield Turner, Admiral, USN (Ret.). "Is the U.S. Navy Being Marginalized?", *Naval War College Review*. (Summer 2003): 103.

² A. T. Mahan, *The Influence of Sea Power upon History 1660-1783*, (New York: Dover Publications Inc, 1987) 28-29.

³ John D. Chase, Rear Admiral, USN, "The Function of the Navy," *United States Naval Institute Proceedings*, (October 1969):31.

⁴ Chase, 27-33.

operations. The carrier's air wing provides the necessary punch to support expeditionary operations, military operations other than war and campaigns. Projection of force inland from the sea is the carrier's forte. The formidable firepower that the air wing brings to battle is unmatched. Force projection has given the carrier a worldwide reputation as a universal solution to world crisis. The ability of super carriers to assist in these functions shows the versatility of these ships.

Threats

“Naval forces’ very presence if made known, can pose a threat that the enemy cannot ignore.”

- Joint Pub 3-0

The U.S. Navy's *Sea Power 21*, as well as*Forward From the Sea*, has stressed the importance of fighting from the littorals. The littorals are any land or ocean within 650 miles of the coastline.⁵ Bringing the carriers in close to support operations raises the threat level to the carrier. With only twelve carriers, each at a cost of \$ 4.5 billion (not including the air wing), the United States cannot afford to lose one in battle.⁶

Today, threats to U.S. carriers include man-made symmetric and asymmetric threats as well as natural threats from operations in the littorals. Mines, torpedoes, aircraft, cruise missiles, submarines and theater ballistic missiles threaten the survivability of the carrier. Asymmetric threats such as fishing boats, low/slow flying aircraft, small, fast moving corvettes and terrorist attacks in port have become more likely in the aftermath of 9/11. Natural threats from tides, currents and shallow water become more threatening as ships shift from operating in open blue water to the constricted littoral arena.

⁵ Dr. Scott Bowden, *Forward Presence, Power Projection and the Navy's Littoral Strategy, Foundations, Problems and Prospects*, < <http://www.irisresearch.com/littorals.htm> >IRIS Independent Research, accessed, 14 April, 2004.

The end of the cold war has left the United States and its allies with no opposing fleet. The vacuum that has resulted prompted a change of doctrine and a focus on the littorals. While not a new environment, it becomes a challenge to transition from a “blue water” navy in command of the seas, to a “littoral” navy where command of the seas is not guaranteed. We have moved from the threat of an enemy fleet comparable to ours to a coastal “shallow water” threat. Moving closer to land presents formidable symmetrical threats such as; submarines, mines, fast patrol craft, small boats, aircraft, land/sea launched cruise missiles and theater ballistic missiles.⁷ Asymmetrical threats in or out of port also pose a threat to the carrier such as fishing boats and low/slow flying aircraft.

Vulnerable choke point passages like the Suez Canal, the Strait of Gibraltar, the Strait of Malacca, the Strait of Hormuz or any passage through constricted or confined waters poses a threat to the carrier and its strike force. With the advent of modern austere anti-ship cruise missiles, advanced mines and fast attack boats, opposing access to vital shipping routes in constricted waters is more probable given the increase of population along coastlines and growing instability in the world. The carrier must pass through these points to access vital sea-lanes and potential crisis areas throughout the world. Proliferation of anti-ship cruise missiles, anti-ship mines and suicide bombers, combined with the necessity to transit critical choke points, make the carrier a viable target.

China must not be overlooked when analyzing threats to the carrier and its strike group. While China is not a current threat to the U.S., future options must include it as a threat, to be prepared for any challenge. According to Arthur Waldron, “China looks for vulnerabilities in their opponent; they will fight asymmetrically if necessary trying to cripple, intimidate and

⁶ “A Different Look for Affordable Platforms,” *Janes’ Defence Weekly*, (01 August, 1997): 24

⁷ Joseph, E. Skinner, “Swarm the Littorals,” *United States Naval Institute Proceedings*, (March 2001):81.

confuse to obtain a respectable payoff for a small risk.”⁸ With this in mind, possible catalysts for conflict with China include the independence of Taiwan, claims to the Spratly Islands, and challenges to vital sea lines of communication that pass through the South China Sea facilitating transport of oil to Japan. China sees the United States’ forward deployed carrier strike groups as a threat to both Mainland China and Taiwan. China’s willingness to acquire weapons from other nations has resulted in obtaining super-sonic anti-ship missile technology from Russia providing it a formidable defense against carriers operating in the littorals. An increase in conventional capability, especially from its navy, must be expected. With an understanding of modern technology and a capacity for asymmetric warfare, China’s future military must be considered when designing tomorrow’s carrier.

In the course of the development of the aircraft carrier, dependence on airpower and escort ships have resulted in a perception that the carrier is unable to defend itself. The idea is reinforced by a focus on the carrier’s vulnerability and promotion as an easy target for symmetrical and asymmetrical attacks. Its reliance on a fleet of ships and aircraft for defense as well as its size, has given opponents of the super carrier reason to doubt its survivability. Simply put, the carrier needs the ability of self-protection in addition to its escort ships and carrier air wing. Recent conflicts have not required the carrier to fight its way into an operating area. The areas like The Gulf and the Adriatic Sea have not required excessive air wing sorties to protect the carrier. When a carrier must defend against coastal anti-ship missiles and mine fields while operating in the littorals, considerable deep strike sorties are reduced and the air wing must focus on protection of the carrier until maritime superiority has been achieved.

To consider that a super carrier is vulnerable due to its size is to fail to appreciate the

⁸ Arthur Waldron, “Why China could be dangerous,” *The American Enterprise*, (Washington: July/August 1998): 41.

advantage of its size. The super carrier's massive size allows it to carry a formidable air wing, which provides protection. In today's age of satellites and modern intelligence, reconnaissance and surveillance (ISR) assets it is difficult to hide a carrier and its strike group. The long-range strike capabilities of its air wing allow it to maintain stand off distances from coastal threats. Operating at a secure distance from the enemy coast allows the carrier to increase aircraft sorties dedicated to power projection and supporting land operations, resulting in negating coastal anti-ship defenses.

Recent operations in the Southwest Asia Theater have shown other nations that in the post cold war era naval power remains key to power projection. Carriers launching modern aircraft to drop guided weapons on targets in Operation ENDURING FREEDOM and Operation IRAQI FREEDOM, all shown on television for the world to see, presents an enticing proposition for other governments and military leaders looking for a key to compete with U.S. hegemony.⁹ A nation seeking to compete with U.S. naval supremacy could, at the same price as raising a "deterrent capable" nuclear arsenal, fund a carrier. While one carrier is not enough to threaten a fleet of carriers, it is a trend that is growing in Asia, especially with India and China. Both countries have expressed interest in carriers.¹⁰ China has far to go in the purchase or development of a carrier while India is committed to acquiring at least one additional carrier. While these are not viable threats in the near future, it is an example of the rise of future challengers to carriers and naval power.

Global Carrier Acquisitions

India, Thailand, Italy, and France all maintain at least one carrier in their fleet. While Thailand and Italy focus on STOVL aircraft, the Indian Navy's order of three Vikrant-class

⁹Nick Smith, "Grand Delusions," *Harvard International Review*, (Cambridge: Fall, 2002): 7.

¹⁰ *Ibid.*, 7-8.

carriers, displacing more than 30,000 tons each, shows their resolve to increase their strike capabilities. The new carriers' capabilities will be designed around the Hindustan Light Combat Aircraft (LCA) and the austere Russian MIG-29K. The ships will have Short Takeoff But Arrested Recovery (STOBAR) capabilities, capable of launching aircraft with no catapult system yet recovering aircraft with arresting gear, by 2012.¹¹ In addition, the Indian government is initiating procurement of the *Admiral Gorshkov* and or the H.M.S. *Invincible*, increasing the navy's carriers to three ships.¹² India's additional carriers will expand their navy's capabilities to project power, command sea lines of communication and protect their littoral areas. Although not a threat to the U.S., Thailand and Italy's small carriers use of STOVL aircraft, show the versatility and economy of a smaller force. Considering the worldwide use of STOVL technology, increased use of STOVL aircraft by the U.S. would facilitate more flexibility and interoperability with allied forces.

The latest French carrier, the nuclear powered *Charles de Gaulle*, in operation since 2000, carries 40 aircraft and is Europe's most modern carrier. The air wing consists of Super Entendards, E-2C Hawkeyes and the Rafale fighter. The De Gaulle's 40,000-ton displacement makes it a modest size carrier that will add to France's military capabilities. Equipped with the same catapult that current U.S. Navy carriers are equipped, it has reduced launch capabilities compared to U.S. carriers. In addition, it is equipped with a stabilization system that enables it to operate in sea states of five to six.^{13,14} The French carrier's CTOL capability differs from

¹¹ Sea Power. (Washington: July 2003) 43.

¹² Ibid., 43.

¹³ James Dunnigan , "How not to Build an Aircraft Carrier," December 7 2003, *Strategy Page*. URL: <<http://www.strategypage.com/dls/articles/2003127.asp>>. Accessed 18 January 2004.

¹⁴Sea state is a scale that categorizes the force of progressively higher seas by wave height. This scale is mathematically co-related to the Pierson-Moskowitz scale and the relationship of wind to waves. See also Pierson-Moskowitz scale. Sea state five to six means that the waves range from 8 to 20 feet with winds ranging from 21 to 33 knots, according to *Resolute Weather Det 1, 18th Weather Squadron* <<http://www.eustis.army.mil/weather/>> .

Britain's modest 50,000-ton STOVL carrier. France is looking into purchasing a British designed and built carrier, which would have the capability to operate CTOL aircraft from its decks bringing them to two carriers. The ability to operate a medium sized air wing on a modest size carrier shows that smaller carriers are possible. The smaller air wing does not compare to the capabilities of the United States' Nimitz class carriers. French desires for more carriers show a rising global interest in carrier capable navies.

The rise in global acquisition of carriers and their power projection capabilities stem from the carrier's early development. As a nation's need for sea power grows, it is only natural to desire more capabilities from its navy. The carrier provides protection for its fleet as well as provides deterrence to potential aggressors while also acting as a symbol of the nation's power and prosperity. By looking at smaller nation investment in carriers a parallel can be drawn to the early development of the carrier and subsequent improvements following World War I.

Historical Background

Stemming from the success of land-based air power, carrier development began during the First World War. Both the British Royal Navy and the U.S. Navy developed their carriers separately, driven by the desire to gain air superiority for their large battle fleets. As the leading sea power, the British were driven by the need to launch aircraft from sea to support naval gunfire, attack German shipping, submarines and combat zeppelins over the English Channel. Following World War I the United States Navy developed carrier aviation largely to support its capital ship, the battleship, and protect its grand fleet from other aircraft.

Simultaneously, the U. S. began developing a carrier. In 1920 the U.S. Navy found the collier, the U.S.S. *Jupiter* to be the best ship in its inventory for conversion to an aircraft carrier. The U.S.S. *Jupiter*, renamed the U.S.S. *Langley* CV-1, was electrically driven and required only

a small crew to operate her.¹⁵ The period 1920 to 1968 was filled with dynamic changes in the development of the carrier. From the U.S.S. *Langley* designated as the first operational carrier, to the first carrier designed from the keel up, the U.S.S. *Ranger*, CV-4, naval aviation gained a foothold in future naval warfare.¹⁶

Past decisions have affected our present and future operations. In 1922, President Warren G. Harding imposed a ceiling on battleship tonnage and convinced congress of the wisdom of converting battle cruisers to carriers, saved \$20 million and ushered in the birth of the U.S.S. *Lexington* (CV-2) and U.S.S. *Saratoga* (CV-3).¹⁷ In 1942 CNO Admiral Ernest King's decision to scrap battleship construction and implement a "crash" program of carrier construction and cruiser conversions created the Essex class fast carriers that smashed the Japanese in the Pacific.¹⁸

The history of modifications to carriers during World War II show how survivability is traded for cost savings. The U.S.S. *Ranger*, *Wasp*, *Essex* and *Yorktown* all had design differences that contributed to damage or reduced performance. The *Ranger*'s scaled down size and smaller displacement while still carrying as many aircraft as the *Lexington* resulted in a slower speed and an inability to launch aircraft in heavy weather.¹⁹ Although the *Ranger* was never sunk by enemy action, her performance did not enable her to participate with the fast carrier groups in the Pacific. The *Wasp*, a victim of reduced tonnage available due to treaty restrictions, was given less armor below the waterline making it susceptible to torpedo hits.²⁰ The *Yorktown* class contained various combinations of defensive measures. The lack of standardization in design showed in the survivability of the three different ships. The *Yorktown*

¹⁵Joseph A. Skiera, *Aircraft Carriers in Peace and War*, (New York: Franklin Watts, Inc., 1965), 5.

¹⁶ Skiera, 51.

¹⁷Irwin R. Manley, "Harding policies foster Future Naval Success," *Naval History* (Annapolis: Aug 2003) 3-4.

¹⁸ *Ibid.*, 3.

class was given an unarmored hangar deck unlike the armored flight deck of her British counterpart the H.M.S. *Illustrious*. Lack of armor under the waterline made them susceptible to torpedo hits. They then relied on their fighter squadrons, speed and defensive armament for protection. The U.S.S. *Hornet* was given more armor under the waterline allowing it to absorb more torpedo hits.²¹ The *Essex* class depended more on its air wing, escorts, damage control and speed for defense, since it lacked heavy armor and might then sustain crippling hits.²²

U.S. development of the aircraft carrier accelerated during World War II. Modifications in the design of carriers stemmed from practical experience in combat specifically during the Pacific island hopping campaign. Particularly, the *Essex* class “Fast Carriers” led by Admiral Marc Mitscher USN, Commander Task Force 58. These carriers supported joint amphibious assaults in multiple campaigns destroying Japanese aircraft, ships, submarines and land targets. The capabilities of the *Essex* class carriers, speed, armament, and capacity to carry large air wings, gave it the necessary punch required for success in the Pacific theater. The main difference between the *Essex* class carriers and their British counter parts was the flight deck. U.S. Essex class carriers had wooden flight decks and British carriers had armored flight decks. The result was a smaller air wing on the British ships but greater protection was afforded from Kamikazes and dive-bomber attacks. The result of experienced gained in combat from success and failure alike, was an austere ship with robust defenses against surface, subsurface and aerial attack.

Following World War II, carrier development continued as the Cold War heated up and tensions in Korea escalated into a major conflict. Intense arguments over the design of the

¹⁹ John Lillard. “Austerity is not Affordable,” *United States Naval Institute Proceedings*, (Aug 1999): 42.

²⁰ Lillard, 42.

²¹ *Ibid.*, 42.

²² *Ibid.*, 42.

carrier began with the development of the carrier U.S.S. *United States*. In 1949, Secretary of Defense Louis Johnson made the controversial decision to stop work on the *United States*, a 65,000 ton carrier. He had this reason: the U. S. Air Force development of the B-36 Peacemaker, touted as a rival and more effective weapon system, caused a heated exchange with the U.S. Navy over the “pointless extravagance” of carriers. Both services, of course, were competing for dominance of the nuclear arsenal. Because of the disagreement over the U.S. Air Force’s B-36 bomber program, the Chief of Naval Operations, Admiral Louis Denfield, was fired in what was termed “the revolt of the Admirals.”

Classes of carriers such as the *Forrestal* and the *Midway* class carriers paved the way to the modern *Nimitz* class carriers carrying large modern air wings. The *Forrestal* class was designed as the first super carriers displacing over 76,000 tons. The U.S.S. *Kitty Hawk* and U.S.S. *Constellation*, both conventional powered carriers designed prior to the *Nimitz* class carriers, are similar in displacement and capabilities to nuclear powered super carriers. The U.S.S. *America* and the U.S.S. *John F. Kennedy* differed from the *Nimitz* class in their propulsion plants. Both carriers were conventionally powered while maintaining comparable flight decks to the *Nimitz* class super carriers.

The development of the *Nimitz* class allowed carriers to evolve below the flight deck as well as above providing more space for improvements in safety and more efficient operations. The increased flight deck space of the *Nimitz* class was required to compensate for the larger more modern aircraft that the *Midway* class was not designed to carry.

Changing carrier designs before and during wartime allowed for the variations in protective measures. Today’s standardized carrier design, particularly the *Nimitz* class carrier’s large size, allow for robust defenses avoiding questionable survivability. The lessons learned

from combat damage and flight deck mishaps have produced strong carriers. Practical applications from combat enabled designers to move from a single wooden deck on a modified collier to the angled steel deck of the modern super carrier.

Air Wing Development

The result of experience gained in combat from success and failure alike, was an austere ship with robust defenses against surface, subsurface and aerial attack. Naval aircraft, on the other hand, experienced an evolution from slow lumbering biplanes to sleek nimble fighters and attack aircraft. By the end of the war, ship design, tactics and aircraft had changed dramatically. Most notable was the increased performance of carrier-based aircraft.

As aircraft evolved, so too did the carrier and its capabilities. The high point of air wing size was the Essex class with 100 aircraft. The introduction of jet aircraft during the Korean War necessitated more powerful and larger catapults and arresting gear. The large, heavy jet aircraft reduced the ability of carriers to carry large numbers of aircraft. Eventually, the higher landing speeds and less forgiving landing performance of jet aircraft, when compared to propeller driven aircraft, facilitated the need for the addition of an angled deck. The angled deck reduced mishaps and allowed aircraft to simultaneously launch and recover from the carrier. Modern developments in carrier aviation have caused the carrier to evolve into today's super carrier. The demands of naval aviation, mainly from the introduction of jet aircraft, attributed to the need for a change in carrier design and capabilities.

The changes in the composition of the air wing, along with the capabilities and performance that modern aircraft possess, have shaped the design of the super carrier. Over the last four decades, there have been three aircraft that have made their indelible mark. These aircraft were the A-6E Intruder, the F-14 Tomcat and the AV-8A Harrier. The A-6E Intruder

was a culmination of the best of American technology to provide an unstoppable, all-weather ground attack aircraft. Designed in the 1950's, it remained in service until the mid-1990's. The F-14 Tomcat, originally designed as an air-interceptor, pushed new frontiers with its radical sweep wing technology and powerful radar. Outlasting its sister aircraft, the A-6E Intruder, the Tomcat evolved as an extremely capable air to ground platform as a result of a capabilities gap left from the departure of the A-6E Intruder and the reduced strike capability of the F/A-18 Hornet. The AV-8A Harrier provided a radical new technology that carried the potential to revolutionize carrier aviation, STOVL technology, while not accepted by the Navy, the USMC developed it for use in an expeditionary role. Naval leadership in the 1970's discussed developing STOVL technology for use in its air wings.

Developments in aircraft technology, particularly the Joint Strike Fighter (JSF), revives an old idea of transitioning to an all STOVL air wing. One of the main problems in achieving a complete transition to a STOVL air wing is the gap in development of the support aircraft, particularly the electronic attack EA-6B Prowler, the airborne early warning (AEW) E-2C Hawkeye, C-2 Greyhound Carrier Onboard Delivery (COD) aircraft, and the sea control S-3B Viking. With the exception of internal avionics changes, these three airframes have not changed since their introduction into the fleet over the last two decades. This resulting "gap" in their development has stagnated the evolution of future air wings. Compared to the development of fighter aircraft, the development of support aircraft has taken a back seat until recent developments. The U.S. Navy's *Sea Power 21*, has highlighted the necessity to upgrade these platforms. The replacement to the EA-6B will be the F-18G Super Hornet or the EA-18. The E/F-18 will assume the role as an organic mission tanker and the E-2 Hawkeye has received upgraded engines and avionics. These improvements to support aircraft increase the

commitment to a CTOL air wing making integration of STOVL aircraft to the air wing unlikely.

Development of STOVL Aircraft

The introduction of the AV-8A Harrier, as the United States' first operational STOVL aircraft, spurred ideas of an all STOVL fleet aiding in the transition to a fleet of smaller carriers. The revolutionary aircraft, though limited in its attack role, was the start of a movement to create an all V/STOL or STOVL fleet. A leader in this movement was then Chief of Naval Operations, Admiral James L. Holloway III USN (ret.). Although the Harrier was solely a day, Visual Meteorological Condition (VMC) attack aircraft, it represented a breakthrough in technology. Besides its limited attack performance, the aircraft was further limited to subsonic speeds mainly from its exhaust ducts extending from the fuselage. As a result, STOVL aircraft could be outperformed by CTOL aircraft. These limitations would stall the movement to convert Naval Aviation to an all STOVL force. In 1977 the CNO, Admiral Holloway, published an article titled, "The Transition to V/STOL," in the Naval Institute's *Proceedings*.²³ Admiral Holloway acknowledged the limitations of the new AV-8A Harrier. Looking forward, he envisioned a VSTOL fleet of ships and aircraft that would change the core of naval aviation. This new idea consisted of an aircraft carrier evolving into a ship with no arresting gear or catapults, launching aircraft without the aid of a catapult and recovering aircraft that hover. Flexibility was his theme, allowing aircraft to be carried by a number of different ships. Admiral Holloway's VSTOL fleet would enable naval aviation to expand, increasing the availability of aircraft to all ships and warfare commanders in the battle group.

Introduction of the Joint Strike Fighter

The limited capability of the early STOVL aircraft ensured the legacy of CTOL carriers.

²³James L. Holloway III Admiral, USN, "The Transition to VSTOL," *United States Naval Institute Proceedings*, (September 1977): 18-22.

The advent, in the last few years, of the F-35 Joint Strike Fighter (JSF) has opened the possibility of integrating STOVL aircraft into the carrier air wings. Three variants of the fighter will be produced: the F-35A, B and C. The F-35A will be a CTOL variant designed for the U.S. Air Force to replace the F-16 and A-10 models of aircraft. The F-35C will be a carrier (CV) variant designed for the U.S. Navy to replace the F-14 and F/A-18C and to fill the void left from the retirement of the A-6E Intruder. The F-35B will be an STOVL variant designed to replace the Marine Corps AV-8B and F/A-18 C.²⁴ The F-35 series of aircraft is projected to be in service by 2010.

The F-35 is a single piloted, single-engine fighter/attack aircraft, designed with low observable technology. The future plan for the U.S. Navy is to develop air wings comprised of the F-35C aircraft and the F/A-18E/F. When the F-35C and B models are introduced to the Navy and Marine Corps in 2010, serious consideration must be made for integration of STOVL and CTOL aircraft into the carrier air wings. Both the F/A-18E/F and the F-35 versions are needed to maintain the formidable strike capability of the carrier air wing.

According to *Marine Corps Concepts and Programs 2004*, the JSF is designed with advanced systems such as the Active Electronically Scanned Array Radar (AESA), Electro-Optical Targeting System (EOTS), and a Distributed Aperture System (DAS). AESA enables both ground mapping radar and superior air-to-air capabilities by an electronically steered beam.²⁵ Reduced numbers of mechanical parts as well as improved solid-state electronics make it a more reliable system. EOTS will allow more accurate targeting at greater ranges for the

²⁴ Steven S. Weatherspoon, "Naval Forces 2/2003," *North American Focus*, (EBSCO Publishing, 2003): 85.

²⁵ Raytheon Electronic Systems, "APG-79 Active Electronically Scanning Phased Array Radar System," Raytheon.com, 2002, URL: <http://www.raytheon.com/feature/apg79_aesa/pdfs/APG-79.pdf>, accessed 01 April, 2004.

aircraft's weapons systems with an improved infrared optics and laser designator.²⁶ DAS will integrate infrared sensors around the airframe to provide the pilot with 360-degree view outside the aircraft, increasing the pilot's situational awareness of the battle space.²⁷ The advanced systems will be fused into a pilot's helmet mounted display removing the need for traditional heads up display in the cockpit by providing streaming video to the pilot.²⁸ No other combat aircraft in the U.S. inventory currently possess this advanced technology.

Comparing the F-35B and the AV-8B yields a marked difference in capabilities. The AV-8B performing a short takeoff deck launch loaded to 38,000lbs has a max range of nearly 600nm without aerial refueling. The F-35 when fully loaded will weigh 50,000 lbs with a maximum combat radius range of over 600nm.²⁹ Both aircraft have similar ranges however, the F-35's low observable stealth technology, advanced air to air /air to ground weapon systems and superior flight performance make the F-35 a more capable platform. The F-35 advanced capabilities make it more survivable flying air strike on the first day of a campaign or operation.³⁰ Additionally, the F-35's interoperability between U.S. forces as well as coalition partners will foster more multinational cooperation make the F-35 a smart choice for Navy/Marine Corps fostering more combined naval operations due to common: weapon systems, maintenance practices and parts inventory and airframe. An aircraft carrier with a combined

²⁶ "Defenses Technology Area Plan Chapter VII," *Federation of American Scientists*, URL:<http://www.fas.org/spp/military/docops/defense/97_dtap/sensors/ch070302.htm>, accessed 01 April, 2004.

²⁷ Marlene Moore, 18 March 2003, "Indigo Systems Awarded F-35 Joint Strike Fighter Contract by Northrop Grumman to Deliver Infrared Sensors," Indigo Systems, URL :<http://www.indigosystems.com/company/PR/pr_030318.html>, accessed 01 April, 2004.

²⁸ United States Marine Corps, *Marine Corps Concepts and Programs 2004*, (Washington, DC: Programs and Resources Department, 2004), 79.

²⁹ "F-35 Joint Strike Fighter," May 13, 2003. *Federation of American Scientists Military Analysis Network*. URL: <<http://www.fas.org/man/dod-101/sys/ac/f-35.htm>>. Accessed 02 January 2004.

³⁰ This refers to "first day strike" survivability, which is the aircraft's ability to survive a high threat environment as would be encountered on the first day of a campaign or contingency operation.

STOVL and CTOL air wing will be the keystone in a transition to a STOVL fleet. As aircraft evolve so will the carrier's flight deck to support the different types of aircraft onboard the ship.

Emerging Technology

Electromechanical Aircraft Launching System

Recent developments in catapult design; changing the current use of steam catapults to electric driven catapults will reduce maintenance and increase reliability. Current steam catapults are inefficient and are maintenance intensive. The electro mechanical aircraft launching system (EMALS) will use electricity to propel the launch shuttle down the catapult track vice a steam driven piston. EMALS will provide a more efficient, more flexible and safer means to launch aircraft from the carrier.

The EMALS will be powered by the ships electrical system. It will consist of four main components: the energy storage device, a power conditioning system a linear motor and a closed loop control system.³¹ The system will use the same launch shuttle as the steam system and will fit into the same area as the steam troughs on current U.S. Navy aircraft carriers.

The energy storage device will use the inertia from the rotor of an electrical generator to power the catapult. The power conditioning system is a solid-state component that regulates the voltage and frequency of the electrical pulse supplied to the shuttle. This will provide a reliable and consistent power source and regulate power distribution. The power control system will provide feedback by way of a closed loop feed back and monitoring system to the operators, to allow a zero to three knot variation on the end speed. This will provide operators better control of the aircraft speed as it launches off the catapult, reducing the risk of a weak catapult launch.

The control system will also monitor the health of the system and inform the operators of any failures providing a graceful degradation of the system vice the catastrophic failure of the steam

catapult. The linear motor will translate electrical energy into linear motion by generating a traveling magnetic wave that will move the launch shuttle down the catapult track as well as providing launch, braking and retracting energy via one component.

Compared to the steam catapult, which requires separate and heavier components to carry out its tasks, the EMALS will require 20,000 cubic feet of space, mostly below the flight deck compared to the 40,000 cubic feet for a steam catapult system, a 50% reduction in the total weight of the system.³² It will be more reliable with 1,300 mean cycles between failures, which, combined with the closed loop feed back and monitoring system will allow operators to address potential problems before they become dangerous. Finally, the overall efficiency of the system is 60%, ten times better than the steam system.³³ When compared to the steam catapult, this is a quantum leap in technology.

The reduction in space required for the EMALS below the flight deck is due to the drive mechanism. Powered by an electrical source, the EMALS will not require hydraulic or pneumatic power, an old system that requires large amounts of space and maintenance to operate effectively. In addition, by using electromagnetic technology, the catapult track itself will not require lubrication since the shuttle (the device that attaches the catapult to the aircraft) will not contact with the catapult track. Current steam powered catapults require intense lubrication, inspection and maintenance particularly in the area of the catapult track and shuttle. The revolutionary technology of the EMALS will provide a stronger, more robust launch capability allowing heavier aircraft to be launched. The design and mechanics of the system will also allow for integration into a ramp capability. Although the system is still under development, there are

³¹ Erwin, 18.

³² M. Doyle, G. Sulich and L. Lebron, "The Benefits of Electro magnetically Launching Aircraft," *Naval Engineers Journal*, (May, 2000): 78-82.

³³ *Ibid.*, 80-81.

certain drawbacks like operability of the fully electrical system in a highly corrosive sea environment and electromagnetic interference (EMI) with shipboard and aircraft avionics on deck, which still require resolution.³⁴

Current CTOL carriers allow large gross weight aircraft from, 30,000 to 68,000 lbs, to be catapulted from its decks. Integrating EMALS with a new carrier design will allow a more diverse aircraft to be launched, from small UAV to heavy strike aircraft. This will give way to a potential STOVL catapult assisted launch. Combining the EMALS with a ski-jump ramp aircraft will require less fuel consumption on take-off and increase the safety margin during launches for aircraft.³⁵

EMALS will aid in the reduction of the overall size of the ship, reducing overall costs and weight. Fewer crewmembers will be required to operate the system, reducing manpower required by 30%, and a reduction in the size and weight of catapult components by 50%. In addition, the EMALS system will be able to launch lightweight Unmanned Aerial Vehicles (UAV) as well as Unmanned Combat Aerial Vehicles (UCAV), increasing the flexibility of the carrier as well as diversifying the composition of the air wing.³⁶

Unmanned Aerial Vehicles (UAV)

UAV and UCAV technology will make their way into future air wings. According to the Pentagon's "UAV road map," \$10 billion dollars will be spent by 2010 quadrupling the current 90 aircraft inventory.³⁷ The road map estimates that, "by 2012, UAVs will be taking off and landing vertically, flying for more than 24 hours at speeds and altitudes greater than today's

³⁴ "Electromagnetic Aircraft Launching System (EMALS)", June 11, 2003. *Global Security.org*, URL: <<http://www.globalsecurity.org/military/systems/ship/systems/emals.htm>>. Accessed 04 January 2004.

³⁵ Jordan, 73.

³⁶ "Electromagnetic Aircraft Launching System (EMALS)".

³⁷ David A. Fulghum. "Pentagon Eye Quadrupling UAV Force by 2010," *Aviation Week & Space Technology*, (February 17, 2003): 35.

UAVs.”³⁸ The plan outlines development ofUCAV for suppression of enemy air defenses and airborne electronic attack capabilities by 2008-2010.³⁹ Additional requirements include demonstration of formation flights as well as unmanned aerial tanking. Success in these areas could reduce the Navy’s requirement for manned tactical aircraft resulting in cost reductions from reduced manpower requirements.

The use of UAV andUCAV aircraft reduces the cost requirements for training aircrew as well as the cost requirements for the aircraft themselves. The prudent course would be a combination of unmanned aircraft with manned aircraft missions. UAV andUCAV aircraft will not be able to cover all contingencies. Current unmanned flight technology does not allow complete autonomy. Maintaining manned missions will continue to provide a responsive and flexible system. A concerted effort to work together, combining the use of UAV and manned missions, will allow for continuous coverage of the battle space.⁴⁰ While unmanned combat aircraft capable of replacing manned aircraft have not entered service, the Department of Defense has shown strong resolve to develop the technology.

In addition to the issue of replacing manned aircraft, UAV technology in a naval environment must have the capability to recover aboard ship. Current trends are focused on vertical landing as the primary means of recovery.⁴¹ However, conventional naval recovery systems should not be overlooked. A recovery system called “Short Stop” would allow recovery of UAVs on surface ships. Shortstop is a recovery system, which allows the craft to execute an automated arrested landing on a small platform. Specialized pilot skills, would not be required.⁴²

Recovery of UAV andUCAV aircraft onto a ship using current technology and

³⁸ Fulghum, 36.

³⁹ Ibid., 36.

⁴⁰J. Michael Johnson, Rear Admiral, USN (Ret.) and Michael Lobb Lieutenant Colonel, USMC (Ret.). “Manned Reconnaissance Must Continue,” *United States Naval Institute Proceedings*, (July 2003): 36

capabilities should focus on two possible methods, vertical or conventional recovery. Both methods are proven effective, while a vertical recovery would allow recovery on diverse platforms with minimal modifications, conventional recovery would be needed for larger and heavier UCAVs. STOVL UCAVs should be considered, especially due to the complexity of a conventional recovery aboard a pitching ship in heavy sea states.

Three reasons for developing the UAV are: to enable continuous coverage of the battle space, increase performance of the vehicle by eliminating the need for life support equipment, and reducing the risk of losing aviators in combat.⁴³ Improved Intelligence, Surveillance and Reconnaissance (ISR) is certainly an added benefit, but removing the aviator from the aircraft decreases situational awareness and removes the human ability to observe and react to the continually changing conditions that require quick reaction and creative problem solving.

Today's technologies, specifically EMALS and UAVs, are a smart choice when considering cost savings. Advancements in technology cannot and should not replace humans as decision makers and problem solvers. A smooth transition from antiquated systems and modern technology as well as a balance between automation and "man in the loop" technology must be obtained in order to advance the capabilities of future carriers. Rapid and poorly planned transitions with new technology and cost saving measures can have unintended consequences that will be difficult to recover from. The British experience in the Falkland Campaign shows the result of relying too heavily on the new technology to cut costs.

British Experience

The Falkland Campaign is an example of the pitfalls of "savage cuts" in carrier

⁴¹ Robert A. Lynch. "Modify the Ship, Not the Vehicle," *United States Naval Institute Proceedings*, (Sep 2003): 46.

⁴² Lynch, 47.

⁴³ Jon R. Olson. "An Alternative Vision of Sea Power 21," *Proceedings of the United States Naval Institute*, (Oct 2003) 81.

aviation.⁴⁴ The British decision to reduce their presence east of the Suez Canal resulted in the retirement of the *Ark Royal* in 1978, their last CTOL aircraft carrier. This decision removed the F-4 Phantom, Blackburn Buccaneers, and Fairy Gannet AEW 3s from the air wing and placed air power in the hands of STOVL Harriers and AEW with Sea King helicopters. The departure of the CTOL F-4 Phantoms with beyond visual range air-to-air missile capability, the Buccaneer with its air-refueling capability and the Gannet's AEW mission severely degraded the British fleet's ability to protect itself and project power. As a result, the Royal Navy relied upon the smaller *Invincible* class anti-submarine cruiser capable of carrying the Harrier GR 3 and Sea Harrier.⁴⁵

As a result of the change from CTOL aircraft to a STOVL centric air wing, the Royal Navy's air arm, the lack of a robust AEW platform reduced overall situational awareness of the British fleet, resulting in reduced offensive and defensive capabilities to protect the fleet, namely the GR 3 and Sea Harrier. The British fleet's only AEW platforms were modified Sea King helicopters, which provided minimal coverage due to their limited capabilities, forcing the British carriers to maintain a safe distance from the islands from fear of air attack.⁴⁶ The decision to reduce the size and mission of its aviation branch set the Royal Navy on a course that would result in catastrophic losses against the Argentine Air Force.

Because of reduced air wing capabilities stemming from the transition to STOVL aircraft, the British suffered significant losses. From a naval perspective, the British lost six ships sunk and 10 badly damaged from air attacks as well as three high value, Chinook heavy lift

⁴⁴David J. Jordan, "Future Carrier Aviation: A British Perspective," *Naval War College Review*, (Washington Summer, 2001): 64.

⁴⁵ *Ibid.* , 65.

⁴⁶ Christopher Chant, *Air war in the Falklands 1982*, (Osprey Publishing, Oxford, 2001) 41.

helicopters from the sinking of the *Atlantic Conveyor*.⁴⁷ The lack of point defense on ships, airborne early warning and powerful air cover contributed to the significant losses of the British Task Force.⁴⁸

Analysis

Carrier Capabilities

In the late 1970's the United States' development of Short Takeoff Vertical Landing (STOVL) technology, combined with the threat of long-range cruise missiles led to the idea of smaller carriers and the possible introduction of STOVL aircraft to the Navy. Carriers were now vulnerable to new threats—air launched, submarine launched, and surface launched cruise missiles, along with improved torpedoes and mines—causing leaders to rethink the idea of big carriers.

In response to budget cuts, combined with the constant requirement to command the seas and be prepared to attack the Soviet fleet in 1978, Chief of Naval Operations Admiral James L. Holloway III envisioned an all STOVL fleet with aircraft operating from carriers as well as other ships. This would spread Naval air out across the fleet and increase the availability of aviation assets to all warfare commanders. Limits in STOVL technology prevented any transition to STOVL aircraft. Progress towards a STOVL fleet of carriers was dependent on development of STOVL technology. The U.S. Navy planned to keep the big deck carriers until a supersonic STOVL aircraft could be developed.⁴⁹ Smaller STOVL carriers were to be introduced to the fleet by 1997.⁵⁰

Two basic options are available for the next generation carrier, STOVL or CTOL. The

⁴⁷ Max Hastings and Simon Jennings, *The Battle for the Falklands*, W.W. Norton & Company Inc. (New York, New York, 1982) 316.

⁴⁸ *Ibid.*, 318.

hull design does not change much with the two options. The flight deck is the biggest difference between the two types of ships. CTOL carriers are the type of carrier we currently produce. The conventional aircraft has shaped the aircraft carrier.

Conventional Carriers

The flight deck of the CTOL carrier has evolved to efficiently launch and recover aircraft. Two areas that affect the size of the deck are the catapult and the landing area. CTOL aircraft require 778ft for the landing area and 302ft for the catapults on the bow.⁵¹ *Nimitz* class carriers are designed with four catapults, two on the bow and two amidships. The landing area, requirements for catapults and parking space attribute to the large size of the flight deck. The landing area must be clear for aircraft to recover, while during launches only the catapult tracks and the path to them must be clear of aircraft. The large flight deck, approximately four acres, provides parking space and work area for the aircraft when the ship is not recovering and launching aircraft. The current design of the flight deck requires deck crews to “re-spot” the aircraft following every recovery to prepare for the next launch.⁵² New designs of the flight deck, particularly the placement of the island superstructure forward or aft of the current position on *Nimitz* class carriers will facilitate a faster turnaround of aircraft and enable easier maintenance. The size and capability of the carrier has evolved around CTOL aircraft. CTOL carriers can currently carry 80 aircraft. The large air wing provides the robust firepower required for current contingency operations and provides the versatility that the country has come to expect from its carrier strike groups.

⁴⁹ Erwin, 24.

⁵⁰ Erwin, 20.

⁵¹Dr. D.A. Perin, and J. D. Raber 16.

⁵² Re-spot is the term used to describe the movement of aircraft to key start positions following a recovery. The re-spot allows aircraft to reach the catapults in an efficient manner. No maintenance is accomplished on the aircraft prior to this evolution.

STOVL vs. CTOL Carriers

A STOVL-only aircraft carrier, carrying the same sized air wing as a CTOL carrier, has different requirements compared to a CTOL only carrier. Landing areas do not require arresting gear to stop the aircraft after it touches down. A STOVL carrier's flight deck is 7% smaller than a CTOL carrier's flight deck. Vertical landing operations require landing spots 80' x 115' for today's STOVL aircraft.⁵³ A STOVL carrier would displace 6% less tonnage and cost 6% less for initial construction and design when compared to a CTOL carrier.⁵⁴ A notional STOVL aircraft carrier would require four landing spots to recover a large air wing. The F-35B, STOVL version, requires a launch area of 750' for takeoff roll without a ski-jump and 400ft with a ski-jump for added lift.⁵⁵ While no catapult system is required for STOVL aircraft, a ramp allows the aircraft to use less takeoff distance to become airborne. When compared to a CTOL aircraft, which uses 302' for a catapult assisted launch, the larger launch area required for STOVL aircraft reduces usable deck space during the launch cycle. A CTOL-only carrier requires a larger recovery area compared to the STOVL only carrier. The CTOL carriers catapult track requires less deck space compared to a STOVL aircraft executing a deck launch in the same area. A STOVL carrier would have a reduced displacement from the absence of arresting and catapult systems as well as smaller flight deck.

Today's LHAs and LHDs with the STOVL AV-8B Harrier operating from its decks are significantly smaller than *Nimitz* class carriers and cannot be classified as a STOVL carrier. While successful at operating STOVL aircraft from its deck, the LHA cannot support the large

⁵³ Dr. D. A. Perin, , and J. D. Raber, 16.

⁵⁴ Ibid., 18.

⁵⁵ Ibid., 16.

number of fixed wing aircraft required to project the same amount of air power as a *Nimitz* class carrier. By shedding its requirement to carry rotary wing aircraft, LHAs and LHDs can increase their power projection capabilities significantly.⁵⁶

Today's CTOL aircraft have been designed to last to the middle of this century. CTOL aircraft are embedded into carrier aviation and the design of the carrier. Current aircraft that make up modern air wings will be in operation until 2030. CTOL aircraft continue to dominate and shape the design of the carrier. The Navy's investment in the F/A-18E/F and carrier version of the JSF, the F-35C, commits the Navy to building CTOL carriers in the near future.

Costs

Cost has always been an issue with the design and building of the nation's fleet of carriers. New ways of assessing the cost over the life of the carrier have given way to the development of total operating costs. By looking at the entire cost from development to operations, the Navy is now able to analyze the total cost to build and operate a carrier. The Total Ownership Costs (TOC) adds manpower and weapon system costs to the life cycle costs. TOC will set a baseline cost that will allow designers and planners to target cost measurable reductions for future ship designs.

Instead of focusing solely on building costs, planners look at the entire cost of the carrier over the life of the ship, the Life Cycle Costs. Life Cycle Costs are broken down into four areas, acquisition, operating and support, modernization and disposal.⁵⁷ New reporting requirements have been put into place to focus on cost reduction. Because of the new requirements, the Office of the Deputy Under-Secretary of Defense for Acquisition Reform has developed Total

⁵⁶ JO1 Sonya Ansarov, "Harrier Carrier: Strike Force for Freedom," *NAVSEA News*, March 24, 2003. -LHA5 USS *Bataan* deploys with 26 Harriers onboard in support of OPERATION IRAQI FREEDOM.

⁵⁷ I. M. Chening and S. J. Moretto, "Advances in Aircraft Carrier Life Cycle Cost Analysis for Acquisition and Ownership Decision-Making," *Naval Engineers Journal*, (May, 2000): 97.

Ownership Cost (TOC). TOC is the same as LCC but adds costs associated with indirect manpower and introduction of a weapon system, but excludes indirect non-linked infrastructure costs that are not affected by individual weapon systems' development, introduction, deployment or operations.⁵⁸ These cost analysis tools do not take into account the air wing or its additional manpower.

TOC enables reduction goals to be established while developing a new class of ship.⁵⁹ This allows decision makers to look at the costs over the life of a carrier spanning 50 years.⁶⁰ Life Cycle Costs of a *Nimitz* class carrier in FY 2000 are approximately \$28 billion; this establishes a baseline for designers and engineers to work from to reduce the costs of the next class of carriers.⁶¹ After CVN-76 is built, designers will use it as the baseline for TOC reductions.⁶²

While it is difficult for planners to reduce non-recurring costs, they must look to areas that can be reduced in the LCC of new carrier designs. The area that appears easiest to reduce providing a large amount of savings is in manpower. Current studies focus on manpower reduction since it appears to be the easiest target. Several other studies look at overall ship design, propulsion plant and flight deck size. Each study uses an "evolutionary acquisition strategy."⁶³ This strategy recommends a step-by-step approach to evolving carrier design vice introducing all the changes in one ship.⁶⁴ An evolutionary approach allows cost reductions in research and development or non-recurring costs by addressing changes resulting from practical experience in the fleet instead of front-loading the spending on research and development for

⁵⁸I. M. Chening and S.J. Moretto 98.

⁵⁹ Ibid., 98.

⁶⁰ Ibid., 97-110.

⁶¹ Ibid., 98.

⁶² Ibid., 99.

⁶³ Ibid. 106.

⁶⁴ Ibid., 106.

systems that will not be used.

Funding for research of the future carrier designs has been funded for FY 2004 at \$1.5 billion.⁶⁵ As of May 2003 11.7 billion has been allocated for the design and construction of the CVN-21. It is estimated that CVN-77 will cost a total of \$6.7 billion. The costs associated in the future, for CVNX-1 and CVNX-2 should be compensated with expected reductions in crew, size, and maintenance costs. Crew size will be reduced from 3,000 to 2,100, not including air wing personnel. The F-35 carrier and STOVL variants will cost between \$35 and \$38 million a copy.⁶⁶ The savings is forecast to be in lower maintenance costs due to the joint use of the airframe and larger sortie generation rate from 160 per day to 220.⁶⁷ CVN-21 represents a combination of the expected designs in CVNX 1 and 2.⁶⁸

The bottom line, after looking at the LCC for *Nimitz* class carriers, is that a new class of ships will be more affordable than continually modifying the current *Nimitz* class design. Upgrades and additions to older *Nimitz* class carrier electrical systems, weapon systems and overall electronic support systems have been reached their maximum capacities. Basically, there is no more room to grow. By analyzing the life cycle costs and total operating costs of ship designs, this will allow a detailed list of costs associated with design choice, resulting in more fiscally responsible ship building.⁶⁹

A 1998 analysis of carrier alternatives showed that large carriers are more cost effective compared to smaller ships carrying less aircraft. Overall, it is cheaper to have 12 large carriers compared to more numerous small carriers. When life cycle costs are compared to different air wing capacities, a large carrier with 75 aircraft matches the costs required to build and maintain

⁶⁵ Kennedy, 43.

⁶⁶ "F-35 Joint Strike Fighter."

⁶⁷ Kennedy, 43.

⁶⁸ *Ibid.*, 44.

the ship, while smaller carriers with smaller air wings cost more and carry less.⁷⁰ The overall reason is that displacement increases with air wing capacity. A smaller air wing would cost less but the ship structure required to support the air wing is very similar to the costs for a large carrier. Value increases as air wing size increases. As shown in Figure 1, the most economical choice between the small and large air wing is the large air wing due to cost efficiency. Sortie generation also increases with air wing size. During a campaign, the large carrier air wing will be able to provide more firepower than a smaller capacity air wing.⁷¹

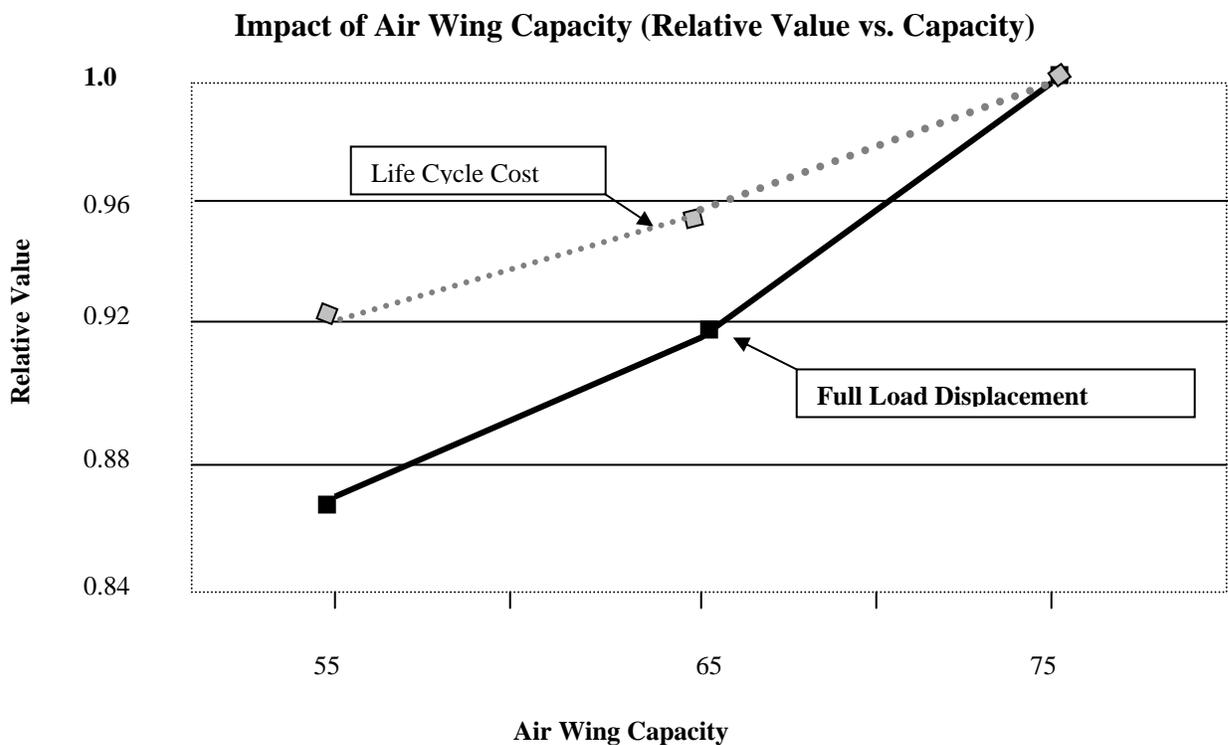


Figure 1.⁷²

⁶⁹ Ibid., 109.

⁷⁰ Dr D. A. Perin and J.D. Raber, "Future USN Aircraft Carrier Analysis of Alternatives," Naval Engineers Journal, (May 2000): 21.

⁷¹ Dr D. A. Perin and J.D. Raber, 20.

The Department of the Navy Fiscal Year 2004/2005 Biennial Budget Estimates states:

“The Navy has experienced cost increases and schedule slips on some ship programs.” The report continues by saying, “The unique attributes of each ship and the small procurement quantities within the shipbuilding program challenge the Navy from realizing efficiencies that could be achieved program-wide. Optimistic budget assumptions have exacerbated this problem.”

This means that the current administration will look to reduce inefficiencies in cost estimates and make decisions based on long-term fleet size and capability goals.⁷³ A general concern for costs and budget overruns is prevalent in all administrations. Today, with the Global War on Terrorism, operations in Afghanistan and Iraq and the multitude of military operations around the globe, money begins to have finite limits. Attention turns to big-ticket items like naval shipbuilding.

A desire to look long term at costs and plan for future operations with emphasis on capabilities means that future ships must be cost effective. This means they must have a Joint focus, benefiting all services, must be interoperable and support a wide range of missions. Naval ships can no longer afford to be specialized. Austere, multi-mission ships are the future.

Alternate Design Ideas

Compared to the evolution of early carrier designs, the latest class of carrier, the *Nimitz* class, designed in the 1960's has only seen marginal change in the last forty years. The time has come for the super carrier to move into the modern world. Two camps exist when it comes to ideas on future carrier designs. Some see the future carrier as a smaller, faster ship with less displacement that carries fewer men, costs less but continues to pack the punch needed to project power and defend our national interests. Others push for super carriers, with a large

⁷² Ibid., 20.

⁷³ The Department of the Navy Fiscal Year 2004/2005 Biennial Budget Estimates , Justification of Estimates February 2003. Shipbuilding and Conversion, Navy. 10.

displacement, designed to continue to carry large air wings, operating with stealth technology, less manpower and systems that are more efficient.

Today the development of the supersonic STOVL Joint Strike Fighter (JSF), electromagnetic launch and recovery systems, Unmanned Aerial Vehicles (UAV) and Unmanned Combat Aerial Vehicles (UCAV) provide ship designers with more options and potential cost saving ideas such as a smaller carrier with the same capabilities as a super carrier. CTOL aircraft cannot operate on a STOVL only platform. STOVL aircraft on the other hand can operate on a CTOL carrier. The advent of the JSF and improved STOVL technology will allow CTOL and STOVL aircraft to integrate on one type of carrier.

An alternative to the aircraft carrier that has emerged is the Mobile Offshore Base (MOB). One version is designed as multiple platforms that can partially submerge and join together forming a large air base that allows large CTOL aircraft to operate from it, the base will become part of the sea basing concept. It will allow transport and fighter aircraft to operate in areas where no access is available. Larger and much less maneuverable than a carrier it would require an extensive force protection operation. The MOB's size and speed will make it vulnerable and difficult to defend. Operation of a MOB would not compete with the mission of an aircraft carrier but it would enhance the capabilities of U.S. forces in Joint operations. The MOB, while not a replacement for the aircraft carrier, would provide an added alternative to lack of host nation support or limited access to airports and seaports of debarkation.

Some visions of future carriers remove CTOL aircraft completely, citing the use of the U.S.S. *America* (CV-66) and the U.S.S. *Kitty Hawk* (CV-63) as special operations carriers in operations UPHOLD DEMOCRACY and ENDURING FREEDOM.⁷⁴ Instead, of an angled deck super carrier a larger hybrid version of an LHA/LHD called the LHA-R an "expeditionary

carrier” designed with a well deck for landing craft, large capacity for troops combined with the MV-22 Osprey tilt rotor aircraft and VSTOL JSF is envisioned. Another future vision is an air wing made up of UCAVs with submarines becoming the center of the fleet. This futuristic concept of operations ignores the importance of manned strike platforms as well as places the focus on expeditionary operations without addressing the need for substantial air power from the sea.

Conclusion

“Domination of large carriers in U.S. fleets will continue into the future until the U.S. decides it no longer wishes to maintain leadership in the world.”⁷⁵

-Admiral James L. Holloway III USN

Future carriers must have the capability to support the specific functions of the U.S. Navy. Assuming the current direction of the navy’s focus on supporting land operations and projecting power inland from the sea will continue for many years, carriers must evolve toward providing more direct support of the littorals, while maintaining a blue water capability. Currently, deep strike, interdiction, and close air support remain the carrier’s area of expertise. Marginalizing the need for blue water capability encourages an asymmetric response from potential threats. Setting a course toward a littoral navy makes shifting back to a blue water threat time consuming and costly. In order to remain a viable platform the carrier must become more of a multi-role platform by emphasizing littoral operations but not ignoring blue water capabilities while developing more capabilities for supporting fixed wing and rotary wing STOVL aircraft.

Since the aircraft carrier’s inception aircraft have shaped the future for these ships. The support and vision of early Naval leadership aided the carrier to weather 84 years of controversy

⁷⁴ Olson, 81.

and heated debates as to the role and design of these remarkable ships. From a single wooden deck to a 90,000+ ton angled deck carrier with four catapults and four acres of flight deck, the carrier has established itself as a major platform for U.S. power projection. Over the course of its 84 years it has evolved into a robust and highly capable platform

As the U.S. seeks to improve the design and capabilities of the aircraft carrier, other nations are looking to increase strength of their naval air. China, while they do not currently possess an aircraft carrier, it must be assumed that it will eventually build or acquire one centering on their own version of a naval fighter. France, Britain and India, all seek to increase their carrier strength by adding additional carriers to their inventories. Changes in these nations naval order of battle center around new aircraft that are entering service, the Euro-fighter, the JSF and the Indian Navy's acquisition of the MIG-29K. Each aircraft will bring advanced technology and superior performance to their naval air arm.

The British Royal Navy is changing its strategic plans from defense of continental Europe, to a more global approach. This has prompted the building of two new carriers as well as a new look at the capabilities required of its modern navy. By shifting its focus from the North Atlantic to a more global presence, new more robust capabilities are required while minimizing cost. The reduction in gross tonnage of their carriers and capabilities of their ship borne air power, have made it expensive to upgrade to larger ships. To build two carriers of 50,000 tons to carry up to forty aircraft Great Britain will pay up to \$6.5 billion.⁷⁶

Convincing politicians to fund larger platforms with more capabilities after over twenty years of smaller cheaper vessels is a difficult task. Britain's shift from a CTOL carrier to STOVL carriers should be a lesson for the United States. The U.S. cannot afford to cut back on

⁷⁵ Erwin, 24.

⁷⁶ Sea Power, (Washington: September 2003) 41.

its power projection capabilities. Shifting to smaller carriers will marginalize the U.S. Navy's capability to support its nine major functions, specifically power projection, deterrence and its ability to support land forces from the sea. While smaller carriers look more attractive to the fiscally minded in the long term, cost savings will not insure national security.

The late 1970's and early 1980's proved critical to U.S. views on carrier size. The performance and capabilities of the AV-8 Harrier compared to the CTOL aircraft at the time combined with the Britain's lackluster performance of their small carrier air wings in the Falkland campaign demonstrated to U.S. leaders that a move to reduce the size of the carrier would result in a marginal role for the carrier of the future. Today's technology, the F-35B, a STOVL variant of the JSF, will be successful in bridging the performance gap between CTOL and STOVL aircraft. Integration of United States Marine Corps (USMC) and United States Navy (USN) tactical air will ease a transition to a STOVL carrier air wing. USMC expertise in expeditionary warfare and use of STOVL aircraft will enhance the U.S. Navy's carrier air wings, enabling it to project further, deeper and with greater endurance and precision. The development of today's emerging technology will determine the make up, design of, tomorrow's super carrier, and carrier air wings

The absence of a suitable replacement for the air wing's support aircraft prevents the development of STOVL only carriers. Limiting organic tanking resources and reducing the airborne anti-surface/anti-submarine capabilities of the battle group is a dangerous step that needs rethought. Until technology is developed to replace support aircraft like the E-2C Hawkeye AEW aircraft and the EA-6B Prowler electronic attack aircraft with either STOVL or UCAV/UAV variants, CTOL carriers will dominate carrier design.

The design of a future aircraft carrier needs to be capabilities based, centering on the

types of aircraft that fly from it. The two basic types of aircraft will be either CTOL aircraft or STOVL. The changes will be driven by three emerging technologies; (1) STOVL aircraft, (2) Electromagnetic Aircraft Launch and System (EMALS), (3) UAV and UCAV technology.⁷⁷ The extent to which these emerging technologies are presently developed will drive the shape of future carriers.

UAV and UCAV aircraft will become integrated into carrier air wings. Caution must be exercised in increasing the role of unmanned aircraft. Focus should be made on UCAVs and UAVs that fly missions, which compliment manned missions like reconnaissance and surveillance. Integration of UCAVs and UAVs into naval aviation will require them to launch and recover from carriers. The introduction of the EMALS replacing current steam catapults will allow these aircraft to be launched since current catapults are unable to launch these aircraft requiring slower end speeds.

Studies in costs and capabilities have shown that STOVL only carriers with large air wings do not provide a dramatic amount of cost reduction. Displacement is the main driver of ship cost. Life cycle costs allow designers to more accurately assess the costs associated with new ships. By comparing the life cycle cost of different carrier design it was shown that, large air wings are more affordable than small or medium sized air wings. This shows that CTOL carriers provide a more affordable ship and allow CTOL aircraft to operate from them well into the century.

The argument for smaller carriers does have merit if you consider the threats to super carriers traveling in constricted waterways and choke points as well as the need to operate in the

⁷⁷ Two different abbreviations used Vertical Short Takeoff and Landing V/STOL and STOVL are to be considered the same type of aircraft for this paper. V/STOL for these purposes is a combination of capabilities; vertical takeoff and landings as well as short takeoff and landings or combinations of the two.

littorals in support of land forces. Smaller carriers would allow the ships to get closer to the threat while maintaining a low profile. Large numbers of small carriers would make losses of carriers in combat easier to manage because of the ability to accept losses since the small carriers would no longer be the fleet's capital ship. Also, the capabilities of the aircraft on board the ship, while operating in smaller numbers, would need to deliver the lethal and non-lethal fires that today's large air wings are capable of delivering. This could be accomplished by massing several carriers in an operating area to provide the required force projection capability and then dispersing following the completion of the operation.

A counter to the previous argument would be that larger air wings are required onboard carriers to provide protection and support to the carrier and its strike force commanding the seas, while simultaneously fulfilling its requirements to support the other naval functions such as; projection of power ashore, support of land operations, and enforcing respect for U.S. interests. Cost analysis, which has already been discussed, shows that it is more affordable to build and operate large carriers, while the size of the super carrier ensures survivability in the event of battle damage. Until STOVL aircraft can replace support aircraft, large carriers will remain the central focus of the fleet. Advancements in STOVL design will enable planners to rethink the size and configuration of future carriers. Design of a multi-mission heavy lifting/long endurance STOVL aircraft similar to the V-22 Osprey would give the air wing an airframe to replace the big wing aircraft, like the E-2C Hawkeye and C-2 Greyhound, and still maintain its combat power.

Small carriers should be considered only when resources are limited and a reduction in a carrier's capability is acceptable. Countries that have no need for global reach or maintaining a forward presence can accept a small carrier force. Large carriers will ensure that the national

interests of the United States are secure. The super carrier will remain as the vehicle with the capabilities required by our nation to support troops on land, maintain a forward presence and ensure command of the seas.

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