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RETREAT FROM RANGE

The Rise and Fall of Carrier Aviation

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The views expressed in this report are mine alone. I am solely responsible for any errors in fact analysis or omission.

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Executive Summary

Over the past 20 years naval aviation in the United States has undergone a dramatic change in focus and capabilities, and not for the better. Its historical and traditional focus on long-range capabilities and the deep strike mission has been overtaken by a concentration on lower maintenance costs and higher aircraft sortie generation rates. American power and permissive environments were assumed following the end of the Cold War, but the rise of new powers, including China and its pursuit of anti-access/area-denial (A2/AD) strategies and capabilities to include the carrier-killing 1,000 nautical mile (nm) range Dong Feng-21 anti-ship ballistic missile, now threatens to push the Navy back beyond the range of its carrier air wings. This push back would limit the service's ability to project power and thus undermine the credibility of the United States and the effectiveness of the global international system of governance that it, in conjunction with its allies and partners, has labored to build over the past 70 years.

That system was built upon the blood and sacrifices of an entire generation of Americans who fought and won World War II. One of the chief lessons learned from that war was that the nation needed to develop the ability to project massive power against enemy capitals across vast distances. The Pacific war had been conducted through a series of oceanic and island battles, slowly bringing the enemy decisionmakers within range of American power. Kamikaze attackers, a brutal early form of A2/AD, inflicted massive blows against the American Navy, whose shorter-range aircraft forced it to operate in close proximity to enemy bases. Naval aviation commanders, in the face of these attacks and the loss of several carriers, decided during the war to pursue the development of larger aircraft that could carry more bombs and fly longer distances to hit targets. They then designed and developed larger aircraft carriers to carry these aircraft in numbers sufficient to mass decisively against enemy centers of gravity. These aircraft and their carriers joined the fleet during the 1950s, providing the Navy with the capability to mass deep strike missions 1,800 nm from its carrier bases.

Through the decades that followed, from Vietnam to Desert Storm, the Navy perfected its ability to go deep against enemy capitals, with the goal of bringing conflicts to a swift, decisive end. Large air wings of 80 or more aircraft characterized by long range, high payload capacities and the ability to mass on targets came to epitomize the American way of war. Along the way, the characteristics of low observability and persistence were added to the repertoire of the carrier's air wing to great effect. The U.S. Navy, with its fleet of supercarriers and accompanying escort vessels, became the gold standard of modern sea power, but beginning in the 1990s the Navy suddenly drifted off course.

The end of the Cold War – followed by the decision to cancel the replacement aircraft for the A-6 Intruder, the A-12 Avenger II – began a precipitous retreat from range and the deep strike mission that had long characterized the carrier air wing. The rapid successive retirements of the A-6 Intruder, F-14 Tomcat, and S-3 Viking that followed, and the decision to replace these aircraft with variants of the F/A-18 Hornet – originally designed as a replacement for the short-ranged fighters and light attack aircraft – shrank the average range of the carrier air wing from over 800 nm in 1996 to less than 500 nm by 2006. This occurred just when competitor nations, led by China, began to field A2/AD systems with ranges of 1,000 nm or more.

Today the Navy faces a future in which its increasingly expensive carriers have been rendered ineffective by defensive systems being developed, fielded, and exported by our competitors, but there are paths back to relevance for these symbols of national greatness if the Navy makes the right investments. New capabilities in the areas of unmanned systems, stealth, directed energy, and hypersonics could be combined to provide the range required to perform deep strike missions. Experimentation, such as that seen with the X-47B demonstration unmanned combat aerial vehicle, as well as the lessons learned from operating unmanned platforms such as the MQ-9 Reaper over the past decade of conflict, provide an opportunity for the Navy and the nation to move forward with an innovative and revitalized approach to sea power and power projection. Cost curves can be bent, and the combination of mass, range, payload capacity, low observability, and persistence – capabilities that emerged as critical during decades of naval air operations – can once again characterize the carrier air wing of the future, ensuring the carrier's relevance for decades to come.

Preface

On the morning of April 18, 1942, search planes from the USS *Enterprise* (CV-6) spotted a Japanese fishing boat serving as a picket ship far out at sea in the northern Pacific, about 700 nm from Japan. Concerned that the boat would signal the imperial Japanese fleet and bring them down upon his small force of two carriers and accompanying cruisers, the naval task force commander, Vice Admiral William Halsey, signaled his Captain Marc Mitscher, subordinate in command of the carrier USS *Hornet* (CV-8), to accelerate the launch of his aircraft. Mitscher, one of the most experienced pilots in the Navy, summoned Army Lieutenant Colonel Jimmy Doolittle, one of the most renowned pilots in the world, and informed him of the situation. Doolittle passed orders to the crews of the 16 Army Air Corps 20,000 pound, land-based medium range B-25 Mitchells tied down to the flight deck of the *Hornet*.[1]

Shortly after the Japanese bombed Pearl Harbor, President Franklin Roosevelt asked the heads of the Army and the Navy to attack the Japanese home islands quickly in order to raise American morale. Several models of bombers were considered, but the B-25 Mitchell emerged quickly as the frontrunner for the mission due to its compact size, large bomb-carrying capacity, and long range. Mitscher had overseen the final construction of the *Hornet* and brought it into commission in Norfolk the previous November. In January he was approached with the question, "Can you put a loaded B-25 in the air on a normal deck run?" Mitscher asked, "How many B-25s on deck?" When told "15" he did a quick series of calculations and said, "Yes, it can be done."[2]

Mitscher was the right guy to ask a question on any topic regarding naval aviation. Not only was he only the 33rd man to earn the gold wings of a naval aviator (soloing on June 2, 1916), he was also one of the most cautious and thoughtful men of his generation. Having served in seaplanes and at all levels of carrier development, he understood every aspect of naval aviation and had developed most of the standard operating procedures involved. When Mitscher said 15 B-25s could fit on his *Yorktown* class carrier and take off, you could be sure that he had done the necessary calculations and that it could be done.

At 0820, 668 nm from Japan, Mitscher brought the Hornet's bow into the wind.[3] Making 20 knots and facing a 20-knot wind, Doolittle's bombers felt the net effect of well over half of the 70 knots they needed to take off with their engines at max power, their flaps fully extended with a full fuel load and 2,000 pounds of bombs in their bays, just as Mitscher had calculated three months prior. At 0824 Doolittle, piloting the lead bomber, released his brakes and accelerated into the air, lifting off 20 feet from the end of the Hornet's 770-foot flight deck. The remaining bombers followed in three-minute intervals until all were safely airborne. Observers remembered Mitscher's arms and feet working unseen flight controls involuntarily as he sat in his bridge wing chair, attempting to will each aircraft into the air. Mitscher's one regret during the operation was that his carrier was not large enough to bring the Army bombers back aboard when their mission was complete.[4] Instead the plan was to bomb their targets in Japan and then go on to land in China and Russia.

The launch of the large bombers, with their 2,000 pounds of ordnance, from the carrier deck nearly 700 nm away from their targets made a significant impression on Mitscher, who soon was promoted to admiral and ultimately placed in charge of the task force of fast carriers that accompanied Admiral

Raymond Spruance's 5th Fleet. In the summer and fall of 1944 during combat operations in the Philippines, Mitscher was forced to operate his carriers in close proximity to the island of Luzon in order to reach Japanese targets, subjecting his forces to constant attacks from Japanese aircraft.[5] In 1944 alone, four aircraft carriers, albeit of the smaller light and escort designs, were sunk by enemy aircraft. By late fall, perhaps remembering Doolittle's bombers hitting targets nearly 700 nm away, Mitscher began to talk openly with his staff about building a huge, flush decked carrier capable of launching and recovering large aircraft with heavy bomb loads that could take off and hit a large assortment of targets on one mission without having to shuttle endlessly back and forth to the carrier, exposing the pilot, his aircraft, and the carrier to needless risk.[6]


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Lieutenant Colonel Jimmy Doolittle and his Raiders with Captain Marc Mitscher onboard the USS *Hornet*.

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This epiphany – from one of the Navy's most senior and combat-experienced aviators – that larger carriers could equate to larger aircraft capable of carrying sufficient bomb loads while operating from a safe range would come to dominate naval aviation for the next generation; but to understand Mitscher's vision, we must first understand naval aviation's past.

CHAPTER 1

The Evolution of the Carrier Air Wing Through World War II

Early Naval Aviation

The requirement and demand for aviation grew out of innovation elsewhere on the battlefield, specifically in the area of artillery and long-range gunfire. As advances in metallurgy and rifling extended the range and accuracy of projectiles beyond the vision of the artillery crew, it became necessary to post observers in high positions to spot hit locations and provide corrective instructions. At first trees and then towers were used (artillery tended to be located on the highest ground near the battlefield to begin with), but during the mid-19th century, balloons were sent aloft with observers equipped first with signal flags and then with telegraph wires leading back to the firing line to communicate high/low, left/right instructions to walk fire onto the target. Tethered balloons, however, made great targets, so it was natural that when aircraft were introduced they should target observation balloons and then ultimately assume the spotters' mission themselves. Aircraft speed and range offered the additional capability of performing reconnaissance missions, seeking out the enemy, and bringing friendly forces into contact in the most advantageous fashion.

This revolution in military affairs rapidly extended to naval warfare, where steam, electricity, and steel rapidly transformed the maritime competition to once again emphasize the offensive. Twelve-, 14-, and ultimately 16-inch diameter guns were by far the most effective and longest-range weapons in the Navy. The key to victory was accurately aiming the weapon, which hurled shells that weighed as much as a modern small car over 20 nm. Pioneers like British Captain Percy Scott, American "Gun Doctor" Admiral William Sims, and the gun sight designer Admiral Bradley Fiske increased the accuracy of fire within the visual range of the eye considerably, but none of them could address how to aim at targets that fell beyond the rim of the horizon, where shells could go but no eye could follow. This is where the airplane came in.

Planes launched to spot the fall of shells quickly found use as reconnaissance platforms. Ship captains would launch their aircraft to go out and find the enemy. Given the preference for battleships to operate together in formation, the aircraft from each battleship could be launched by the battleship division commander and sent out on a distinct vector, covering multiple paths of approach. The United States became the first nation to launch an aircraft from a ship when Captain Washington Irving Chambers built a short platform on the deck of the cruiser *Birmingham* and launched Eugene Ely, a civilian pilot, into history on November 14, 1910, in a Glenn Curtis built bi-plane. Two months later, on January 18, 1911, Ely would score another naval first when he landed a second Curtis aircraft on the cruiser *Pennsylvania*.[7] Neither of these events led directly to the construction of an aircraft carrier, but they demonstrated the capability to operate aircraft from ships.

Britain's Royal Navy was the first to design and launch the aircraft carrier. Heavy demands for surface search and anti-submarine patrols in the sea approaches to the United Kingdom placed great strains upon British aircraft. Seaplanes were used extensively, but there was a strong desire to get wheeled aircraft, which could be launched from ships but not recovered, into the rotation. Shipbuilder William Beardmore first proposed an aircraft carrier in 1912, but it was not until the Battle of Jutland – a strategic draw between British and German ships in the North Sea – confirmed the limitations of the cruiser as a reconnaissance platform that the British Admiralty reexamined his proposal. It soon authorized the conversion of a passenger liner then under construction into the world's first aircraft carrier. The HMS *Argus*, which carried 15–18 aircraft, was not completed in time to serve in World War I, but ultimately provided an opportunity to test key launch and recovery concepts in the years that followed. In this capacity, the *Argus* revealed broad implications for other navies of the world.[8]

These implications were not lost on U.S. Army Air Corps Brigadier General William "Billy" Mitchell, who began to lobby, from both an organizational and philosophic viewpoint, for an independent U.S. Air Force, which could be established by consolidating the nascent aviation elements of the Army and the Navy. Navy leadership, including visionary admirals and civilian leaders, moved to publicly preempt this initiative by raising the profile of Navy aviation and demonstrating its service-related uniqueness and relevance. The General Board, composed of senior admirals nearing retirement and organized to provide advice to the Secretary of the Navy, then a presidential cabinet level position, issued a June 1919 report calling for a robust naval air component to operate "with the fleet in all waters of the globe." Admiral William Sims, the previous commander of U.S. naval forces during the recent war in Europe, used his post as the president of the Naval War College to advocate for the development of large aircraft carriers capable of operating 80 planes as the capital ship of the future.[9]

Eighty aircraft was a far cry from what the U.S. Navy was capable of putting to sea in the early 1920s. The 1919 General Board memorandum resulted in the conversion of the collier *Jupiter* (AC-3) into an experimental flush decked aircraft carrier that emerged as the *Langley*, or CV-1 (C for carrier, V for fixed wing), on March 22, 1922. Never intended to serve as a combatant, the *Langley* was slow, making a top speed of 14 knots, but its 542-foot wooden flight deck provided enough space to launch and land aircraft as well as test experimental technologies like flywheel and compressed-air aircraft catapults, arresting gear cables, and elevators to move aircraft from storage in a hangar bay below the flight deck.[10] The *Langley* was equipped with a mere 10 percent of the aircraft Sims sought, eight Vought VE-7 aircraft, when it was first put to sea. The naval aviators assigned thought it dangerous to carry any more due to congestion on the flight deck.[11]

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The USS *Langley* was the United States' first aircraft carrier and laboratory for aviation experimentation.

Early naval aviators learned to be circumspect regarding the mission of their aircraft. The battleship dominated American strategic and tactical thought in the early 1920s, and in the minds of the Navy's battleship admirals the aircraft carrier existed to provide critical scout aircraft for the line of battle and then to make shot correction calls for the battleship's gun crews once they engaged the enemy. To suggest at the outset that naval aviation should play a larger role in naval warfare would invite ridicule at the least and program termination at the worst.

The Fleet Problems

The rapid evolution of U.S. naval aviation owed much to the combination of wargames conducted at the Naval War College and the series of 21 "Fleet Problems" that were conducted at sea between 1922 and 1940. Admiral William Sims had returned from commanding U.S. naval forces in Europe during World War I to take the presidency of the Naval War College. An iconoclastic intellectual, Sims challenged accepted conventions throughout his long and tumultuous career. During the 1890s he pointed out problems with ship design, going so far as to describe the battleship *Kentucky* as "the worst crime in naval construction ever perpetrated ..."[12] His experiences during the war had convinced him of the need to experiment and explore other means of conducting war at sea. This insight led him to accept demotion to rear admiral following the war in order to return to War College. Once installed again in Newport, Sims invested himself in the intellectual growth of the fleet and in wargaming.

Sims saw wargaming as important because it allowed officers to grow by practicing the art of command on a small scale. Additionally, it allowed them to work with new technologies in a closed environment that encouraged innovation. Sims deliberately inserted both submarines and aircraft into the games in proportions not seen in the actual fleet in order to ascertain how younger officers would use them. The results of these games caused him to write in the early 1920s to Rear Admiral Bradley Fiske, a fellow technophile, that "the battleship is dead."[13] Lastly, wargaming generated ideas that were eventually tested in the fleet through the emerging annual "Fleet Problems."[14]

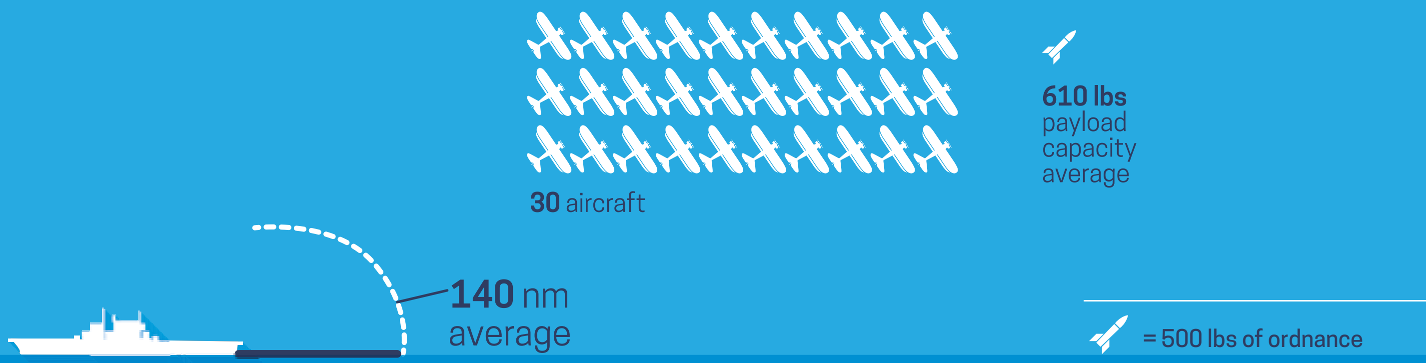
The Fleet Problems' objectives were to operate the fleet in large-scale maneuvers; to train commanders in situational estimates and plans; and to examine war planning, operational instructions, and doctrine. The Problems themselves increased in complexity and magnitude over time and were revealing and suggestive of the actual conditions in which the fleet would be employed in World War II. During the exercises Pearl Harbor was attacked (along with the Panama Canal) and Midway Island and the Aleutians were defended. The Navy also explored anti-submarine warfare and convoy operations.[15] Over the course of the Fleet Problems, commanders identified characteristics of naval aviation that they desired above all others: mass of platforms, range, and payload capacity.

Mass described the size of the air wing and the number of aircraft that could be directed at a target or a set of targets at any given moment. Range characterized the distance from the carrier that the carrier air wing could operate. Some aircraft had longer ranges, but if they were to operate together to provide mutual offensive and defensive support then the average combat range of the air wing became the key measurement. The last characteristic, payload capacity, refers to the ability to carry ordnance to targets. Range is not important if the aircraft is incapable of delivering its payload. Ironically, the first individual to identify these characteristics as a whole or in part, Joseph Reeves, was a non-aviator.

1922

USS *LANGLEY*

Air Wing Averages (unrefueled)



The *Langley's* flight deck carries an increased number of aircraft in preparation for Fleet Problems.

Rear Admiral Joseph "Bull" Reeves reported onboard the *Langley* as the commander of Aircraft Squadrons, Battle Fleet, in October 1925, having received his "JCL" (Johnny Come Lately) Aviation Observer Wings just weeks earlier in Pensacola. Congress had passed a law requiring naval aviation assets, to include aircraft carriers and tenders, to be commanded by qualified naval aviators. Given the relative junior rank of the earliest aviators, more senior officers were quickly run through a new "observer" course to qualify them for command.

Bull Reeves was a good fit. Although he came out of the battleship community, he was an ardent fan of naval aviation and had a good instinctive grasp of its potential. When he walked onboard he noted that the *Langley* was operating eight aircraft, a number that he thought small and not up to the large surveillance requirements of the fleet. Three days before the ship got underway to participate in the Fleet Problem, he ordered six additional aircraft hoisted aboard, a request that met resistance from the pilots, but Reeves remained firm. Soon the pilots and crew learned to work with the increased "crowding" on the flight deck and how to make more efficient use of the elevator to quickly move aircraft to and from the hangar bay.[16]

With his extra aircraft, Reeves innovated early and often, launching a wave of six aircraft to intercept incoming attacking aircraft in 41 seconds and following up with a second wave launched shortly thereafter.[17] Reeves kept up the pace, flying his 14 aircraft almost continuously in cycles, fanning them out across the exercise areas in newly developed search patterns, looking for the opposing force. Surprisingly, Reeves' aircraft were able to meet all the demands of the force commanders, logging 116 hours of flying during the exercise and making 174 contact reports on the enemy's ships.[18] Given the vast expanse of the ocean, Reeves came to understand mass – the unique quality of quantity – which extended from its distributive capacity to cover a large area to its ability to converge on one location for an overwhelming attack.

Joseph "Bull" Reeves reported onboard the *Langley* as the commander of Aircraft Squadrons, Battle Fleet, in October 1925.

When Reeves returned to the *Langley* in 1928 after a brief overseas assignment, he announced his intention to increase again the complement of aircraft aboard *Langley* to an unimaginable 42 planes. John H. Towers (Naval Aviator #3), then in command of the *Langley,* strongly resisted, but "Bull" Reeves remained true to his nickname and personally oversaw the craning aboard and "spotting," or placing, each of the 42 aircraft at a specific spot or location on the flight deck. When the job was completed, Reeves looked to the *Langley*'s bridge and said, "Captain Towers, there is your complement."[19] One month later, during Fleet Problem 8, Reeves launched his complement in a dense mass at a single target – Pearl Harbor – "bombing" the Navy base, nearby Wheeler airfield, and Honolulu with flour sacks to great effect and local consternation.[20] In this arena, mass counted, but so did range and bomb load.

Fleet Problems 9 through 11 highlighted the ability of the carrier air wing to strike land targets (9), an enemy carrier force (10), and an enemy air force (11), all at significant ranges. These were the first Fleet Problems to fully integrate the new carriers *Lexington* (CV-2) and *Saratoga* (CV-3), converted cruisers with incredibly long 888-foot flight decks and high 33-knot steaming speeds. The longer flight deck and higher operating speed meant that larger aircraft could launch and recover from the new carriers. Larger aircraft equated to wider wingspans, larger engines, higher speeds, longer ranges, and more ordnance. The *Lexington* and *Saratoga* provided Navy leaders the opportunity to see new possibilities in naval aviation. By the end of Fleet Problem 11 there was a new consensus that carriers should be detached from the battle line and allowed to operate freely as an "offensive scouting force."[21] This freedom allowed the carriers to more expansively cover the ocean more quickly. The Navy had the carriers it wanted, but it did not have the right type of aircraft to operate from them. To get these, the Navy turned to its own peculiar institution, the Bureau of Aeronautics (BuAer).

The Navy's Bureau of Aeronautics lay at the center of a particular innovation strategy. Much as it had with its gun factory at the Washington Navy Yard, the Navy recognized that there simply was not a commercial market for some of the unique naval aviation components that the Navy required. To meet its specialized needs, BuAer created a large industrial entity in Philadelphia, the Naval Aircraft Factory, to supply items such as steam catapults and arresting gear for their ships. When it came to actual aircraft, BuAer built some aircraft but was largely dependent on companies such as Consolidated Aircraft, Grumman Aircraft Engineering Corporation, Douglas Aircraft Company, and Curtiss Aeroplane and Motor Company, but during the depression years none of these companies had much private incentive to build engines to the unique specifications the Navy desired. The Navy's solution was to design and build radial piston engines at its Naval Air Factory and then to invite companies to design and build aircraft around them.[22] Soon the Wright Aircraft Company and the Curtiss Aeroplane and Motor Company began to churn out the increasingly powerful and reliable engines. Fighter aircraft designs valued speed, torpedo aircraft favored range, and dive-bombers sought altitude and strength in wing design. Several evolutionary iterations of each type of aircraft were rapidly developed that soon found their capabilities tested in the maturing naval aviation fleet.

Aircraft Missions and Design

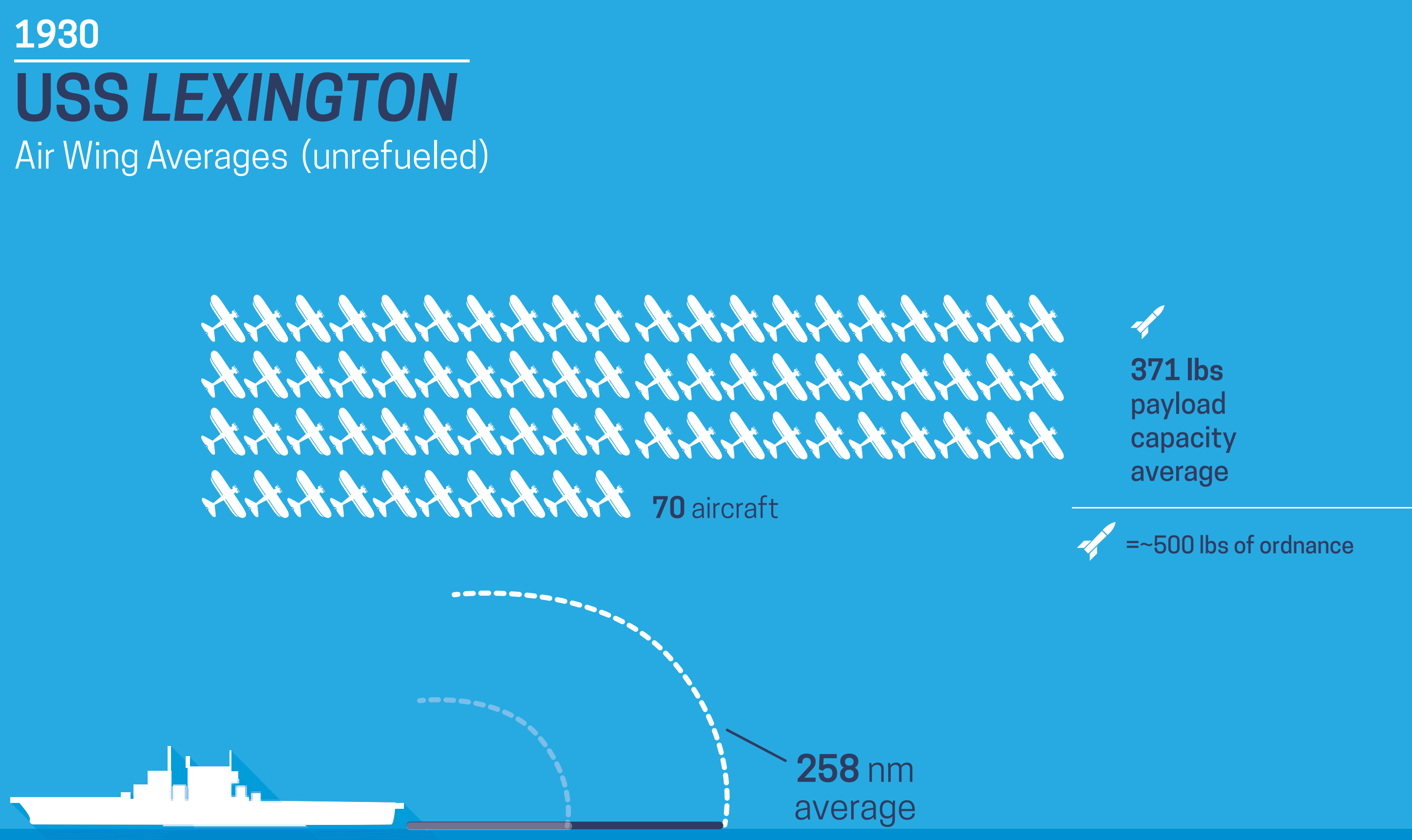
In May 1936 Admiral Reeves, who had risen to the senior at-sea command in the Navy after spending 10 years deeply immersed in aviation, wrote a confidential note to the chief of naval operations observing that the Navy could not just passively submit to attacks from other forces' aircraft. "The Fleet must have airplanes that can fight other airplanes" was his culminating statement. The essential capability of the fighter aircraft was speed, and this was derived not just from the size of the aircraft's engine but also from the design of the aircraft, its ease in slipping through the air, and its strength and ability to withstand violent aerial maneuvers.[23] Over the relatively short period of 12 years, the Boeing F2B bi-plane (Pratt and Whitney 425hp engine) fighter quickly begat the Grumman FF-2 bi-plane (Wright 700hp engine), F3F bi-plane (Wright 950hp), and finally the F4F mono-wing fighter (Pratt and Whitney 1200hp engine), with level flight airspeeds rising from 140 knots to 290 knots.[24]

Another warfare capability found on the flight deck, dive-bombing, represented an interesting evolution in naval offensive power. In 1926, while acting as the commander of Aircraft Squadrons for the Battle Fleet, Captain Reeves posed a series of questions that had occurred to him as he had progressed through his flight training. One such question was, "How can we bomb effectively?" Lieutenant Frank Wagner, commander of the fighters onboard the *Langley*, arrived at a solution. Reasoning that the highest accuracy could be attained by getting closest to the ship but also that flying in horizontally at the ship in the face of small and large caliber gun fire was near suicidal, Wagner decided to climb high above his target and then plunge down at almost a vertical angle.

Wagner made his first attempts by climbing to a high altitude, pushing the aircraft's nose over, cutting his engine, and gliding down. He then attempted the feat with his engine idling and finally with full power. Along the way he installed additional support wires to his bi-plane's wings to reinforce them against the strain of higher speeds and the forces of the pull-up maneuver. His tests terrified the people on the ground as they saw Wagner's aircraft plunging downward only to pull up at the last minute, barely missing them and the buildings around them. Soon he had his entire squadron trained in this technique. When Wagner's squadron practiced their new technique against ships at sea, they found that the guns used for anti-aircraft fire could not be elevated high enough to target the aircraft. A new form of aerial offensive warfare was discovered, and a new aircraft, powerful enough to haul bombs high aloft and strong enough to bear the stresses of the dives, was required.[25] Designed in three-year cycles, the Navy moved from the Curtis SB2C Helldiver to the SBD Dauntless to the AD1 Skyraider over a 10-year period.

Another flight deck warfare capability, torpedo bombing, was a natural outgrowth of naval weapons design, which had placed the torpedo at the center of the Navy's arsenal since the late 1890s. Unlike bombs, which fell from the sky in the hope that they could penetrate the armored deck surfaces of Navy ships, torpedoes attacked below the waterline, where magnifying hydrostatic effects aided efforts to destroy main propulsion machinery, vent fuel, set fire to bunker stores, and, most obviously, open the hull to the intrusion of water, thus robbing a ship of buoyancy. In a mass torpedo attack, only one such weapon needed to reach its target to have the desired destructive effect. It was natural that naval aviation would design an aircraft to deliver these weapons and that the emphasis in aircraft design be placed on weapons carriage (torpedoes weighed more than 1,000 pounds) and range. The 1934 Douglas TDB Devastator had a range of 700 nm with a 1,000-pound torpedo, and the 1940 the Grumman TBM Avenger carried 1,600 pounds of ordnance out to 1,200 nm.[26]

The lessons learned during the Fleet Problems of the 1930s directly led to the design and manufacturing of the aircraft that would see the United States through World War II in the Atlantic and the Pacific oceans. Within the confines of the massive fleet maneuvers, naval aviation found value in mass, range, and payload capacity. The net effect of these lessons saw the average size of the carrier



With a larger flight deck and larger air wing, the USS *Lexington* began to demonstrate the importance of mass.

air wing grow from 60 to 90 aircraft, the average range of the carrier air wing nearly triple from 258 to 701 nm, and the ordnance carrying capacity multiply five times from 371 pounds to 1,800 pounds. These were the capacities and numbers that the fleet carried into the war that followed the Japanese attack on Pearl Harbor.

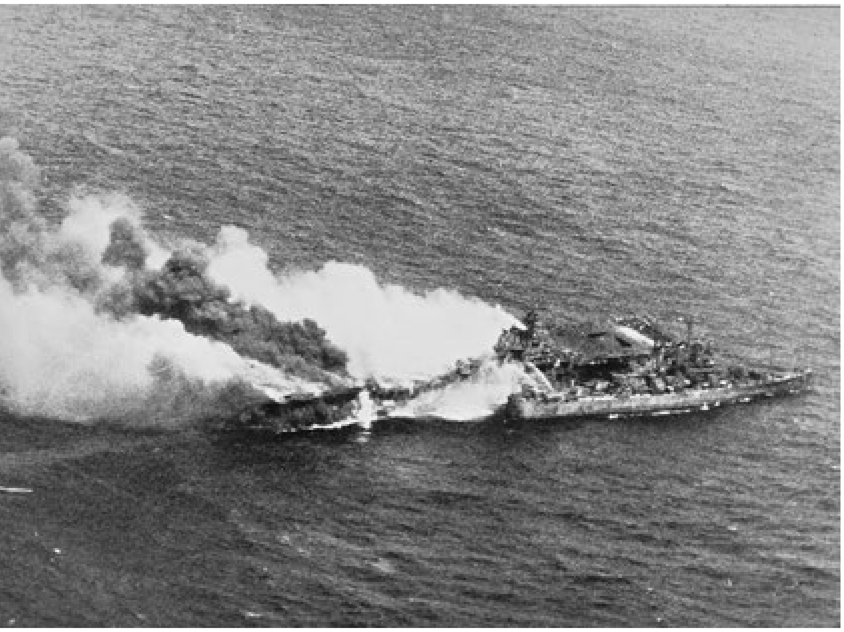
The Lessons of War

It is fair to say that the Fleet Problems contributed significantly to the early evolution of naval aviation, but combat in the Atlantic and largely the Pacific theaters was the crucible that purified the vision of naval aviation. The Navy had triumphed in World War II, achieving great victories in the Mediterranean Sea and Atlantic and Pacific Oceans, but with great losses.

Naval History and Heritage Command

Vice Admiral John McCain (pictured here) and Vice Admiral Marc Mitscher drew upon lessons from World War II to lay down the requirements for post war supercarriers.

In the fall of 1944, Vice Admirals Marc Mitscher and John S. “Slew” McCain turned over command of the fast carrier task forces in the Pacific campaign. Mitscher commanded the carriers while Spruance led the force as the commander of 5th Fleet, and McCain commanded them while Halsey led as 3rd Fleet commander. The ships and their crews remained the same; only the admirals and their staffs changed. McCain, four years senior to Mitscher, had successfully commanded the carrier *Ranger* and numerous other aviation commands. Both Mitscher and McCain shared a common understanding of the threats being thrown at the forces under their command.[27] Midway had taught Mitscher, then in command of the carrier *Hornet*, that battles would be decided at long range and could turn in an instant. Four minutes of attacks by American dive-bombers had sunk three of the four Japanese carriers, but the one that survived was able to launch a devastating blow against the American carrier *Yorktown* (CV-5). The next day a Japanese submarine torpedoed her, and she joined her sister, the *Lexington* (CV-2), which had been attacked the previous month at the battle at Coral Sea, at the bottom of the Pacific. Tasked to provide close air support to ground forces attacking and capturing Japanese-held islands as part of a slow and steady march towards Tokyo, American carriers found themselves operating close to land, limited by the 500-nm range of the dive-bomber aircraft. This range when stacked against Japanese dive-bombers and the advent of the one-way, suicide Kamikaze aircraft, created a primitive anti-access/area-denial weapon of awesome effectiveness. Following the loss of the *Yorktown* at Midway, the U.S. Navy would go on to lose nine aircraft carriers, including the *Langley* and the *Hornet*, to Japanese submarines, dive-bombers, and



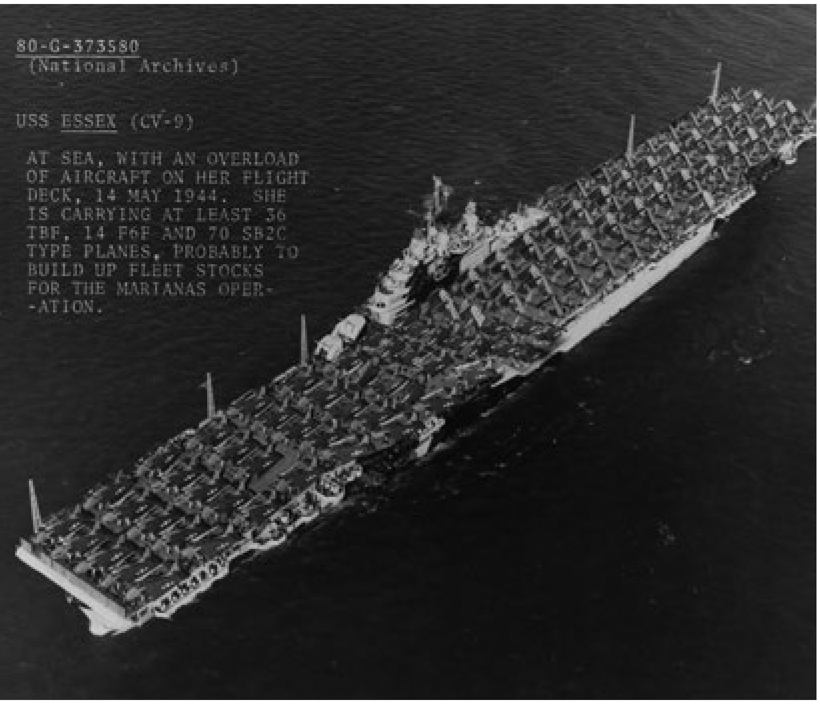
The U.S. aircraft carrier USS *Franklin* (CV-13) pictured burning in the waters off Japan after being hit during an air attack on 19 March 1945. The light cruiser USS *Santa Fe* (CL-60) is alongside. The photo was taken by planes from the USS *Essex* (CV-9) returning from a strike on Kobe, Japan.

Kamikaze attacks, resulting in the loss of 1,757 lives. Still yet, other ships were attacked and survived, adding overwhelming numbers to the casualty lists. Twenty-seven aircraft carriers of escort, light, and fleet designs were struck by Kamikazes, some multiple times, resulting in over 8,000 American deaths. The USS *Franklin* (CV13), a large *Essex*-class fleet carrier, suffered 807 deaths and 487 wounded from one attack alone.

To defend against this Japanese onslaught, the mix of aircraft on the flight deck was shifted to provide more fighters to defend against aerial attacks, leaving less room for dive-bombers and torpedo attack aircraft. During Operation Downfall, the 1945 assault on Okinawa, only 15 percent of sorties (704 of 4,841) from American aircraft carriers were launched to provide close air support or strike missions. The remaining 85 percent were launched to defend the force against Kamikazes.[28] As carrier commanders, Mitscher and McCain understood the importance of preserving the lives of their men while simultaneously executing the mission. Mitscher's chief of staff, Captain Arleigh Burke, remembered that during their 5th Fleet/3rd Fleet turnover meeting in the fall of 1944, Mitscher and McCain discussed the importance of adding significant range to the air wing in order to stand off beyond the range of the Kamikazes and still hit their targets. Both understood that longer range meant larger aircraft, and larger aircraft required larger ships from which to take off and land.

TWENTY-SEVEN AIRCRAFT CARRIERS OF ESCORT, LIGHT, AND FLEET DESIGNS WERE STRUCK BY KAMIKAZES, SOME MULTIPLE TIMES, RESULTING IN OVER 8,000 AMERICAN DEATHS.

Both also understood that they would be trading smaller aircraft, shorter ranges, smaller bomb loads, and higher numbers of sorties per day for larger aircraft carrying bigger bomb loads to longer ranges with fewer sorties per day in order to fulfill the mission of defeating the enemy. Mitscher and McCain had come to understand that the ultimate aim of the war was to project power against Tokyo, the enemy's capital, in order to coerce capitulation. The Pacific campaign represented a long, painful process of gaining control of sea and establishing dominance in the air, which was, in turn, followed by ground assaults to capture islands in order to build air bases. Each island brought another island within range until – month by month, island by island – Tokyo was brought



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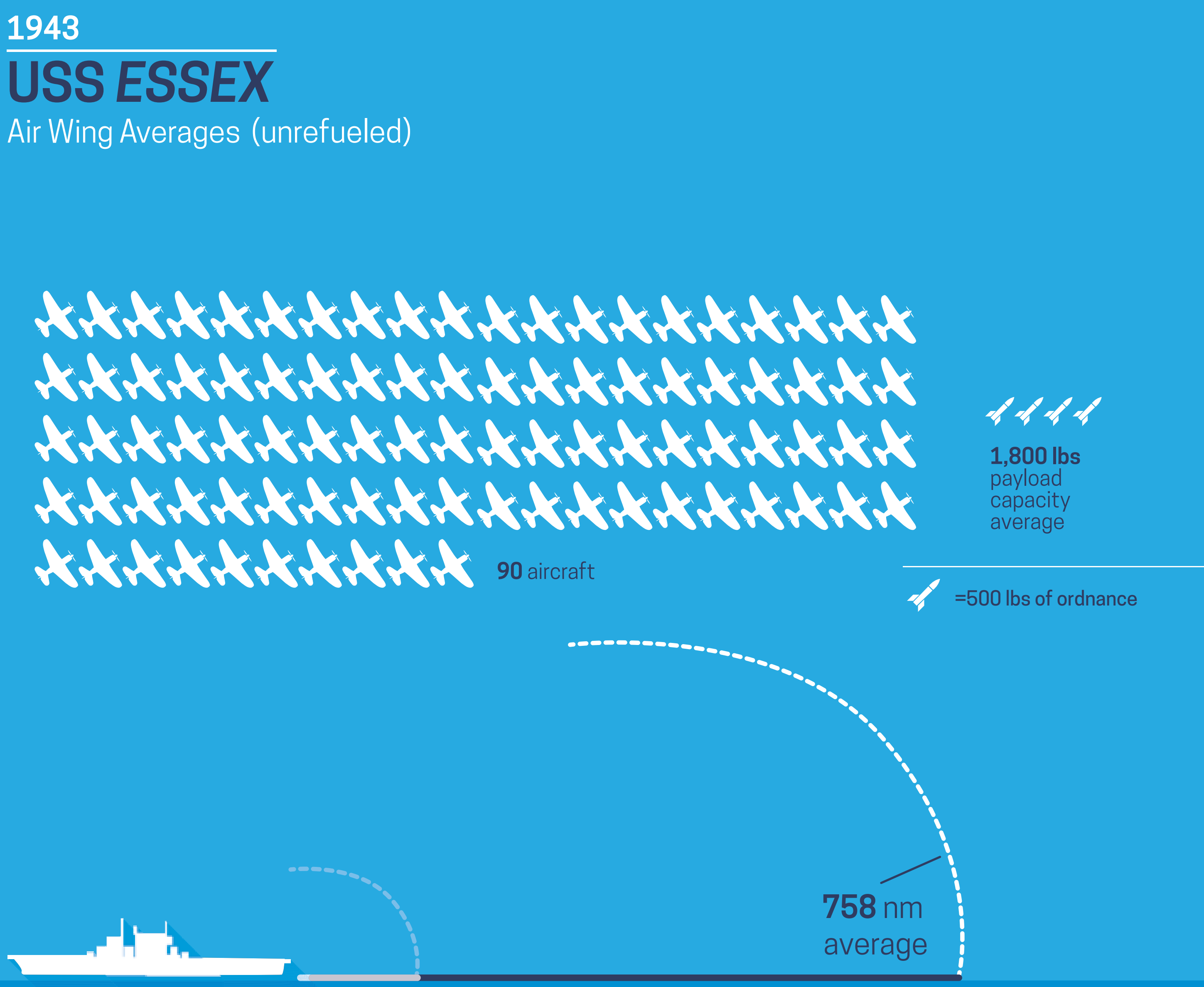
The USS *Essex* with a full combat load of aircraft during World War II.

within range. The aim of the war was to project power into the heart of the enemy's capital in order to change the minds of their leaders; sea control was the means to that end. Mitscher and McCain desired an aircraft optimized for long-range power projection, not high sortie rate sea control campaigns. Exhausted by their efforts, both men desired shorter wars.[29] This was the lesson that naval aviation learned in World War II.

Following the war, Mitscher returned to Washington, D.C., where he was assigned as the deputy chief of naval operations for air. In this role he drew upon his experiences off Luzon in the summer of 1944, and in January 1946 he authored a memorandum recommending that the Navy create a new class of carrier capable of launching and recovering bombers that could carry 8,000–12,000 pounds of ordnance 2,000 nm. Such a bomber, denoted in Navy planning documents as the ADR-42, would weigh 100,000 pounds at takeoff and cruise at 500 knots near an altitude of 35,000 feet. Such performance would require a 100-foot wingspan and length of 85 feet. Just as Doolittle's B-25s could not land on Mitscher's *Hornet*, the ADR-42 aircraft would require a longer and wider carrier with stronger catapults and arresting gear. Supporting this type of aircraft, then, would require a new type of aircraft carrier.

This carrier, designated the "6A," would be nearly 1,100 feet long and 130 feet wide. It would have no "island" to interfere with wider wingspan aircraft. To meet these design requirements, the carrier itself would come in at nearly 100,000 tons. It would be a "supercarrier." All this – the bigger bomber, the larger carrier, the increased bomb load, and the longer range – was derived from the painful lessons that emerged from the latter stage of World War II when the Japanese imposed a highly effective anti-access/area-denial strategy on the United States. Having suffered significant losses and perceiving the war as an existential threat to the United States' existence, the nation had borne the loss of carriers and lives to accomplish its goal of the unconditional surrender of Japan, but it did not wish to do so in the future.



The lessons learned during the Fleet Problems of the 1930s directly led to the design and manufacturing of the aircraft that would see the United States through World War II in the Atlantic and the Pacific oceans. Within the confines of the massive fleet maneuvers, naval aviation found value in mass, range, and payload capacity.

CHAPTER 2

The Evolution of the Carrier Wing During the Cold War

Nuclear Mission

There was, of course, another reason beyond Mitscher and McCain's wartime experiences that the Navy was anxious to procure a larger bomber and bigger aircraft carriers. In the immediate aftermath of the end of World War II, following the dropping of atomic bombs on Hiroshima and Nagasaki, two initiatives dominated American strategic thought: how to demobilize the massive U.S. military that had won the wars and how to leverage the atomic bomb to ensure American security. Cost was a factor in both of these cases. Shrinking the size of the force would have an ancillary effect of lowering the cost of the national defense, and atomic weapons held out the promise of a new, cheaper method of providing security for the nation – more "bang for the buck" as the idea became known during the Eisenhower administration. But first the nation had to go through the transition era of the Truman White House.

The unification of the services within the Department of Defense, previously organized under the Department of War (Army and Army Air Forces) and the Department of the Navy (Navy and Marine Corps) emerged as an issue in the waning days of World War II. The Army, jealous of the resources and reputation gained by the Marines during the war, sought to do away with the Navy's amphibious force. More importantly, during the war General Harold "Hap" Arnold, the head of the Army Air Forces, had been given a seat at the table with the Joint Chiefs of Staff despite being nominally subordinate to Army Chief of Staff George C. Marshall. Additionally, air power advocates had been lobbying incessantly for the creation of a separate service that would absorb anything that flew, including naval aviation.

This move revealed a war within a war, as bomber advocates within the Army Air Corps took a dim view of tactical aircraft of all types. Fighters, naval or land based, were thought to have no real place in future wars. Bombers, loaded with atomic bombs, would settle all conflicts. General Carl Spaatz, who had commanded all U.S. Army Air Forces in Europe during the war, asked the question, "Why do we need a Navy at all?" Moreover, now General James Doolittle, who ironically gained his highest fame flying bombers off of an aircraft carrier, observed, "The carrier has reached its highest usefulness now and … is going into obsolescence."[30] The Navy's problem was the atomic bomb – or more precisely, its problem was that it had no role in delivering atomic bombs.

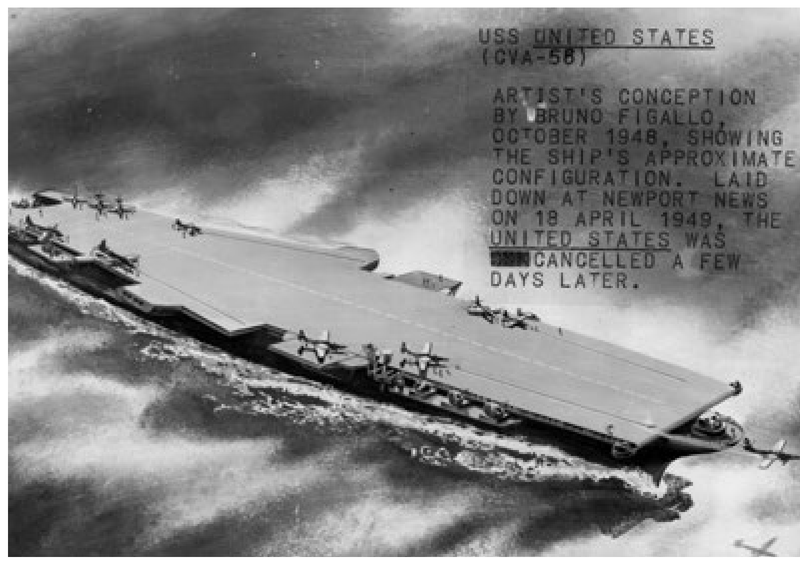
In 1945 the only bombs in existence, the Fat-Man and Little-Boy designs used on Japan, were too large, heavy, and bulky to be dropped from carrier-based aircraft. In November of that year, Chief of Naval Operations Fleet Admiral Earnest King established a Special Weapons Division under the leadership of Rear Admiral William Parsons, a brilliant scientist and engineer, to consider what type of Navy should be built for future conflicts.[31] It was soon apparent that if the Navy were to remain relevant in the new Department of Defense, it would need to develop a role in the delivery of atomic bombs.

By 1949 the new U.S. Air Force was moving out with the development of the B-36 inter-continental bomber and making the argument that bombers could provide sea control, eliminating the need for a Navy altogether. The Navy had no intention of being left on the sideline with regard to nuclear weapons, sea control, or power projection and adapted Mitscher's 1945 memorandum to include nuclear weapons delivery capability from aircraft carriers.

Beginning in 1946, tests of aircraft flying one-way missions were conducted using modified 52,000-pound AJ-1 Savage aircraft operating from three modified 45,000-ton *Midway*-class carriers. The plan was to crane the aircraft onto the carriers, sail, and then launch the planes carrying 10,000-pound Mark III atomic bombs on no-return-to-the-carrier profiles in much the same way Doolittle's Raiders had flown from the *Hornet*.[32] To create a scenario wherein the aircraft could launch and recover a nuclear bomber from a carrier deck, the Navy had proceeded to design an aircraft carrier of sufficient size to host Mitscher and McCain's envisioned larger aircraft.

Plans for the USS *United States* (CV-58) resembled those of the *Langley*, the original U.S. aircraft carrier, in that she was to be flush decked with no island to impede the growth in wingspan of future aircraft. It was assumed that the heavy bombers would reside on the flight deck, but the ship required a large hangar bay to store the more conventional aircraft in the air wing. The magazines in the *United States* would be smaller than the previous *Midway*-class carriers owing to the smaller number of weapons carried, perhaps 100 nuclear bombs in all. The *United States* was to displace 69,000 tons, lie 1,200 feet in length, and have a beam of 130 feet. She was to have four catapults: two on the bow and two on the waist, one port, and one starboard. The carrier was to be equipped with an air wing composed of 52 F2H Banshees (1,500-nm combat radius) and 12 ADR-42 89,000-pound nuclear bombers capable of carrying 10,000 pounds of ordnance 2,000 nm and returning to the carrier.[33]

Despite attempts by the Air Force and the Army to derail the carrier, initial support for the new ship was strong. President Truman approved the construction of the *United States* in the spring of 1948, and that summer Secretary of the Navy John Sullivan testified in support of the program before the House Senate Armed Services Committee. The congress authorized the construction of the ship within the fiscal year 1949 on June 24, 1948. President Truman signed the bill into law the following day.[34] At this point, however, fate conspired against the Navy.



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An illustration of the planned USS *United States*, intended to be the first super carrier to host larger aircraft capable of hitting the Soviet Union.

To assuage concerns regarding the unification of the three services under the Department of Defense, the first Secretary of Defense selected was James Forrestal, a former Secretary of the Navy who had opposed unification. However, Forrestal, exhausted by years of wartime service, was neither effective nor long lasting and was replaced by Louis Johnson, a political ally and chief fundraiser for Truman during his 1948 campaign. Johnson sought to support his own presidential ambitions by slashing post-war department spending, with the Navy and the Marine Corps serving as the chief target of his cuts.[35] The new secretary's reputation for political manipulation was such that the veteran Cold Warrior Paul Nitze once described him as "the only person that I have ever known who would rather lie than tell the truth even when it was to his disinterest to lie."[36]

Johnson vowed to "cut the fat" without touching the nation's military muscle or bone.[37] A former director for Convair, the aviation company that produced the B-36 bomber, the secretary was a strong supporter of the Air Force and took on Truman's inherent negative bias against the Navy.[38] On April 23, 1949, after consulting with the Army and the Air Force while the secretary of the Navy and chief of naval operations were unavailable, Johnson unilaterally canceled construction of the *United States*, whose keel had just been laid. Johnson revealed his thinking to a journalist later: "while he was SecDef, the Navy would have no part in long range or strategic bombing …." Both Secretary of the Navy Sullivan and Chief of Naval Operations Louis Denfield resigned their offices in protest. Other flag officers who had defended the carrier were demoted or forced to resign, while others had their names stricken from promotion lists. The advent of the Korean Conflict soon put truth to the lie that Johnson had cut only fat. In the days after North Korea's invasion of the south, the U.S. military found itself hard pressed to respond, and Louis Johnson soon found himself out of a job.[39]

Of course, the supercarrier did not end with the cancellation of the *United States*.[40] The Korean War infused money back into the Department of Defense's budget, along with a stated request for four aircraft carriers to be continuously deployed to the Far East.[41] The desire to participate in the nuclear attack mission and the experience with Kamikaze suicide planes during World War II still drove the Navy toward a larger aircraft that was capable of delivering a heavy load of ordnance to targets well in excess of 1,000 nm away from the carrier. In order to operate quickly-larger aircraft from carrier decks, the Navy integrated the angled deck design developed by the British into existing American carriers. By the end of 1952, they had converted the USS *Antietam* (CV-36), an *Essex*-class carrier, for test purposes. By May 1953 the concept had been proven to both British and American observers. Shortly thereafter, additional *Essex*-class and the three *Midway*-class carriers were converted to angled decks.[42]

IT MUST BE UNDERSTOOD THAT THE *FORRESTAL* AND THE SHIPS THAT FOLLOWED HER WERE DESIGNED FOR ONE SPECIFIC PURPOSE: TO LAUNCH AND RECOVER AIRCRAFT LARGE ENOUGH TO CARRY A HEAVY LOAD OF ORDNANCE A LONG DISTANCE.

The USS *Forrestal* (CV-59), a new class of carrier and the very first supercarrier, was included within the FY-52 budget. It must be understood that the *Forrestal* and the ships that followed her were designed for one specific purpose: to launch and recover aircraft large enough to carry a heavy load of ordnance a long distance. The load could be nuclear, which was clearly the intent in the beginning, or it could be conventional, a capability used repeatedly in Vietnam and the deserts of the Middle East. In either case, the size of the carriers would henceforth be tied to the larger aircraft carried aboard them.

At this time, the design of the ADR-45 bomber aircraft, which became the A-3 Skyraider, had advanced to sufficient detail that ship architects knew with confidence that they could scale down supporting systems onboard, lessening the weight of the ship. As such, the *Forrestal*'s original 1951 designs reveal a scaled down version of the *United States*, retaining the flush deck, a retractable bridge, and four angled catapults: two port and two starboard. She would be smaller than the *United States*: 100 feet shorter at 990 feet, narrower by 20 feet, and weighing in at just shy of 60,000 tons. The ship was required to carry 2,000 tons of aviation ordnance and 750,000 gallons of fuel. Beyond angled decks, which were incorporated into the *Forrestal* design midway through the development process, the ship also integrated another leap-ahead capability: the steam powered, slotted tube catapult, which replaced the massive hydraulic catapults designed for the *United States*. The *Forrestal* was commissioned on October 1, 1955.[43]

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The *Forrestal*'s air wing represented a leap ahead in aviation capabilities operating from a sea base.

The *Forrestal*'s air wing represented a leap ahead in aviation capabilities operating from a sea base. Combining new jet engines with traditional radial piston engines, straight wings with swept wings, high speed, and low velocity spread across four aircraft, the *Forrestal* carrier air wing had one predominant characteristic: range. The oldest aircraft on the deck was the AD-1 Skyraider, a radial piston driven design off the drafting table of Douglas Aircraft Company's legendary engineer Ed Heinemann. Drawn up during the war as the replacement for the SB2 Helldiver and the TBF Avenger torpedo bomber, the Skyraider entered service in December 1946 and continued flying through the late 1960s. The AD-1 was both famous and infamous for the power of its radial piston engines. Capable of carrying 8,000 pounds of ordnance over 1,000 nm to a target, the engine's torque was so powerful that it was prone to spinning the aircraft into the carrier deck or the sea if the pilot injudiciously added power too quickly. The engine did come with limitations. A relatively low operational ceiling of 29,000 feet and a top speed of 320 knots paled in comparison with its jet-powered counterparts on the supercarrier's flight deck, but the Skyraider's reputation for toughness and ability to loiter for a long period of time with a large weapon load made it a favorite aircraft for providing combat air support to ground troops in contact with a massed enemy.

McDonnell Aviation's F2H3 Banshee brought its own group of capabilities and capacities to the *Forrestal*'s deck. Westinghouse turbojets gave the fighter-bomber – designed in the mid-1940s – a respectable speed of 580 knots and an operating ceiling of 46,000 feet. However, its straight wings shaved nearly 100 knots off its highest potential speed, a real handicap when it attempted to bring its six 20mm cannons to bear against MiG opponents. The straight wings were an artifact of Navy decisions in the early days of jet aviation to avoid swept wing aircraft due to concerns about their handling characteristics in the low speed/low altitude conditions that characterized the landing pattern around the carrier. It would take some time before carrier procedures, approach speeds, and approach paths would be adapted to take into account the capabilities of the new jets. The Banshee's sturdy design and large fuel load gave it the ability to carry 3,000 pounds of ordnance to targets nearly 1,500 nm away. As such, the Banshee was adapted to the nuclear mission and could deliver either the Mark 7 or Mark 8 nuclear bomb from specially reinforced pylons under its wings.

The third aircraft in the new supercarrier air wing, North American Aviation's FJ3 Fury, made the first landing and takeoff from the deck of the new *Forrestal*. An adaptation of North American's F-86 Sabre, which had been so successful for the Air Force during the war in Korea, the Fury had the Sabre's sleek swept wings and a stronger engine, the Wright J65. The Fury could climb to 47,000 feet and reach 590 knots in level flight. The FJ3 represented an evolution in the aircraft's design, shifting it from a pure fighter configuration, carrying only air-to-air missiles and four 20mm cannons, to a fighter/bomber role with the addition of two inboard pylons capable of carrying 1,000-pound bombs and two outboard pylons capable of carrying 500-pound weapons. These weight limitations meant that it was not nuclear delivery capable, as these bombs weighed more than 1,000 pounds at this point in their development. The Fury's combat radius was only 650 nm, but with aerial refueling, its range could extend to nearly 1,250 nm. Aerial refueling, a relatively recent technological innovation, enabled the Fury to provide fighter escort services for the A3D Skywarrior, the heavy nuclear bomber that the *Forrestal* had been designed to launch and recover.

The Skywarrior was the culmination of the ADR-42 heavy bomber program. It was capable of carrying 12,800 pounds of ordnance, nuclear or conventional, 1,826 nm. Conceived in 1945, designed in 1949 by Douglas Aircraft's chief engineer Ed Heinemann, first tested in 1951, and introduced operationally in 1956, the Skywarrior represented a feat of aeronautical engineering. It cruised at over 500 knots and could reach an altitude of 42,000 feet. With a wingspan of 72 feet, a length of 76 feet, and a loaded takeoff weight of 83,000 pounds, it was the largest aircraft ever to fly from a carrier's deck. Its size, versatility, and sturdiness would make it one of the most adaptable aircraft the Navy would ever fly. It would not retire until 1991.

Another aircraft that had a strong role in the nuclear weapon delivery mission was the Douglas A-4 Skyhawk, which stood out as one of the great aeronautical designs of the legendary engineer Ed Heinemann. Produced at the request of the Navy to provide a jet attack aircraft, capable of delivering nuclear weapons and replacing the AD-1 Skyraider, the highly maneuverable, delta winged Skyhawk was a marvel of simplicity.[44] The Skyhawk's max speed was 550 knots. Its top altitude was just over 40,000 feet and combat range was 550 nm unrefueled (it did not have external fuel tanks) while carrying up to 9,000 pounds of ordnance of all types, including nuclear weapons.[45]

The nuclear weapon delivery mission led Skyhawk pilots to develop the "over the shoulder" delivery tactic. This maneuver called for the Skyhawk pilot to approach his target at a low level and a high rate of speed. Once past the target, the pilot would pull the aircraft up in a looping maneuver that would end with it on a reciprocal course, but as the aircraft pulled through the vertical the pilot would release his nuclear weapon, which continued upward in a high, arcing lob to 10,000 feet before plummeting back to earth to explode above its target. The trick was for the pilot to have his A-4 beyond a safe range from the blast before the bomb hit its target.[46]

Any discussion of the nuclear mission from the carrier has to include a mention of a very unique aircraft that enjoyed but a short life on the carrier's deck. As stated earlier, the A-3 Skywarrior had been designed to meet a Navy requirement for nuclear weapons delivery from a carrier deck, and the supercarrier *Forrestal* and all subsequent carriers were designed to support the large, heavy Skywarrior. The advent of the nuclear ballistic missile submarine eventually supplanted the carrier as the Navy's primary nuclear weapon delivery platform, but not before North American Aviation designed the long-range, high-altitude, supersonic A-5 Vigilante nuclear bomber. Seventy-six feet in length, 53 feet across, and weighing 63,000 pounds at takeoff, the Vigilante could fly nearly 1,300 nm unrefueled, delivering a 1,700-pound nuclear weapon while traveling twice the speed of sound. Its role as a nuclear bomber was short lived, but the Navy made good use of its capabilities by employing it as a reconnaissance aircraft.

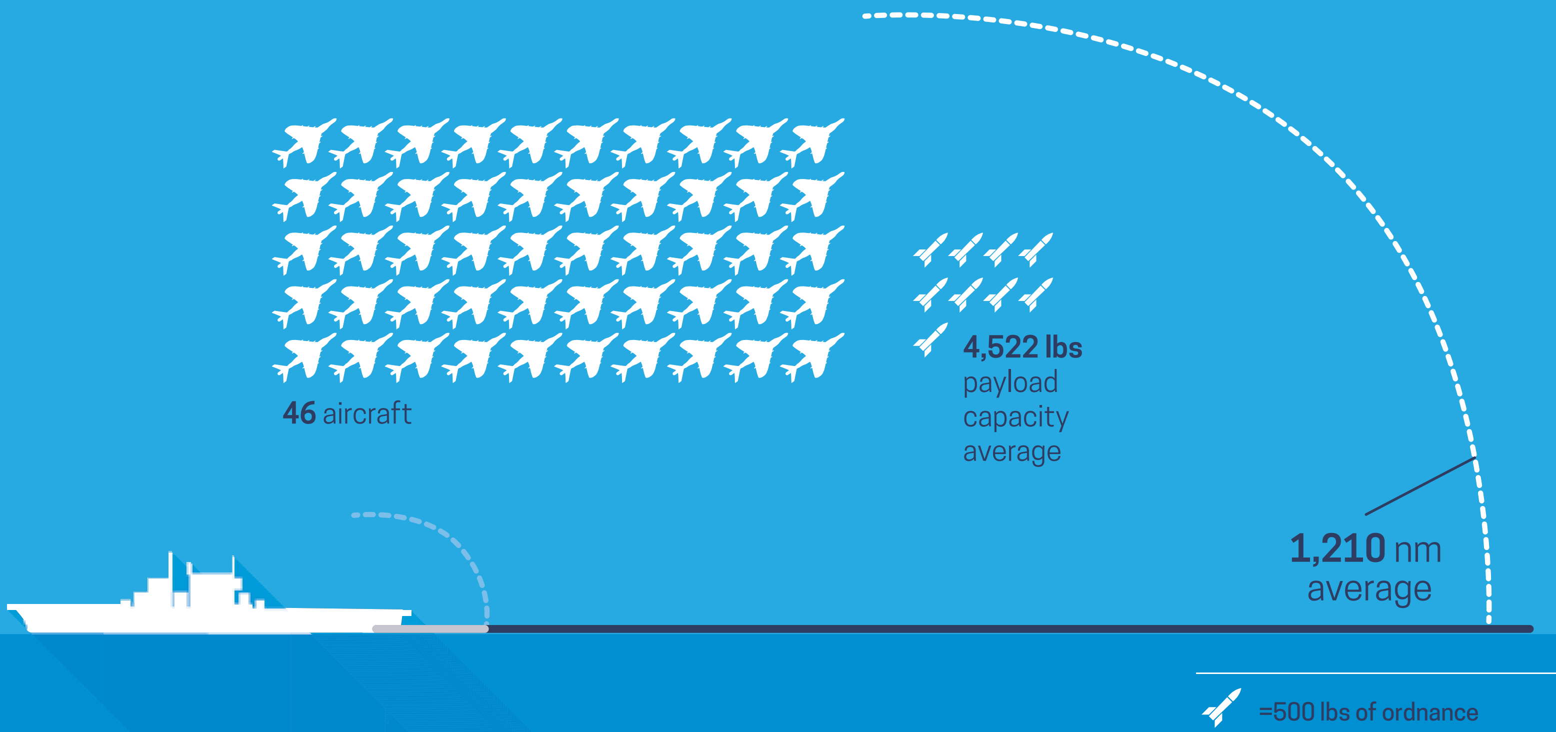
The primary focus and role of carriers shifted during the late 1950s. Two developments of the Eisenhower administration – one organizational, one technological – soon provided strong alternatives to carrier aviation as nuclear delivery platforms. The Strategic Air Command had been established in 1946, but it was not until General Curtis LeMay assumed command of the nuclear bomber force in 1948 that its performance and professionalism approached legendary status. Additionally, the decade saw the development of the nuclear-powered submarine under the guidance of Admiral Hyman Rickover. Shortly thereafter, the enhanced survivability of the nuclear-powered submarine was married to the destructive power of nuclear-tipped missiles in the commissioning of the ballistic-missile submarine *George Washington* (SSBN-598), which went from its keel-laying to its first operational patrol in two and a half years. The development of multiple platforms capable of launching nuclear weapons against the enemies of the United States led to the establishment of a Single Integrated Operational Plan (SIOP) at Eisenhower's direction. The creation of the SIOP led to a prioritization of nuclear delivery platforms, and the carrier receded in importance when compared to strategic bombers, land-based missiles, and ballistic missile submarines, which became known as the nuclear "Triad" force. While carriers remained nuclear capable, they were no longer considered a primary delivery platform. However, the events of the 1960s ensured that the carrier was not targeted by budget cutters.

The key characteristics of naval aviation identified during the Fleet Problems of the pre-World War II era remained constant. The air wings remained in the 80–90 aircraft range onboard the newly commissioned supercarriers, and the desire for range and payload capacity

1956

USS *FORRESTAL*

Air Wing Averages (unrefueled)



The creation of the *Forrestal* class and its accompanying air wing demonstrated the Navy's ability to swiftly craft a solution to a complex problem in a relatively short period of time.

resulted in the *Forrestal*'s initial deployment air wing having an average unrefueled range of 1,210 nm and an average weapons load capacity of 4,522 pounds. The range represented a 58 percent increase over its World War II predecessors, and the payload capacity more than doubled that of the air wing that flew from the *Essex* class. The creation of the *Forrestal* class and its accompanying air wing demonstrated the Navy's ability to swiftly craft a solution to a complex problem in a relatively short period of time. It was the answer to Mitscher and McCain's original Kamikaze anti-access/area-denial challenge and the Navy's means of getting into the nuclear weapons delivery game at a time when that appeared to be the only game in town, and when it appeared that the Navy's very existence was being threatened by the rising Air Force. As the Navy faced the challenges of Vietnam and the Cold War, the evolution of the aircraft carrier and its accompanying air wing would continue, with naval aviation adapting to new threats and creating innovative methods to extend the range and lethality of the entire air wing.

The Vietnam-Era Air Wing

The *Forrestal* air wing never got to fight the nuclear war it was designed to execute, but it continued to evolve, adapting its wide range of capabilities to the challenges the nation faced in the decades that followed. The air wing would drop older designs, such as the Banshee and the Fury, while adding new aircraft that brought advanced designs and new capabilities. The aircraft were complemented by a new generation of supercarriers. The *Forrestal*-class ships – the *Forrestal*, *Saratoga*, *Ranger*, and *Independence* – with their large complements of aircraft and high sortie generation rates, established the benchmark for modern supercarrier operations. These ships, along with the three *Midway*-class carriers and an assortment of modified *Essex*-class ships, provided the backbone of the U.S. fleet as it took up its positions around the world, providing naval air support for America's national interests in several power projection missions even as the Cold War and the threat of nuclear exchange hung in the background.

The conflict in Vietnam that came to dominate American life from 1964 to 1973 had its roots it the anti-colonial movement that emerged following World War II. Imperial powers in Europe, exhausted by two great wars and facing local political actors in their colonies bent on self-determination, were unable to stem rising revolutions. While President Eisenhower had attempted to keep the United States out of the conflict, John Kennedy was unable to resist his own call to "bear any burden, meet any hardship, support any friend, oppose any foe, in order to assure the survival and the success of liberty." Kennedy took the initial steps of increasing the number of U.S. military advisors deployed to Vietnam. Following Kennedy's death, his successor, Lyndon Johnson, dramatically increased the number of U.S. military forces in Vietnam after an alleged August 1964 incident in the Tonkin Gulf that has since been discredited by declassified National Security Agency electronic intercepts.[47] By the end of that year, 100,000 American troops would be in Vietnam, and three American aircraft carriers would take up positions at Yankee Station.

Yankee Station was a geographic point approximately 100 nm east of Da Nang, Vietnam, from which American aircraft carriers provided 1,000-mile round-trip interdiction, strike, and reconnaissance flights into North Vietnam and neighboring Laos. The north used Laos as a supply route and base for operations against the south.[48] Judging that neither

Russian nor Chinese forces would enter the war on the side of North Vietnam, the U.S. Joint Chiefs of Staff recommended that U.S. forces strike North Vietnamese targets to dissuade the north from supporting insurgents in the south. The 82,000-ton, oil fueled USS *Kitty Hawk* (CV-63) arrived on station on May 19, 1964, followed by the 36,000-ton USS *Bon Homme Richard* (CV-31) and finally the USS *Constellation* (CV-64), sister ship to the *Kitty Hawk*, on June 6.[49] Three aircraft carriers were required in order to provide round-the-clock flight operations.

The carrier air wing continued to evolve and adapted to its new environment. The F2H3 Banshee and the F3J Fury were gone. Their spots on the flight deck and in the cavernous hangars of the supercarrier were taken by the McDonnell F-4 Phantom II and the Vought A-7 Corsair II. In addition, the Douglas A-4 Skyhawk made its appearance during the early 1960s. Each brought substantive new refinements in key aviation capabilities.

The F-4 Phantom II grew out of an insight by Dave Lewis, lead designer for McDonnell Aviation, that the Navy needed a new type of aircraft and attack fighter. Begun as a revision of McDonnell's F3H Demon, the F-4 Phantom soon gained a personality of its own. Centered on a titanium fuselage built around two massive General Electric J-79 engines, each of which generated 12,000 pounds of thrust in normal range and almost 18,000 pounds in afterburner, the new aircraft could reach Mach 2.2 (1,674 nm per hour). The Phantom was a dual seat aircraft, with a pilot in the front and a navigator/bombardier/radar intercept officer manning the rear seat. Equipped with an innovative Doppler radar lodged in the aircraft's distinctive bulbous nose cone, the aircraft could perform well in either the fighter or bomber role. For weapons it carried up to 18,000 pounds of ordnance on external hard points in various combinations of air-to-air and air-to-ground configurations.[50] The Phantom's one limitation was its combat radius on internal stores. The high fuel consumption of the J-79 engine yielded an average combat range of less than 300 nm.[51] Phantom crews overcame this limitation by exchanging ordnance for external fuel tanks and by midair refueling.

Despite its limitations, the Phantom II is viewed as a great success overall but as a failure in specific areas. In air-to-air combat its performance was lackluster. While it was credited with 164.5 MiG kills, the Phantom's win to loss ratio against the MiG-21, the frontline fighter flown by the North Vietnamese, was only two to one. In a departure from previous designs, the Phantom was designed without a gun or cannon, a point that met with some consternation once pilots became engaged in dogfights over Vietnam.[52] However, the win to loss ratio was somewhat skewed. The F-4 spent 118,860 cumulative days "on the line" in Vietnam, with only 75 aircraft lost in total, or a 1,585 days per aircraft lost ratio.[53]

The aircraft excelled beyond expectation in its air to ground role. Its ability to carry up to 18,000 pounds of ordnance made the F-4 a favorite of American troops in contact with the enemy. Be it providing close air support to ground units, bombing bridges, or interdicting trucks driving the supply route south through Laos, the Phantom had the ability to inflict high numbers of casualties upon its enemies.[54]

In Vietnam, the A-4 Skyhawk was used extensively as a bomber, flying more sorties in support of Operation Rolling Thunder than any other Navy aircraft. It first saw combat in August 1964 and remained in service throughout the war, a remarkable record of longevity in an era of rapid aeronautical evolution. A-4s flew targeted bombing missions of roads and bridges as well as close air support missions for ground troops, especially after the development of gun pods that could be attached to the aircraft's hard points, greatly expanding its bullet magazine capacity and lethality.[55] Losses to ground gun emplacements and surface to air missiles led to the development of the Bullpup (AGM-12B) and Walleye stand off weapons.[56] These primitive precision bombs were the first step in the evolution of the modern strike weapons. The war did not come without losses. The attack profile of the Skyhawk left it vulnerable to ground fire, and during the war the aircraft served a cumulative 140,940 days on the line, resulting in the loss of 196 aircraft.[57]

The A-7 Corsair II arose from the desire to have an aircraft similar to the A-4, but with greater ordnance carrying capacity and longer range. Strikes into northern Vietnam, Laos, and Cambodia stressed the limits of the A-4's capabilities. Given the eight years' separation between the designs of the two aircraft, engineers were able to take advantage of other innovations: better navigation instruments, higher quality radars, and an integrated map display. The single seated A-7 could fly 150 nm further than its A-4 counterpart while carrying 15,000 pounds of bombs. Its fuel consumption rate was legendary, burning only 30 pounds per minute versus the F-4 Phantom's 100 pounds per minute. The A-7 entered service in 1967 and spent much of its early life in the skies over Vietnam, where the aircraft was known for its ease of flying, accuracy in bombing, and ruggedness.

The A-3 Skywarrior saw little service in Vietnam in its original role as a heavy bomber. Its size and lack of maneuverability left it highly vulnerable to surface to air missiles and the anti-air gun batteries that dotted the North Vietnamese landscape. Losses convinced Navy leadership to repurpose the Skywarrior, first as an organic mission tanker and then as an electronic warfare platform.

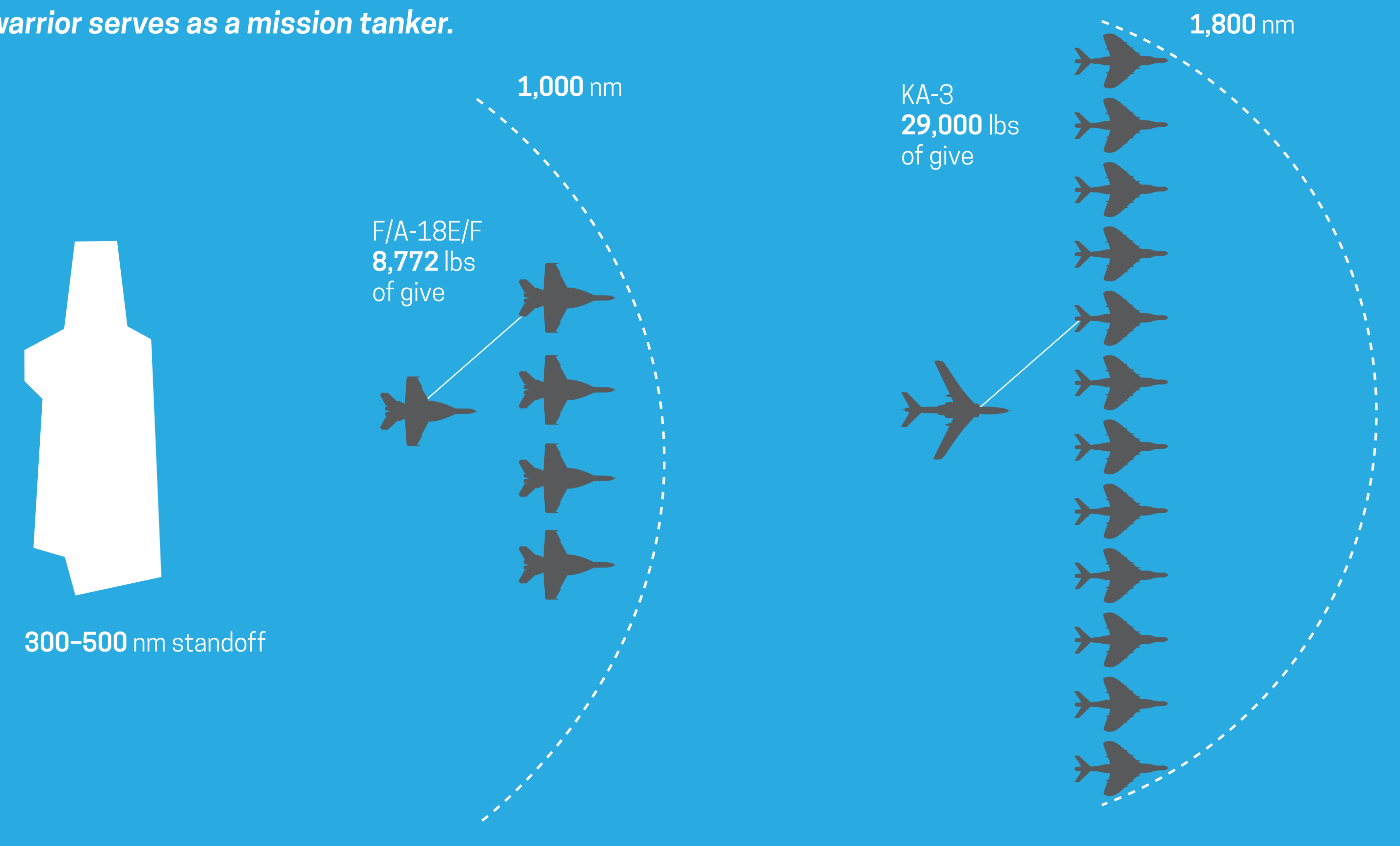
The term "organic" is important and deliberate. The Air Force and its antecedents in the Army had been fielding refueling aircraft since 1923 and had used large "Big Wing" tankers during the 1950s to refuel its bombers and tactical fighters mid-flight.[58] The Navy could have nominal access to Air Force tankers, but when push came to shove during the roles and mission battles of the early Cold War, Air Force assets were often "not available" to support Navy missions.

One highly visible example of this was "Project Bullet," a naval aviation attempt to set a new transcontinental speed record with an F-8 Crusader piloted by Marine Corps pilot Major John Glenn. Glenn's Crusader needed to be refueled three times to complete the journey at supersonic speed, and the ideal tanking asset was the Air Force's KC-135, a modified Boeing 707. The Air Force, not anxious to see naval aviation set a new record, stated that no aircraft were available due to "operational commitments." Glenn succeeded in setting his record, using older, slower Navy tankers, and went on to become one of the nation's first astronauts.[59] This incident and many others left the Navy wary of trusting the Air Force to be there for them when real requirements emerged for tanking support. Besides, the Navy, operating far from land in the open ocean, liked to depend upon itself to get things done, hence its development of tanking that was "organic" to the carrier.

Organic mission tanking in the 1960s was not a new capability for the carrier air wing. The North American AJ-1 Savage, with two propellers driven by rotary piston engines, served as the first carrier based tanker for the air wing. With a combat range of 700 nm and an ability to carry 10,000 pounds of ordnance or fuel, the Savage was able to extend the range of other attack aircraft out to 1,400 nm. In 1953 the Navy developed the D-704 "Buddy Store," an external pod that mounted on the wing and could carry 300 gallons (2,244 pounds) of fuel, dispensing it through a self-contained hose-reel assembly. When the A-4 Skyhawk joined the air wing, the small aircraft quickly adapted the D-704 to its long-range nuclear bomb delivery profile, sending two A-4 tankers equipped with one D-704 Buddy Store and two 550-gallon external fuel tanks, and one A-4 nuclear bomber equipped with one nuclear weapon and two external fuel tanks, out on 1,800-nm delivery profiles.[60] The tanker configured A-4 had 9,800 pounds of fuel to "give" to its air wing compatriots, but when aviators examined the A-3 Skywarrior they soon realized that they had found a bonanza of give that would change the face of naval aviation in Indo-China.

The A-3 Skywarrior was a big plane, weighing 85,000 pounds at takeoff. When a specially configured fueling system was fitted within the A-3's bomb bay, aviation planners found that the aircraft could provide 35,000 pounds of JP-5 jet fuel during a normal mission profile. This profile included taking off from the carrier at the beginning of the launch cycle, climbing quickly to 6,000–7,000 feet to take whatever gas was left in the previous returning mission tanker, and then sprinting ahead of the force to a position just off the Vietnamese coastline. Once there, the A-3 would soon be joined by striking aircraft, A-4s, A-7s, and later A-6s, who would "top-off" their tanks before going "feet-dry" and heading inland to targets in North Vietnam or Laos. The tanker would then loiter, listening on the radio to determine who would need fuel on the way back to the carrier. On more than one occasion aircraft would come back so battle damaged and leaking fuel that they would have to hook up for "wing wet tanking," feeding their

KA-3 Skywarrior serves as a mission tanker.



starving engines with external fuel all the way back to the carrier. If no additional mission tanking was required, the A-3 would return to a position over the carrier to provide fuel for aircraft struggling to land and low on fuel before taking their own position as the last aircraft to recover at the end of a launch and recovery cycle.[61] The importance of organic mission tanking cannot be overstated. The tanking mission was unglamorous but necessary, and it extended the average range of the Vietnam-era air wing considerably. One tanker configured A-3 (or KA-3 in naval parlance) could "drag" 12 aircraft out 1,800 nm, a real mission enabler.

THE IMPORTANCE OF ORGANIC MISSION TANKING CANNOT BE OVERSTATED. THE TANKING MISSION WAS UNGLAMOROUS BUT NECESSARY, AND IT EXTENDED THE AVERAGE RANGE OF THE VIETNAM-ERA AIR WING CONSIDERABLY. ONE TANKER CONFIGURED A-3 (OR KA-3 IN NAVAL PARLANCE) COULD "DRAG" 12 AIRCRAFT OUT 1,800 NM, A REAL MISSION ENABLER.

What was being dragged along out to 1,800 nm had changed over time. Mass, range, and payload capacity remained key considerations as naval aviation proceeded through the 1960s, but advances in science and technology brought new adaptations to the carrier air wing as well. Refinements in engine design increased the speed, range, and altitude of friend and foe alike, altering the battlefield. Radios, radars, and inertial guidance systems had previously been developed, but their physical size and the complexity of their arrangement rendered them ill-suited for smaller, carrier-based aircraft. The invention of the transistor at the Bell Laboratory in 1947 and the subsequent development of the integrated circuit at Texas Instruments in 1958 led to leap-aheads in miniaturization of communications and sensors and their rapid introduction to naval aviation.

When Heinemann's "Hotrod" A-4 Skyhawk, with its simple yet elegant instrumentation, wanted to bomb a target, it needed to see it. If it flew to the target's coordinates and found a cloud layer blocking its view, it needed to retreat until it could find a hole in the clouds, descend, and then hope to get to its target without its visibility being obscured. This was the era of "visual flight rules" (VFR) mission profiles, but pilots knew that the requirement for a clear view was costing American lives. Ground combat, and resulting requests for close air support, did not stop in bad weather or at night. As early as 1955 the Navy Long Range Objective Study Group identified a requirement for a day/night, all weather, long-range bomber to carry out nuclear attacks against the Soviet Union. The requirements document signed a year later by the chief of naval operations stated that the aircraft would carry two crew to fly the aircraft and simultaneously monitor targeting instrumentation, make 500 knots, and carry 10,000 pounds of ordnance 1,000 nm. Eight aircraft manufacturers responded with 11 design proposals (four companies sent two designs each: one turbo propeller and one jet). Grumman's submission of a two seated, twin engine, swept wing aircraft powered by two Pratt and Whitney turbojets won the competition. Thus was born the A-6 Intruder.

The Intruder was developed to be a nuclear bomber. Its range and weapons carrying capacity were optimized for this role, and flight profiles from every ocean-based approach into the Soviet Union were part of every A-6 squadron's intelligence shop. The aircraft's range and ordnance carrying capacity were legendary, with crews later recounting flying from Whidbey Island, Wash., to Pensacola, Fla., without refueling, or dropping 28 500-pound bombs on one pass.[62] The A-6 represented a true attack aircraft that harkened back to the focused designs of dive-bombers in the 1930s.

The most noticeable characteristic of the A-6 over its predecessors was its large bulbous nose and its side-by-side crew canopy configuration. The bulbous nose was designed to contain both advanced all weather search and tracking radars, which were stacked one on top of the other. These radars were integrated electronically within the digital integrated attack and navigation equipment system. Its combination of radars, inertial navigation systems, a ballistics computer, and electronic displays gave the aircraft an unparalleled understanding of where it was under all conditions: good weather or bad, day or night. The aircraft's systems were run by a bombardier-navigator (BN), a commissioned, non-pilot officer who would later be termed a naval flight officer. Sitting to the right, slightly lower and aft of the pilot, the BN closely monitored the sensors and navigation systems, guiding the aircraft and its bombs to the target by passing steering commands electronically to the pilot.

In early 1963, the first A-6 Intruder squadron was stood up at Naval Air Station Oceana near Norfolk, Va. Just over two years later the A-6 made its first deployment onboard the USS *Independence* (CVA-62), which proceeded to Yankee Station off Vietnam. The A-6 became the first aircraft to deploy directly into combat since World War II. The A-6's targeting systems made it the logical aircraft to be assigned to the tough targets, but its drawbacks (a large radar cross signature and relatively low speed of 500 knots in an increasingly super-sonic world) left it vulnerable to ground anti-air artillery and missile fire. This vulnerability would haunt the aircraft through the remainder of its operational life, resulting in losses in Lebanon in 1983 and Iraq in 1991.

The A-6 airframe made additional contributions to the carrier air wing in the areas of mission tanking and electronic warfare. The Intruder's ability to carry significant weight and the persistent rumor that the A-3 Skywarrior was to be retired led naval aviation to look to the A-6 as a more permanent solution to its organic mission tanking requirements. Initially A-6s within the squadron were equipped with temporary A1D "buddy store" tanks, but eventually the decision was made to permanently modify 78 A-6As, along with 12 A-6Es, into KA-6s. Each one of these aircraft was modified with stronger internal bulkheads and improved fuel cells. Their ordnance dropping systems were stripped out. With five 300-gallon external stores attached, each KA-6 could give 26,000 pounds of fuel, enough to drag eight additional aircraft out to 1,800 nm. After 1971, each A-6 squadron deployed with 12 standard A-6 attack aircraft and four KA-6 tanker variants to provide their services to the entire air wing.[63]

One additional mission assigned to the A-6 airframe, and by extension the carrier air wing and the aircraft carrier strike group itself, was electronic attack. In the early 1960s the Marines modified A-6As within their inventory to provide "electronic attack" capabilities within their air wings. Electronic attack referred to "jammer" pods carried by the aircraft that disrupted enemy radars and communications devices. Because of the success of these aircraft, the Navy and Marine Corps moved forward to build a purpose-built, electronic attack aircraft as a derivative of the A-6 design. The forward half of the aircraft, dubbed the EA-6B Prowler, was extended to make room for two additional crewmen (naval flight officers described as electronic countermeasures officers or ECMOs) and the vertical stabilizer was raised to make room for an internal antenna. The aircraft also carried a series of pods on its wing stations to create disturbance or "jam" opposing radars and radios. The aircraft also carried AGM-88 HARM (high-speed anti-radiation missiles) that could be fired and would target radar emitters for physical destruction.

Conceptually, the Prowler accompanied the air wing during large "alpha-strike" missions. The ECMOs would analyze the emitters being used against the force and then carefully tailor their jamming response against the frequency bands being used. Enemy air defense operators would observe radar displays overcome by static and would frantically attempt to shift frequencies in order to reacquire the incoming attackers. ECMOs also served as a basic command and control element within the attacking formation, calling out bearings and ranges to anti-air sites. ECMOs could also monitor enemy communications and often relay shifts in tactics and countermeasures to the American force. The electronic attack community became a critical enabler to air power, so much so that when the Air Force's EF-111 Raven retired in 1998, Navy and Marine Corps EA-6B squadrons became the sole electronic attack resource within the joint force until the advent of the EA-18G took over that role.

With regard to the mass, range, and payload capacity metrics, the Vietnam-era carrier air wing remained stable in terms of mass; decreased but compensated in terms of range; and leapt ahead in terms of payload. The air wing had stabilized around the 80–90 aircraft figure. The supercarrier's size had remained fairly constant and, despite some adjustment, so had the sizes of the aircraft embarked, which in turn drove the air wing population. However, if consideration of mass took into account how much lethality could be focused on air wing targets, then the dramatic increases in payload capacity more than offset limitations on the size of the air wing. Vietnam-era aircraft were capable of carrying 300 percent more ordnance, 13,754 pounds on average versus the 4,522 pound average of the *Forrestal*'s mid-1950s air wing. The average unrefueled combat range of the air wing did decrease, however, from 1,210 nm to 732. This was largely due to the short range of the F-4 Phantom II, but the air wing made up for this shortfall by pioneering organic tanking through the use of A-3 Skywarriors, A-4 Skyhawks and A-6 Intruders as mission tankers, enabling the air wing to consistently execute missions in the 1,000-1,800 nautical mile range. All in all, the Vietnam era represents a net advancement in carrier air wing capabilities.

The Cold, Cold War: Competing with the Soviet Union and the Need for Range

The other iconic aircraft to emerge out of the challenges of the Vietnam era was the Grumman F-14 Tomcat. While Vietnam dominated the day-to-day thinking of the military services of the United States, the Cold War, the long simmering competition between the capitalist, democratic West and the communist East, continued unabated and drove both the force structure and force posture of the U.S. military. The emerging chief threat to the U.S. Navy in general, and its aircraft carriers in particular, was the Soviet Union's Tupolev

TU-95 “Bear” bomber, which entered service in the mid-1950s and had an unrefueled range of just over 8,000 nm.[64] The Bear emerged first as a conventional bomber, capable of carrying and gravity dropping over 20,000 pounds of ordnance on its targets. Later the aircraft was equipped with a battery of air to surface missiles ranging from the AS-3 “Kangaroo” to today’s AS-15 “Kent.” These nuclear-weapon tipped missiles had ranges in excess of 300 nm, so it was critical that the U.S. Navy field a long-range air superiority fighter that could find and engage the “Bear” bomber before it could launch its missile, thereby targeting the archer not the arrow.

The effort to build an aircraft to address this threat began with the Tactical Fighter Experimental (TFX) program. The TFX was the brainchild of the Kennedy administration’s Secretary of Defense Robert McNamara. When he came into office in January of 1961, both the Navy and the Air Force were looking for a twin engine, supersonic, high performance, multi-mission aircraft. He directed that one single aircraft be developed to meet the requirements of both services. This aircraft became the F-111, which was really a fighter/bomber. The Navy viewed the F-111 as sub-optimal. Its high wing architecture forced a higher than normal angle of attack during the final approach to the carrier, rendering the pilot blind in the final moments of approach, and its engines were too under-powered to respond to the minute adjustments required during carrier landings or while acting as a pursuit fighter.[65] When asked by the chairman of the Senate Armed Services Committee if the F-111’s engine was too weak for naval aviation, the Deputy Chief of Naval Operations (Air) Vice Admiral Tom Connolly angered both the secretary of Defense and secretary of the Navy by answering truthfully, “Mr. Chairman, all the thrust in Christendom couldn’t make a fighter out of that plane,” and thus died Connolly’s career and the F-111 as a carrier-based aircraft.[66]

The ultimate fighter-interceptor selected by the Navy, the Grumman F-14 Tomcat, emerged as a strong naval long-range aircraft. Its variable geometry wing design driven by an onboard computer meant that the aircraft’s maneuverability was optimized at all speeds. Its two 27,600-pound thrust General Electric engines may have been moderately underpowered when compared to other aircraft such as the Air Force’s F-15 Eagle, but their efficient burn rate of 3,600 pounds of fuel per hour meant that the Tomcat could loiter at its combat air patrol station 650 nm from the carrier for a prolonged period of time.[67] On station, the F-14’s backseat naval flight officer (radar intercept officer) scanned the threat axis with his AWG-9 multi-band radar out for an additional 100 nm. Capable of detecting and tracking 24 targets simultaneously, the AWG-9 was linked with the Tomcat’s primary weapon system, the AIM-54 Phoenix missile. The Phoenix represented the first beyond visual range (BVR) weapon capable of powered flight for 60 nm out while climbing to over 100,000 feet, where it began its downward arc, trading altitude for airspeed, until intercepting its target and exploding its continuous rod fragmentation warhead.[68] The F-14 was also equipped with AIM-9 Sidewinder and a 20mm Vulcan cannon. To engage incoming “Bears” before they could shoot the carrier, the combination of the Tomcat’s combat range, the AWG-9’s sensor range, and the Phoenix’s lethal range was the optimal solution.

The Tomcat was aided in its mission by the introduction of the E-2 Hawkeye, the epitome of the electronic revolution, to the carrier air wing. The E-2 emerged out a requirement to have an airborne command and control platform that was capable of seeing outward several hundred nm and reporting its contacts through the Navy's new naval tactical data system (NTDS). Developed by legendary computer designer Seymour Cray, the NTDS system was a revolutionary system that allowed combat systems on ships and aircraft throughout the naval force to communicate with each other in real time. "Contacts" created by the E-2 could be fed to shipboard systems and targeted. The E-2's task was to track up to 300 airborne and surface contacts with its APS-120 radar and share those tracks with the fleet.

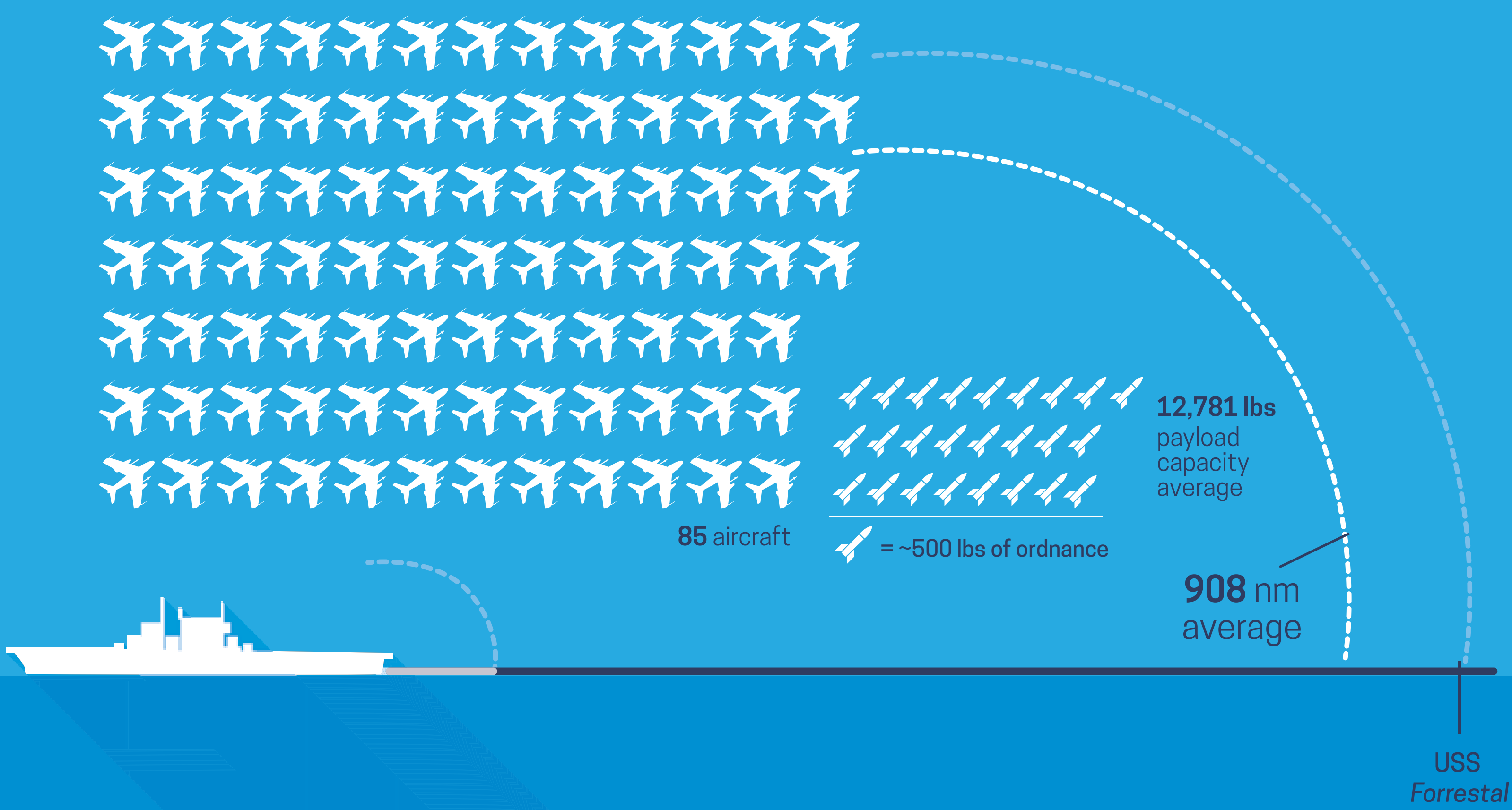
Early problems with avionics cooling and frequent system failure in flight due to heat caused the cancellation of the Hawkeye program. However, system upgrades allowed the production line to gear back up and re-enter carrier operations. Each carrier deployed with four Hawkeyes, one of which was usually one of the first aircraft to launch, and, with its six-hour endurance, was also one of the last to land. The Hawkeye carried a crew of five, originally two pilots, two naval flight officers, and an enlisted air crewman, to operate the radar. The first Hawkeye entered service in 1964, and the aircraft, highly modified, remains a mainstay of the fleet to this day, with some carrier strike group commanders recommending increasingly the Hawkeye complement assigned to the carrier from four to six.

One critical aircraft and capability that emerged out the 1960s that no longer has a place in the fleet is the S-3 Viking anti-submarine platform. Designed to replace the S-2 Tracker aircraft that had been employed on the smaller anti-submarine carriers during the 1950s and 1960s, the S-3 was developed with the rapidly modernizing Soviet submarine threat in mind. Capitalizing on electronic miniaturization, the new Lockheed aircraft, introduced in 1974, was manned by a crew of four: two pilots, one naval flight officer, and one enlisted air warfare systems operator. It was equipped with a robust surface search radar, a magnetic anomaly detection sensor, an acoustic suite capable of monitoring and analyzing sounds transmitted back to the aircraft from sonobouys dropped into the ocean, and a bomb bay that carried four lightweight torpedoes. The S-3's major characteristic was superior range: 1,750 nm of patrol over a 10-hour flight duration. This range and the addition of the ability to fire the Mk-84 Harpoon missiles against surface targets gave the S-3 two missions and shifted its community description from "anti-submarine" to "sea control." However, despite continuing demonstrations of the effectiveness of submarine detection and tracking aircraft carriers, as well as the rising requirement for surveillance and range, the S-3 surprisingly was retired from the carrier deck in 2009 with no replacement.[69]

1986

USS *NIMITZ*

Air Wing Averages (unrefueled)



Mass of platforms, range, and payload capacity...should serve as the benchmarks for measuring the effectiveness of the carrier air wing and the carrier itself.

CHAPTER 3

The Post-Cold War Retreat from Deep Strike

In 1996 the flight deck of American supercarriers sported an air wing comprised of a mass of 75 aircraft that possessed an average combat range of 815 nm unrefueled. This was not as impressive as the 1956 average range of 1,210 nm on internal gas, but it remained a respectable number, especially in light of the demise of the Soviet Union and the fading requirement for long-range nuclear strike. The average payload capacity had fallen following the retirement of the A-3 Skywarrior in 1991, but the 1996 average of 11,575 pounds of ordnance per aircraft still represented a decidedly lethal bomb load. However, within a decade the character of the flight deck would change radically, shrinking the average unrefueled range to 496 nm and the size of the air wing to approximately 60 aircraft, numbers not seen since the carrier air wings of the 1930s Fleet Problem era. The average payload capacity remained nearly constant at 12,040 pounds. Understanding how the Navy arrived at this position via the success of one aircraft and the failure of another and why naval aviation is in no hurry to reverse course presents the critical questions for policymakers today.

Birth of the F/A-18 Hornet

The F/A-18 Hornet, the ubiquitous aircraft of modern U.S. naval aviation, actually began as a land-based aircraft design presented to the U.S. Air Force. During the mid-1960s both the Air Force and the Navy were in the hunt for a fighter to replace the F-4 Phantoms that both services used heavily in Vietnam. The "F-X" study, which included submissions from General Dynamics, McDonnell Douglas, Fairchild-Republic, Grumman, Lockheed, and North American (the last four companies participated using their own funds), settled on a requirement for a single seat aircraft possessing twin engines, capable of flying 260 nm on internal fuel, and equipped with an offensive mixture of a gun and standoff missiles. In September 1968 the Air Force requested the "F-15" designation be assigned to the program. Oddly enough, both the Navy and the Air Force chose for superstitious reasons to bypass the F-13 moniker, which should have been the next fighter developed.

Not everyone in the Air Force was happy with the design parameters. Air Force Colonel John W. Bohn authored a study that called for the procurement of a high-low mix of aircraft with a small fleet of high cost/high complexity aircraft to be complemented by a large fleet of low cost/low complexity aircraft.[70] This study aided a group of iconoclasts led by Pierre Sprey and John Boyd who felt that the F-15 design was too complex to succeed and that rising costs would lower the number of platforms bought, ultimately shrinking the size of the force. Sprey and Boyd pushed for a 25,000-pound aircraft that rejected complexity and that was designed to operate primarily in the Mach .7-1.2 transonic region of maneuverability and would pursue simplicity in maintenance.[71]

The F-14 and the F-15 would remain central to service force structure strategies, targeting the new Soviet Mig-25 Foxbat fighter, but the new aircraft under consideration would handle the "low end" of the air dominance mission, going up against the more plentiful MiG-17s and 21s.[72] The combination of Sprey's and Boyd's vision led to the lightweight fighter competition. The two submissions for this competition were General Dynamic's YF-16 and Northrop's YF-17. General Dynamic's aircraft won the competition and went on to become the F-16 Falcon, one of the most successful programs in Air Force history, and the YF-17 was left an orphan – but not for long.

Naval aviation had quietly watched the Air Force's lightweight fighter competition with keen interest. Cost and complexity were already driving down the number of F-14s the Navy could buy, and many, including nearly all of Marine Corps aviation, were skeptical of the Tomcat's ability to take on missions other than that of long-range fighter-interception. Coming out of Vietnam, the carrier flight deck reflected a multitude of aircraft performing a virtuous, diverse spread of missions, from deep strike to light attack. In 1973 the Navy initiated a new effort, the Naval Fighter-Attack Experimental program, which soon was renamed the Navy Air Combat Fighter program, focused on the design and procurement of a single aircraft to replace the soon to retire F-4 Phantom II, A-4 Skyhawk, and A-7 Corsair II. During the Air Force's lightweight fighter competition, both General Dynamics and Northrop assured the Navy that they could manufacture a variant of their designs with the reinforced landing gear and tailhook required to land on the aircraft carrier.

Institutionally, the Navy took a dim view of single jet engine designs, and the narrow tricycle landing gear of the F-16 portended a long road of numerous, significant design changes to effectively transition the F-16 to the carrier environment. The YF-17, however, with its wide landing gear and dual jet engines, attracted the Navy's attention. The aircraft would still require numerous design modifications, including folding wingtips to allow for closer storage spacing, to make it carrier ready. The aircraft would eventually grow in every dimension, enough that the Navy designated its new fighter the F-18 and named the new jet the "Hornet."[73] Originally there were to be two variants of the Hornet: the F-18, an air to air fighter equipped with one set of sensors and weapons to replace the F-4; and the A-18, with a second set of sensors and weapons to replace the A-4 and A-7. Improvements and miniaturization in avionics and sensors soon led to the realization that both the fighter and attack missions could be accomplished by one aircraft, and hence the F/A-18A was born.[74]

The first iteration of the Hornet was acceptably cheap, reliable, effective, and efficient. In flight, guided by one of the first production fly by wire control systems, it quickly became known for its relative stability and ease of maneuverability. The aircraft was powered by the General Electric F404-400 engine, which produced 15,800 pounds of thrust in afterburner and could shift from idle to full power in four seconds, a characteristic that was much desired in the landing pattern where second by second adjustments of aircraft power were critical to survival. The engine, half as large as others producing similar power and composed of far few moving parts, held great potential to lower overall maintenance costs of the aircraft.

The aircraft's basic sensor was an all weather, multi-mode Hughes (now Raytheon) APG-65 radar. This radar gave the Hornet the ability to search for targets and then track them individually while continuing to scan for other aircraft while operating as a fighter-interceptor. As a ground attack aircraft, the radar's Doppler sector and ground mapping synthetic aperture radar capability allowed it to break out individual targets in a cluttered environment. The radar was supplemented by other instrument packages such as a forward-looking infrared pod or laser designator pod to aid in the delivery of precision weapons. These instruments, along with a standard electromagnetic countermeasure, were carried on one of the Hornet's nine weapons pylons: one on each wing, two under each wing, and three under the fuselage. These stations could carry up to 13,700 pounds of fuel, instruments, or weapons in any combination.[75] Taken together, the aircraft's flight characteristics, avionics, and weapons load combined to create an aircraft that was equally proficient at both fighter and ground attack modes. The term proficient as opposed to adept is an important distinction.

Around the carrier, the Hornet gained a reputation as a workhorse aircraft, but when compared with the F-14 and the A-6, aircraft that were tailor-made for their missions, the Hornet came away as a "jack of all trades, master of none" in comparison, which was acceptable at the time it was introduced. It could not carry as much ordnance as the A-6, nor outmaneuver the A-4 or outrun the F-14. Additionally, and perhaps most damning, it could not go as far as any of the other fixed wing aircraft on the flight deck. Designed to have a combat range of 400 nm unrefueled in its role as a fighter, the aircraft struggled to reach 380 nm from the carrier. In air to surface attack mode, loaded down with ordnance, the Navy's unrefueled combat range requirement was 450 nm. In testing, it reached 420.[76] Later, with the advent of the FA-18C, which entered full production in 1987, the combat ranges were noted as 366 nm for air to air and 415 nm for attack.[77] When compared alongside the A-6's 880 nm with a combat load or the F-14's 1,065-nm range in air intercept mode, the new Hornet came up woefully short in range, a characteristic that had dominated aviation requirements since the end of World War II.[78] This was acceptable so long as the carrier air wing continued to have a strong bias towards long-range capabilities and contained an offsetting strong organic tanking capability in the KA-3 and the KA-6, but the retirement of these aircraft and subsequent decision regarding their successors had significant impacts on naval aviation in the years ahead.

The A-3 Skywarrior made its final wartime deployment in early 1991 as part of Operation Desert Storm. Later that fall the decision was made to formally retire the aircraft from service. Its tanking mission was taken up by the KA-6s and the electronic surveillance capability was integrated into the S-3 Viking community, which fielded a small population of highly modified aircraft to provide the carrier with support. In the days following the end of the Cold War, the requirement for a continued long-range, heavy attack capability could not be justified. The A-6 Intruder would continue the medium-range strike.

The A-6 Intruder, for its part, approached the end of the 1980s in a strong position. To replace aircraft lost in training accidents and integrate improvements along the way, the aircraft had remained in low rate production of four to six aircraft per year throughout the post-Vietnam era. A systems/weapons improvement program (SWIP) incorporated upgrades including a new targeting and navigation suite and an integrating system computer. These improvements added the ability to self-designate and drop laser-guided bombs, bringing the Intruder into the precision strike age. Software improvements also added a moving target indicator, which allowed the aircraft's sensors to follow, target, and attack a designated platform (tank or truck) even if it moved. The Intruders were also given a weapons control system improvement upgrade that enabled the venerable Intruder to carry new weapons such as the Harpoon, Skipper, and Stand-off Land Attack Missile (SLAM). A string of issues related to wing fatigue, not at all unexpected given the nature of low level attack routes, led to the replacement of the wings on 80 percent of the fleet. The new wings, constructed of a composite of graphite, titanium, and aluminum, were stiffer and stronger than the original designs they replaced. The unexpected result was that they imparted more force to the base fuselage, causing the fleet's material readiness to expire earlier than expected. However, the Intruder community had reason to hope; after all one of them, John Lehman, a reserve A-6 bombardier navigator, was the Secretary of the Navy and a big proponent of the A-6F Intruder II.

A Lost Gamble for Range, Payload, and Survivability: The A-12

In 1984 Naval Air Systems Command began setting aside money to develop a new variant of the Grumman A-6 design. Integrating the new F404 engines designed for the F/A-18 Hornet, the Intruder II would have the very latest in sensors, weapons, and onboard computers to integrate it all together. The AN/APQ-173 radar promised better imaging capabilities at longer ranges as well as new targeting modes. The radar was to be integrated into a digital avionics suite based on lessons learned from the Hornet's development, as well as recent upgrades to the F-14 Tomcat. The new avionics would feed five displays inside the aircraft: two for the pilot and three for the naval flight officer, providing both with state of the art "heads up" awareness. With regard to weapons, Grumman added two new wing stations that could carry the AIM-9L Sidewinder and AIM-120 advanced medium range air to air missile (AMRAAM) for self-defense without decreasing the number of bombs the aircraft could carry. The new avionics suite, with its digital interfaces, ensured that the aircraft could deploy the very latest in precision strike weapons.[79]

The upgraded design met resistance from many circles. The A-6 was increasingly vulnerable to radar-guided gun and missile fire, mostly due to its large radar cross section. While its combat range and large payload capacity continued to draw support, analysts looked to a future where increasingly dense anti-air defense networks dominated and felt that it was time to move on to a design that leveraged new stealth technologies that had emerged out of the second offset investments of the late 1970s. It can be said that it was at this point that low observability, or "stealth," joined mass, range, and payload capacity as a key characteristic desired by naval aviation. Grumman made one final attempt at retaining its niche in the naval attack market by "stealthying" an A-6, but even Grumman fan Lehman had to inform company officials that time had moved on and that the Navy would be looking for a new design within the advanced tactical aircraft (ATA) program. To their credit, the engineers at Grumman looked at the requirements laid out for the ATA and stated that the aircraft could not be built for the price requested.[80] They proved to be prescient.

On August 21, 1980, after years of secret development in partnership with industry, the Department of Defense announced that it was developing a new technology that promised to change the balance of power: stealth. Deputy Secretary of Defense Paul Thayer, a former Navy fighter pilot in World War II and later the CEO of an aerospace company, thought that a new type of aircraft could be designed for the same price as it would cost to upgrade the existing A-6: $800 million. Analysts within the Pentagon's Program Analysis and Evaluation office pushed back hard, suggesting that a new aircraft would cost several billion dollars to develop and, given the costs associated with stealth, each aircraft's unit costs would be very high. The Navy in turn pushed back, estimating ATA unit costs as 20 percent above remanufactured Intruders.[81]


Naval History and Heritage Command

A bow view of the nuclear-powered aircraft carrier USS *Nimitz* and its airwing underway during Operation Southern Watch.

The Navy issued a series of guidelines describing the new attack aircraft. There was room for some aircraft growth, as much as 7 percent above the size of the A-6. The maximum wingspan was 82 feet. Supersonic speed was also desired, using existing engines, in all probability the FA-18's F404 engine, which was getting enthusiastic reviews for its maintenance costs and stability. Payload capacity was reduced from the A-6's 18,000-pound load down to 6,000 pounds, all carried internally in the bomb bay. Range remained critical. The Navy wanted an aircraft that could double the A-6's 880-nm range to 1,700, and they wanted the aircraft to incorporate stealth, specifying a radar cross section signature smaller than that of the F-117 aircraft.[82] It was an ambitious, even audacious, request, but was well in line with the arc of technology and remained true to naval aviation's desire for mass, range, and payload capacity. The Navy also wanted the selected manufacturer to build the aircraft, named the A-12, under a fixed price construct with a maximum program ceiling built in. This had immediate negative results.

The Navy expected that three teams would bid to build the A-12: Lockheed; Northrop, teamed with Grumman and Ling-Temco-Vought; and a team made up of McDonnell Douglas and General Dynamics. The Navy thought that this type of open competition among all the major defense aviation companies would help to drive costs down. It didn't. The first two teams, led by Lockheed and Northrop, pulled out of the competition rather than risk their company's bottom lines and financial solvency on a fixed cost contract for a new aircraft. This left the McDonnell Douglas/General Dynamics team as the last player on the field, a fact that the Navy did not see fit to share.[83] Now, McDonnell Douglas/General Dynamics strained themselves to win a completion that had no competitor.

The McDonnell Douglas/General Dynamics team presented a flying wing design in the shape of an isosceles triangle. The cockpit, which would hold two crewmembers, a pilot, and a naval flight officer in a continuation of the A-6 crew combination, would sit atop the apex of the nose. The aircraft would be larger: 70 feet from wingtip to wingtip and 36 feet long, weighing in at 80,000 pounds fully loaded. When completed, it would be more akin to the A-3 Skywarrior than the A-6 Intruder. Capable of carrying 6,000 pounds of ordnance within its internal bomb bay, the aircraft was originally designed with a combat radius of 1,000 nm .[84] Modifications and additional weight ultimately brought this range down to 785 nm.[85] McDonnell Douglas/General Dynamics were selected as the prime contractor in January 1988 with the expectation that they would begin delivering aircraft in 1990. That did not happen.

The decision by then-Secretary of Defense Richard Cheney to cancel the A-12 program on January 7, 1991, has been autopsied more than any other acquisition decision in recent history, including a full disclosure review in the federal courts that resulted in a multi-billion dollar settlement. The combination of many factors – the advent of the Goldwater-Nichols Act and accompanying survey of service roles and missions; the end of the Cold War and subsequent drawdown of the size of the Department of Defense with a concurrent contraction of the defense budget; and fundamental mismanagement and fiduciary malfeasance on the part of Navy managers – during the critical embryonic stages of the A-12 program culminated in its failure. Unfortunately, with its demise so too went the Navy's ability to conduct sustained deep-strike missions from the carrier.

The Goldwater Nichols National Defense Reorganization Act of 1986 sought to strengthen civilian control of the military and delineate clearly the powers of the chairman of the Joint Chiefs of Staff with regard to his role as the senior military advisor to the commander in chief, as well as the powers of the regional and special combatant commanders. The act also called for increased oversight of cost growth in major weapons programs and the elimination of existing overlaps in roles and missions between the services. In particular, Section 153 of the act empowered the chairman of the Joint Chiefs of Staff to conduct a periodic review of the threats facing the United States and to use the reviews to eliminate unnecessary duplication of capabilities within the joint force.[86] The end of the Cold War, symbolized by the fall of the Berlin Wall in November 1989 and subsequent dissolution of the Soviet Union, gave more than ample reason and opportunity for such an examination.[87] Both the chairman of the Joint Chiefs, General Colin Powell, and the staff of the Office of the Secretary of Defense were inclined to believe that deep strike was a mission with excessive overlap between the services.[88] There was also a desire to reap a "peace dividend" and shrink the Pentagon's budget, which had risen dramatically under Ronald Reagan during the 1980s.

The administration of George H. W. Bush continued the initiative begun at the end of Reagan's second term to shrink the defense budget. After a dramatic rise from 1981 to 1984, Reagan's budget peaked and then declined by an average of $15 billion a year for the remainder of his presidency. When Bush came into office in January 1989 the Soviet Union was already headed toward dissolution, so there was no reason to reverse this trend and build up again. Hence, Bush defense budgets continued to decrease by an average of $20 billion per year. This fiscal contraction pressurized existing procurement programs and terminated new ones.[89]

Poor, if not criminal, program management on the part of naval aviation provided the final nail in the coffin. The A-12 design underwent numerous changes, many of which negatively impacted the fundamental mission of the aircraft (long-range strike). The government withheld vital information gathered as a result of previous government sponsored (and hence non-proprietary) research regarding stealth and engine design from the manufacturing team, resulting in rising costs and program delays. Combat range came down as aircraft weight went up. When the mass of difficulties came to light and Cheney decided to pull the plug on the A-12, the program had gotten so out of control that consideration was given to court martialing the active duty military program manager under a charge of dereliction of duty.[90]

It was not immediately understood that the cancellation of the A-12 represented an end to naval long-range strike. The A-6 Intruder was still in the fleet and remained in production in various forms at the Grumman plant on Long Island, which continued to produce new aircraft until January 1992.[91] There was every expectation after the cancellation of the A-12 that the Navy would "re-attack" the problem, come up with a less expensive and complex design, and get a replacement for the A-6 into production. However, the 1993 Defense "bottom up review" (BUR) and the parallel roles and missions review arrived at a controversial decision. The BUR advanced a requirement to fight two major regional conflicts simultaneously, presumably on the Korean peninsula and in the Middle East. Air and sea dominance arguments within the force structure advanced. The roles and missions discussion took the next step of seeking to streamline the force and eliminate unnecessary capabilities overlaps. Powell announced that there was no requirement for the Navy and the Air Force simultaneously to maintain long-range strike aircraft.[92]

In the meantime, the Navy recognized that it had an immediate problem to solve: the prospect of a rapidly depopulating flight deck. The cancellation of the A-12 and subsequent decision to not acquire a replacement aircraft for the A-6 did nothing to extend the life of the existing aircraft. A low-level, high-G maneuvering platform meant that Intruders needed strong wings, and time and flight hours were rapidly weakening them. The decision was made to "sundown," or remove the aircraft from the Navy's inventory. The last Intruder carrier landing occurred in 1997.[93] Their absence represented a considerable hole in the carrier air wing's inventory.

Sortie Generation Trumps Range: The F/A-18E/F Super Hornet

As early as the late 1980s, senior government officials and Navy admirals were looking to spiral develop the F/A-18 Hornet to "enhance" its capabilities. The original F-14 airframes were nearing the end of their service life, and aviation leaders were casting around for a suitable successor to the now venerable aircraft. Attempts to sell a "Tomcat 21" modified F-14 for use in the 21st century met resistance from a growing "Hornet Mafia" within the Navy and the Department of Defense.[94] The F/A-18's low costs, ease of maintenance, and forgiving nature in the air won it fans and adherents from all aspects of naval aviation.[95] With the last new Tomcat produced in 1992, the aircraft continued to serve until 2006, even leveraging their vaunted long-range capability to deliver laser-guided ordnance into Iraq and Afghanistan as "Bombcats" before retiring from the fleet in 2006.[96]

[GENERAL COLIN] POWELL ANNOUNCED THAT THERE WAS NO REQUIREMENT FOR THE NAVY AND THE AIR FORCE SIMULTANEOUSLY TO MAINTAIN LONG-RANGE STRIKE AIRCRAFT.

The decision to pursue a modified F/A-18 rather than a new replacement aircraft of similar or better characteristics for the F-14 Tomcat and the A-6 Intruder represented recognition of the constrained fiscal environment in the years immediately following the end of the Cold War. Navy officials in 1991–1992, as related in a later Congressional Research Service F/A-18E/F program brief, believed that "greater range/payload capabilities … [were] less essential for fleet defense with the demise of a Soviet threat." Instead, planners elected to invest in lower-end conflict scenarios that foresaw carriers operating in the littoral waters nearer their targets. Emphasis was placed on reliability and sortie generation capabilities. In the language of strategic planners, long range was an area where the Navy and the Department of Defense decided to "accept risk." The decision was made to purchase new variants of the F/A-18 Hornet, the "E" and "F" models, to replace retiring Intruders and Tomcats.[97]

The F/A-18E/F aircraft in many ways should not be considered as a mere extension of the legacy F/A-18 Hornets of the A, B, C, and D varieties. The new Hornets shared very little in the sense of dimensions. Whereas the F/A-18C measured 56 feet in length and 40 feet in wingspan, the newer F/A-18E "Super Hornets" rolled off the assembly line at 60 feet in length and with a 45-foot wingspan. Both aircraft were Mach 1.8 capable in speed.[98] A key difference in the aircraft was fuel load. The legacy Hornets carried 10,381 pounds of fuel internally, but the Super Hornet's larger size allowed it to carry 14,500 pounds. This translated to an increase of 100 nm in range for the Super Hornet, pushing the aircraft out to just beyond 500 nm on internal fuel.[99] Recently, Boeing has pioneered super-laminar conformal fuel tanks for Super Hornets that can carry 3,500 additional pounds of fuel, extending the range of the aircraft by 100 nm with little lost to drag or increased radar cross section.[100] This capability could significantly alter the mission profile of current carrier air wings if conformal tanks are purchased in bulk. Super Hornets cost $85 million each to produce.[101] In the end, the E, and F "Super Hornets" shared a common profile with legacy Hornets but were dramatically different in capabilities.

The Super Hornet also came with mission enhancements, including some significant stealth accruements that lowered the aircraft's overall radar cross section. In addition, the new planes came equipped with the Raytheon built AN/APG-73 radar, which had three times the processing power and was more reliable than the predecessor APG-65 system. Its processor demonstrated an ability to detect smaller targets at an increased range and saw similar advances in its track while scan (TWS) mode. It also incorporated ground-mapping capabilities that aided the aircraft in its ground attack role, allowing for precision strikes on targets from an increased range.[102]

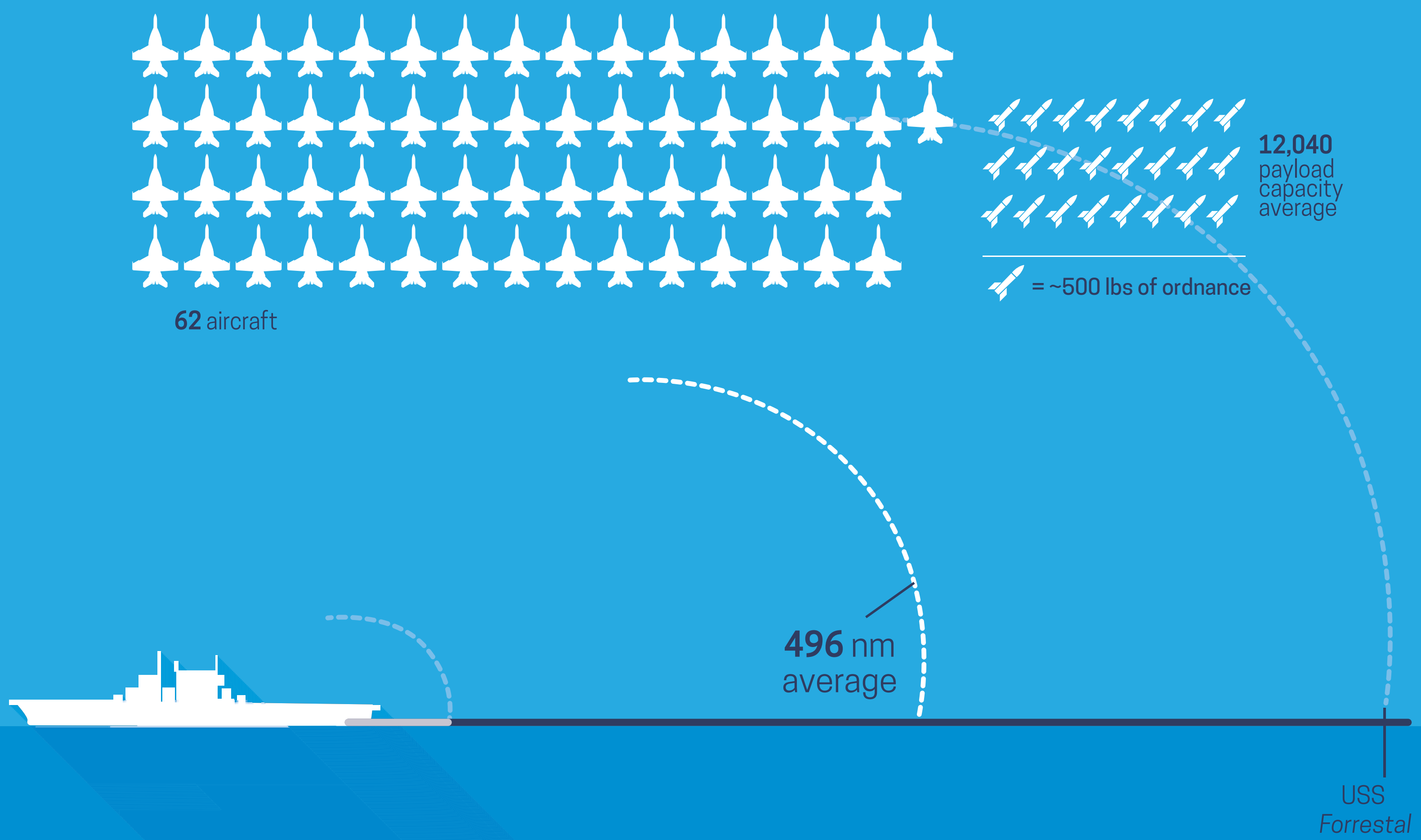
The air-intercept and ground-attack missions were aided by the aircraft's increased weapons load out capacity. The legacy Hornets could carry 13,700 pounds of ordnance hung on nine stations, but the Super Hornet's increased size allowed it to carry 17,000 pounds on 11 stations.[103]

The demise of the A-6 coincided with the extinction of the KA-6 mission tanker. As previously stated, the KA-6's 26,000 pounds of fuel give allowed it to drag eight aircraft out to 1,800 nm. The Navy recognized the loss of this capability would have a significant impact on carrier air wing operations. As such, the F/A-18F was configured to serve as a mission tanker by carrying up to five external fuel tanks. In a "three-wet" configuration (carrying three external fuel tanks), the standard for most air wing operations, the Super Hornet has nearly 9,000 pounds of fuel give and can drag four other Hornets out to 1,000 nm. Still, the gentle decline from the KA-3 Skyraider's ability to tank 12 aircraft out to 1,800 nm to the KA-6's ability to enable eight aircraft to that same distance is dramatically interrupted by the Super Hornet's limitation of only being able to support four aircraft to 1,000 nm. However, Navy and Congressional leaders recognized this limitation and planned accordingly for the Joint Strike Fighter (JSF) to take up the long-range strike role and extend the range of the carrier air wing.[104]

2006

USS *NIMITZ*

Air Wing Averages (unrefueled)



The combination of diversity and balance in the air wing design remained until the 1990s, when the cancellation of the A-12 and subsequent default to a F/A-18 Hornet-centric, "jack of all trades, master of none" air wing resulted in a reduction in mission capabilities, decrease in average range, and increased imbalance in the overall makeup of the air wing as the short-ranged, light attack mission crowded out other capabilities. These effects have significant implications for the Navy and the nation whose interests it protects.

Completing the Retreat from Range: The F-35 Lightning II

The JSF, following a decade behind the introduction of the Air Force's F-22 stealth fighter-interceptor, was intended to serve as a fifth generation replacement for the Navy's F-14 Tomcat and F/A-18C/D legacy Hornet; the Air Force's F-16, F-15, and A-10 Thunderbolt II; and the Marine Corps' AV-8B Harrier. It represented an attempt at a significant qualitative leap in aircraft design and performance. The original design focused on incorporating stealth technology – the new metric of success in naval aviation along with mass, range, and payload capacity – in the aircraft's external shape, which is designed with a series of odd and un-aerodynamic angles that are intended to reflect radar energy away from a receiver, and its skin, which is composed of a variety of radar absorbent materials. The aircraft's radar is Northrop Grumman's AN/APG-81 advanced electronically scanned array (AESA) system, whose processor electronically steers the beams emitted by the system in a very discreet and accurate manner. [105] The aircraft also comes equipped with the AN/ASQ-239 electronic warfare suite that both senses and transmits in a multispectral manner to protect the JSF and blind its opponents.[106] Advanced designs and software integrate sensors and communications in a sophisticated manner to both ease the transfer of information and present massive amounts of data in a coherent manner.

Presentation of tactical information is a key element of the JSF design. While glass panel instrumentation remains a leading feature of the JSF cockpit, a new helmet produced by Visual Systems International will provide the pilot with critical aircraft performance indicators, as well as threat and targeting information, in a more intuitive manner. The objective of the helmet's design was to increase pilot awareness of his entire environment and to allow him to focus on tracking targets vice monitoring the aircraft. The aircraft itself, through the fusion of instrumentation, was intended to become an extension of the pilot's own senses and body. New upgrades to weapons, both air to air missiles as well as air to ground ordnance, were designed to fire and hit targets off-axis, which is to say that the aircraft need not be oriented at its enemy in order to engage it. If successful, this tightening of the observe-orientate-decide-act loop would represent a true leap ahead by the Joint Strike Fighter in air warfare over the fourth generation aircraft, such as the F-14 Tomcat and A-6 Intruder, it was designated to replace.[107]

However, if the Joint Strike Fighter truly was going to replace the capabilities of the F-14 Tomcat and the A-6 Intruder, then range should have been a critical factor in its design. According to the Defense Acquisition Executive Approved Acquisition Baseline dated Oct. 26, 2001, the carrier variant of the Joint Strike Fighter was to have a combat range of 730 nm with a full combat load of 6,000 pounds of ordnance carried within its internal bomb bay.[108] This distance represented only 75 percent of the range of the aircraft the JSF was intended to replace, but it was thought that tanking could extend the platform's range to allow for mission accomplishment, an odd assumption given the contraction of tanking capability within the carrier air wing. By 2010, when the first lot of prototype aircraft completed initial testing, the F-35C's estimated unrefueled combat range had dropped to 615 nm. Extensive tests on the Air Force's F-35A version, which represents a lighter version of the aircraft, have resulted in a combat radius of 590 nm for that aircraft. Analysis suggests that the F-35C, built with the heavier landing gear and tailhook assembly required for aircraft carrier operations, will have an effective combat radius around 550 nm, exceeding the F/A-18 E/F Super Hornet aircraft by 50 nm, but falling several hundred nm short of the fourth generation Tomcat and Intruder aircraft. [109] The naval variant of the F-35 is expected to cost $130 million apiece to produce.[110]

CHAPTER 4

Restoring Balance to the Carrier Air Wing

Throughout its history, the carrier air wing was characterized by aircraft of varying capabilities and attributes. While key characteristics such as range and payload capacity lay behind the overall design of the air wing, at the squadron level the aircraft were originally optimized for roles as fighters, dive-bombers, torpedo bombers, and scouts, and they were designed accordingly. As such, the carrier air wing brought a diverse and yet balanced set of capabilities to bear on challenges that confronted the Navy and the nation at sea. This combination of diversity and balance remained until the 1990s, when the cancellation of the A-12 and subsequent default to a F/A-18 Hornet-centric, "jack of all trades, master of none" air wing resulted in a reduction in mission capabilities, decrease in average range, and increased imbalance in the overall makeup of the air wing as the short-ranged, light attack mission crowded out other capabilities. These effects have significant implications for the Navy and the nation whose interests it protects.

… THE CANCELLATION OF THE A-12 AND SUBSEQUENT DEFAULT TO A F/A-18 HORNET-CENTRIC, "JACK OF ALL TRADES, MASTER OF NONE" AIR WING RESULTED IN A REDUCTION IN MISSION CAPABILITIES, DECREASE IN AVERAGE RANGE, AND INCREASED IMBALANCE IN THE OVERALL MAKEUP OF THE AIR WING AS THE SHORT-RANGED, LIGHT ATTACK MISSION CROWDED OUT OTHER CAPABILITIES.

Learning from the Past

The present challenges facing naval aviation are not all attributable to the Navy or naval aviation writ large. Rather, current circumstances are the product of a series of decisions that immediately followed the demise of the Soviet Union and the end of the Cold War. The triumph of liberal, democratic capitalism announced "the end of history," and the sense of ebullience that characterized this period led to a series of choices that had roots in fiscal constraint, a desire to refocus on internal challenges, and a sense of an advantageous and permissive strategic environment.

The first decision point was the cancellation of A-12 Avenger II aircraft. Massive cost overruns and the lack of a tangible existential threat to justify the expense made the decision to terminate the A-12 easy. Similarly, in the bottom up review and roles and missions review that occurred in the early 1990s, the sense of invulnerability allowed political leaders to cut the size of the military and uniformed leaders to streamline roles and mission in such a way that the long-range deep strike mission no longer fell within the Navy's portfolio.

Within the strategic context of the 1990s, the decisions to replace A-6 Intruders and F-14 Tomcats with F/A-18E/F Super Hornets and to allow the future Joint Strike Fighter's designed range requirements to shrink do not seem completely out of order. The campaigns that the nation and the Navy found themselves participating in gave a false sense of permanence. Operation Desert Storm in 1991, operations in Yugoslavia from 1995 to 2000, and the 2003–2012 Iraq War were all conducted in permissive maritime environments that allowed U.S. aircraft carriers to operate just offshore of target nations, maximizing the on-station time of their aircraft. Even in the Afghanistan campaign, where naval aircraft had to transit hundreds of nm, tanking several times from large Air Force and allied tankers, occurred in an aerial environment that was permissive. Even though knowledge of rising anti-access/area-denial capabilities rose in the late 1990s, the Navy's mindset chose to emphasize sortie generation as the preeminent requirement, not long-range, long-duration flight profiles. Today there is an entire generation of naval aviators, to include rising admirals, who do not "remember" the long-range fighter-interceptor or deep strike missions of the past. They also don't remember the pain of long slog campaigns, and have even recommended a return to a sea control, long war, and attrition strategy as a means of dealing with anti-access/area-denial capabilities.[111]

Intensifying Challenges to the Carrier Air Wing

The nature of the military campaign has evolved. Following the 45-month slog of World War II, military planners sought to develop weapons and platforms that could project power deep into enemy territory in order to reach their capital and effect regime change. Short, decisive wars were considered the ideal form of modern warfare, and the development of stealth and precision strike weapons represented the natural expression of this ideal. However, as history consistently tells us, the enemy gets a vote in battle.

Following Chinese missile tests into waters around the island of Taiwan in order to intimidate the island nation prior to the 1996 Taiwan presidential election, the United States dispatched the supercarrier *Nimitz* (CVN-68) to sail through the strait in a demonstration of U.S. support for free, democratic elections. China, noting the success of the United States in utilizing precision strike weapons against Iraq during the 1991 war and its success with precision strike and stealth during recent Yugoslavia campaigns, set upon a path to develop a series of weapons focused on pushing American power-projection forces away from their nation. Bombers, anti-ship cruise missiles, submarines, and mines all emerged from this initiative, but the prime example of Chinese innovation was the DF-21D anti-ship ballistic missile (ASBM), otherwise known as the "carrier killer."

The DF-21 ASBM represents World War II Admirals Mitscher and McCain's Kamikaze threat reincarnate. A knockoff of the American Pershing II missile, the DF-21D has a range of around 1,000 nm. It earns its ASBM designation through the addition of a maneuverable reentry vehicle warhead that approaches its target at a near-vertical ballistic angle, at hypersonic speed, and with the capability to execute a series of complex maneuvers during its descent, greatly complicating defensive counter-fire. The warhead is thought to be composed of numerous cluster munitions that would spread out across the deck of the supercarrier, disabling or destroying exposed aircraft, radar dishes, and antennae as well as killing the flight deck crew, achieving a mission kill without necessarily sinking the ship. To keep the carrier in the fight, the U.S. Navy has invested billions of dollars to develop a ballistic-missile defense capability, including anti-ballistic missiles, directed energy, electromagnetic rail guns, and electronic jamming and deception. Analysts, however, remain unconvinced as to the effectiveness of these efforts or their relative cost efficiency.

There is also a challenge to the air wing itself as presently composed. Vietnam represented a significant rise in the complexity of integrated air defense systems (IADS), and the number of American pilots killed or captured during that conflict ably demonstrates that nations who are willing to invest in IADS can deter others from operating with impunity within their airspace. The opening hours and days of the campaigns in Iraq, Yugoslavia, and Libya, which saw concentrated attacks on those nation's IADS, demonstrate the respect owed to even older air defense systems. However, these IADS networks pale in comparison to the more modern IADS capabilities being fielded by nations such as North Korea, Iran, Russia, or China, which are comprised of layers of sensors, aircraft, and missiles that are overlapping, dense, and lethal, making it difficult for carrier aircraft to penetrate and impossible for the large-winged Air Force tankers, the only aircraft with sufficient fuel give capacity to drag a carrier air wing into the threat zone, to operate in and around.

If the carrier is to remain relevant in the future security environment, if the nation is to plan short power projection campaigns rather than revert to slow sea control campaigns, the Navy needs to re-establish range and a deep strike mission capability as a core design parameter along with the increased survivability (i.e., broadband, all-aspect radar cross section [RCS] reduction) that proved elusive a quarter-century ago with the A-12. This could be done by developing a new long-range, deep strike asset in line with the A-3 Skywarrior and A-6 Intruder of the past that could take off from the carrier, fly more than 1,500 nm, penetrate a dense anti-air network of sensors and missiles, deliver multiple weapons on target, and then return to the carrier. Given the physiological demands of the length of the mission driven by stand-off distance and/or the need to loiter on-station to find mobile or time critical targets, the minute energy management and split second timing involved in penetrating a dense anti-air network, and the current development of technology, the research community has begun to investigate the development of an unmanned platform to accomplish this mission.

The X-47B arose out of the Joint Unmanned Combat Air System, which was canceled in 2006, with the nearly $2 billion in funding associated with it allocated to the Navy for further development. The Navy initially attempted to reallocate the funding line to other programs, thus effectively killing the Navy unmanned combat air system in its infancy, but then-Secretary of Defense Robert Gates intervened through his 2008 *Guidance for the Development of the Force* document, which directed the development of the X-47B as a test vehicle for integrating unmanned combat craft into the carrier air wing. Currently, the X-47B aircraft has completed carrier landing as well as air-to-air refueling tests with only minor difficulties.[112] The X-47B weighs 40,000 pounds fully loaded and has a range of 2,100 nm.[113] As a test vehicle it carries no ordnance.

United States Navy

The X-47B serves as the vital experimental bridge between manned and unmanned carrier aviation.

In May 2010 the Navy issued a request for information for a carrier-based unmanned platform nominally called the unmanned carrier launched aerial strike and surveillance (UCLASS) aircraft. Initial requirements suggest that the Navy is seeking primarily a surveillance aircraft with low-observable (stealthy) characteristics that can fly for 10–14 hours. In future deployments, each air wing would be equipped with four to six of these craft. These initial requirements have been met with resistance on Capitol Hill, where senior defense-focused senators and representatives from both political parties have urged the Navy to consider making long-range deep strike the primary focus of the aircraft's design.

The implications behind the emphasis on surveillance as the predominant mission of the UCLASS platform has startling parallels with the actions and attitudes of the battleship admirals of the 1920s and 1930s with regard to early naval aviation. As previously discussed, calcified in their ways, the battleship clique could only envision naval aviation serving as spotters in support of battleship gunfire. Today the public statements of tactical naval aviation admirals, who make up 26 percent of unrestricted line flag officers, do not appear to consider unmanned aircraft operating from the carrier deck in any other role than surveillance or "spotter" for the carrier and its air wing. Air-to-air and strike missions, it seems, can only be performed by manned aircraft. As a wise man once said, history may not repeat itself, but it sure rhymes.

If the Navy wanted to build on the lessons of naval aviation's evolution in the post-World War II period and purchase a carrier-based unmanned combat aerial system (UCAS), such an aircraft could provide the long-range, deep strike capability necessary to keep the supercarrier relevant and in the fight, even in a mature anti-access/area-denial environment. Such an aircraft would possess a wingspan of approximately 60–70 feet, a gross takeoff weight of 60,000–70,000 pounds, and an internal bomb load of 4,000–6,000 pounds. It would also have an unrefueled combat radius of over 1,500 nm, a refueled mission endurance measured in days, and broadband, all-aspect RCS reduction. With a very low RCS across the threat radar spectrum, a carrier-based UCAS could also provide difficult to counter, low power, stand-in jamming support, reducing the vulnerability of manned F-18s and F-35s to enemy IADS.

These aircraft would bring a new critical characteristic to the carrier air wing that would both complement and strengthen the mass, range, payload capacity, and low observability characteristics identified in the past. The new characteristic would be persistence: the ability to remain present and on-station for days on end. The baseline design would have both a very long mission duration and combat range on internal fuel. When combined with additional UCAS manufactured without stealth accruements serving as a mission tanker capable of providing over 25,000 pounds of give fuel to its counterparts within the air wing, the mission aircraft could remain airborne for up to 50 hours at a time during critical periods, landing only to change lubricating fluids. Persistence would allow these aircraft to maintain constant, unblinking surveillance and targeting of key geographic areas, enabling these aircraft to locate mobile platforms that move infrequently and yet quickly. It would also eliminate the need for constant transit to and from the carrier.

To be sure, such an aircraft would not be inexpensive. An unmanned combat air system for the carrier could cost upwards of $175 million to procure. It would, however, have two to three times the unrefueled combat radius of manned fighters, several times the mission endurance, and enhanced survivability. Moreover, it is important to realize that while a $130 million Joint Strike Fighter might spend 80 percent of its life in the air pattern around the carrier maintaining the day and night carrier landing qualifications of its human pilot, the UCAS could be flown only when needed for combat operations and could be shifted from carrier to carrier as they deploy, allowing for a smaller buy of five or six squadrons' (90–110 units) worth of aircraft to equip each operational carrier in the fleet with a squadron, rather than the 10 squadrons and training birds that are purchased for manned programs. As CNAS Senior Fellow Paul Scharre recently stated, the range of potential savings associated with a decision to shift from manned to unmanned aircraft on the carrier could save the Navy anywhere from $54 to $170 billion over the life of the program.[114] In the end, a UCAS may well be not only the most lethal aircraft on the carrier, it could also be the most fiscally efficient aircraft in the air wing.

Options

Naval aviation has a number of options going forward, all of which are restricted by technological maturation and the fiscal environment. The current path as planned must remain under consideration, though the Navy has to accept that such a path in the face of a rising competitor who is clearly targeting the carrier's unique capabilities will result in continued questioning of the viability of the carrier as a funded program, given the range limitations of the aircraft within the air wing. A second option would explore maintaining the core of the current carrier air wing program path while amending the UCLASS program to re-orient its focus on the strike mission versus reconnaissance in A2/AD environments. The third path would seek to shatter the current carrier air wing construct to free resources to accelerate the development of a new air wing to address current and future threats.

OPTION 1

Option 1 continues the trajectory of purchasing two Super Hornet squadrons of 12 aircraft each, two Joint Strike Fighter squadrons of 10 aircraft each, and one UCLASS squadron of six aircraft focused primarily on surveillance and reconnaissance for each carrier air wing. Naval aviation will also continue to pursue the development of a sixth generation FA-XX aircraft to replace the Super Hornets when they retire. This option has the advantage of continuing an established procurement plan that has already cleared most of the acquisition hurdles and has the potential for the fewest surprises. The aircraft in question are well understood and have either already worked together and with the aircraft carrier or are undergoing transition and development testing now.

However, this path provides few options in terms of mass (the air wing, at 62 aircraft, is not large enough to cover the area of responsibility), range (the average range unrefueled remains around 500 nm), persistence (the Hornets and Joint Strike Fighters do not have the endurance or the tanking support to remain on-station for long), and aircraft survivability (Hornets are not able to operate safely within modern IADS networks). Policymakers will face a hard decision when going up against an enemy with a fully developed anti-access/area-denial infrastructure. They will either have to risk the lives of 5,000 American sailors and $14 billion in assets (the cost of the current *Ford*-class carrier) by committing the ship and its air wing to a power projection mission within the enemy's A2/AD envelope or choose to pursue a long and costly sea control campaign that slowly destroys the enemy's navy and merchant fleet over time.[115] Neither alternative is compatible with current American methods of war.

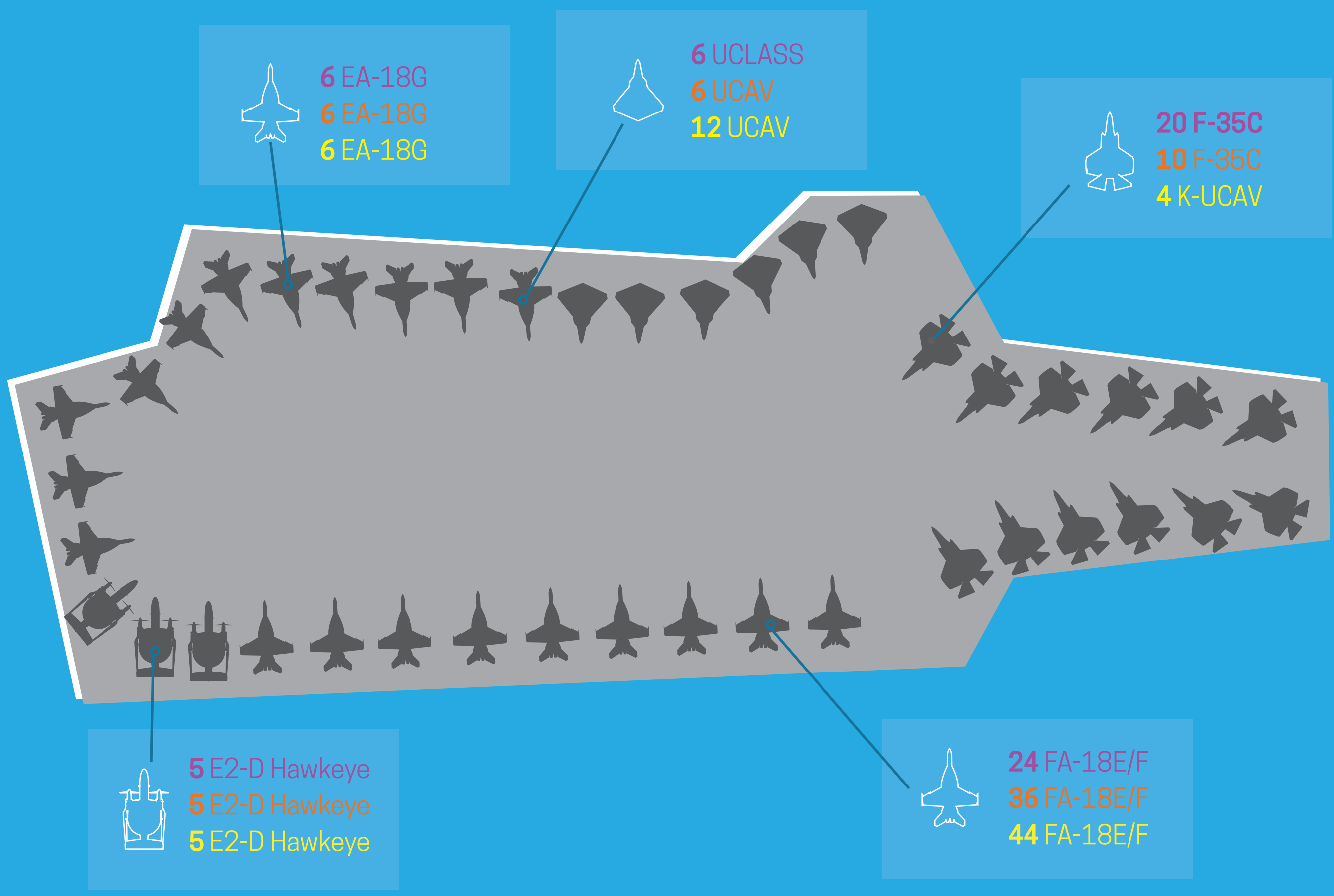
The participation of naval aviation in the long campaigns in Iraq and Afghanistan placed unforeseen pressures on the force. Aircraft life is measured in flight hours, and many legacy F/A-18C/D Hornets burned up their 8,600 hours of operational life well before expected. The naval aviation force presently finds itself with a 140 aircraft shortage in its planned inventory. However, deployments and training continue to place demands on the remaining force, and given that there are fewer aircraft in the inventory, those that remain find themselves in what is called within the profession a programmatic "death spiral" wherein aircraft are increasingly called upon to fly more hours than originally planned to make up the shortfall, accelerating their own demise. In this environment, the replacement aircraft, the Joint Strike Fighter, cannot arrive in the fleet soon enough. Considering the cost associated with the naval variant of the Joint Strike Fighter ($130 million apiece in flyaway cost), it is unlikely that the Navy will achieve a one for one exchange of Joint Strike Fighters for legacy Hornets aircraft as the older aircraft retire.

Such pressures suggest the need for Congress to extend the Super Hornet production line to make up the inventory deficit, and there will be a strong temptation to continue this as the aircraft continues to evolve, incorporating conformal fuel tanks, more efficient engines, and other electronic sensors that will improve its performance. The extension of this reasoning also suggests that limited budgets will compel the Navy to look closely at canceling of the UCLASS program given its estimated cost (approximately $100 million apiece) and the fact that the Navy has sufficient off-carrier unmanned surveillance and reconnaissance capacity in the land-based MQ-4C Triton broad area maritime surveillance aircraft to meet its ISR requirements.

OPTION 2

Option 2 accepts the inevitability of the underlying factors that led to the outcome of option 1 and proposes the moderately conservative approach of a "slip and trim" truncation of the Joint Strike Fighter buy, which would move the initial purchases of the naval F-35C further out and trim the total number of F-35s purchased, making up the shortfall by extending Super Hornet production to provide three squadrons (36 aircraft total) per air wing with just one Joint Strike Fighter squadron of 10 aircraft. This plan balances between the need for the advanced penetration, sensors, and networking capabilities of the Joint Strike Fighter with the relatively low costs, and hence higher numbers that could be purchased, of Super Hornets. Given that two Super Hornets could be purchased for the cost of one Joint Strike Fighter, this plan would allow the Navy to grow its aircraft inventory while living within the fiscal constraints of the current budgetary environment. The F-35 naval variant would be slipped further to the right, delaying its initial fleet operational capability by three years, an option that is available because of the size of the F-35A production schedule due to Air Force and partner nation orders. From the standpoint of program maturity, option 2 has an advantage over option 1 in that its emphasis on a larger number of Super Hornets, an aircraft with well-established lower unit costs and a superb maintenance record, aids the Navy with increased stability in the future.

	Option 1:	Option 2:	Option 3:
Average Range	725 nm	789 nm	902 nm
Average Payload Capacity	8,443	15,920	11,845
Years to Regain Range	Never	15 years	5 years



Naval aviation has a number of options going forward, all of which are restricted by technological maturation and the fiscal environment.

In this scenario, when networked with the Joint Strike Fighter's advanced sensors, the Hornets could serve as "missile trucks" for the newer aircraft, extending the JSF's magazine while also allowing it to remain in a non-external stores, low- observable configuration. Each JSF, equipped with four missiles within its bomb bay, could be accompanied by a minimum of three F/A-18 E/F Super Hornets, each carrying six beyond visual range AIM-120 AMRAAM missiles that could be fired on targets identified and shared by JSF sensors. While it is understood that the Hornets could not penetrate and survive in a dense anti-air defense environment, the linkage between the JSF and Hornet could provide a capability for the JSF to move forward with its low observable survivability while providing data to Hornets orbiting outside the threat ring.

Option 2 would use the financial resources recouped from the truncated JSF program to refocus and accelerate the UCLASS program, which is currently aligned against a surveillance requirement, to emphasize strike as the primary mission. Six of these unmanned combat aerial vehicles (UCAVs) would be purchased for each air wing. The combination of 36 Super Hornets, 10 JSFs and 6 UCAVs will enable the option 2 carrier air wing to begin addressing the long-range strike shortfall within 15 years. However, this accepts large risks over the next decade as the interim air wing would lack sufficient range or mass in the 800–1,400-mile range associated with emerging A2/AD threats, and leaves decision-makers with the same two options in wartime as option 1: risk the carrier or conduct a long war campaign. However, option 2, given its smaller aircraft complement, does open a door of opportunity for the purchase of smaller (and hence cheaper) aircraft carriers in the 70,000-ton range, which could result in substantial cost savings in the shipbuilding account.[116]

OPTION 3

Option 3 sets aside the current carrier air wing development plan and accepts substantial innovative risk by plunging ahead toward the goal of buying back the range, persistence, and penetrating low observability necessary for the carrier to perform deep strike missions as soon as possible. In order to do so, fiscal resources are required. Possible sources of funding could be found through a plus-up in the aviation procurement budget or through the truncation or cancellation of current programs to free up money. Option 3 chooses the latter case and cancels the naval variant of the F-35 program while extending Super Hornet production to cover the near-term shortfall in aircraft inventory. The $85 million per aircraft cost difference between the Hornet and the F-35C naval Joint Strike Fighter would, in turn, be invested in the accelerated production of six attack squadrons composed of 16 true unmanned combat aerial vehicles, 12 aircraft configured as low observable strikers, and four aircraft configured as tankers/ISR platforms (minus stealth accruements). The design of these UCAVs would emphasize range, ordnance carriage, and survivability through low observability and autonomous avoidance of threats. Such an approach would, of necessity, heavily leverage research already completed on programs like the X-47B, as well as experience gained from operational platforms like the MQ-9 Reaper, MQ-4C Triton, and RQ-4 Global Hawk. Information gained through publicly funded research should be made available to all bidders in order to establish fair competition, but emphasis should be given to the prospect of accelerated production and initial operating capability within the next five years.

Option 3 leverages the advantages inherent in a Super Hornet/UCAV, high-low mix air wing and provides an opportunity to buy back range with UCAV and mass through the purchase of additional Super Hornets. If the Navy terminated its portion of the F-35 program, it could afford to purchase two squadrons of 12 Super Hornets (in addition to the two Super Hornet squadrons already present) to replace the two squadrons of 10 F-35Cs and purchase six squadrons of UCAVs with 16 aircraft apiece (12 strikers and four tankers) and still be able to return money to the taxpayers.[117] When combined with E-2D Hawkeyes and EA-18G Growlers plus helicopters, this high-low mix option would grow the carrier air wing to 84 aircraft, a number and mass capability not seen since the 1980s. There would even be room for four dedicated carrier-based unmanned ISR platforms.

The disadvantage of option 3 lies in the research, development, and initial production costs of a new program. Something new and aggressive in design, like a large, unmanned autonomous attack aircraft built to hit targets 1,000 nm from its base, will have technological challenges and will be expensive at the unit cost level. Communications will be critical to the success of the platform, including an ability to maintain a mission profile in a jamming environment and with the potential loss of satellite communications and navigation. Sensors to detect and track threats to the aircraft and software to build in both benign and lethal aspects of autonomy would also be needed. None of these challenges would be easy, but given the mature state of the X-47B test program, they are not insurmountable.

Key Characteristics Reexamined

Mass of platforms, range, and payload capacity – the original defining characteristics of naval aviation that emerged from the inter-war era of Fleet Problems – plus the additional attributes of low observability and persistence that have emerged due to the technical innovations of the past generation, should serve as the benchmarks for measuring the effectiveness of the carrier air wing and the carrier itself. They were derived from lessons learned under harsh conditions, including the hot crucible of World War II, and nothing within the strategic environment has changed sufficiently to justify abandoning them. Those who have argued or will argue for sortie generation proceed from a false premise that both the oceans and the air above them will remain accessible and permissible to U.S. naval assets. This is an assumption that is neither borne out by history nor supported by strategic logic. Nor is the argument for a shift to sea control from power projection as the basis for U.S. naval strategy supportable or wise. The nation does not accept or support long wars of attrition, and its industrial base has evolved toward a specialization in manufacturing that will not allow for the rapid re-purposing of factories as was done during World War II. Given these facts, a reexamination of the basic characteristics of naval aviation is worthwhile.

MASS

Mass of platforms has been a core tenet since Admiral Reeves realized that dispatching the maximum number of aircraft to a target provided the best opportunity for success. In the beginning, there was an expectation that a certain number of friendly aircraft would not make it to the target – the victims of either mechanical failure or the defensive capabilities of the enemy. These lessons were borne out by U.S. wartime experiences in World War II, Korea, Vietnam, and even into the modern era, wherein nine naval aircraft were shot down by Iraqi forces. The advent of precision strike technology has mitigated the requirement to drop multiple bombs in order to take out a single target, but precision strike is rightly seen as a tool to speed the completion of wartime aims and cannot be seen as an offsetting argument against mass. Hitting the highest number of critical targets in the shortest period of time lies at the center of modern "shock and awe" operations. Today, the density of enemy defenses has only increased as nations, including China, Russia, Iran, and North Korea, have viewed with alarm the ease with which the United States has taken down the air defenses in the opening moments of campaigns. The advent of new radars and missiles and the density of placement of these systems provide more than enough justification for the argument that quantity will retain a quality all its own within the carrier air wing.

Unfortunately, the rising cost of platforms, especially the costs associated with the Joint Strike Fighter, has placed significant downward pressure on the size of the air wing. With procurement budgets remaining largely flat and the price of aircraft going up, the natural result has been smaller air wings, shrinking from more than 80 aircraft in the 1990s to more than 60 today. Should the cost of the Joint Strike Fighter continue to increase and funding remain flat, as expected, the air wing will continue to shrink and utilization rates among the remaining aircraft will increase, accelerating the "death spiral" phenomenon that has already resulted in a 140 aircraft deficit in the tactical naval aviation inventory. Only significant changes in funding of the present plan, truncating the JSF buy and increasing the Hornet inventory, or outright cancellation of JSF with subsequent investment in a new UCAV capability can correct the negative trends in aircraft mass.

RANGE

Range quickly emerged as a critical element of naval aviation. With the early focus on scouting for enemy forces, range was crucial to spotting the enemy early and then maneuvering U.S. forces to a position of advantage. Later, as air-to-air and strike missions emerged for the air wing, longer ranges were desired to project power against enemy forces while maintaining the carrier and its accompanying ships at a safe distance. This lesson was borne out during World War II when U.S. forces found themselves without sufficient range to stay outside the reach of threatening Kamikaze attackers. Over 20 carriers of all varieties were attacked – some sunk but all significantly damaged. This hard lesson of war convinced naval aviation leaders such as Mitscher and McCain to invest in aircraft with longer ranges and aircraft carriers large enough to operate them. This vision aided the Navy a few short years later when the Soviet Union emerged as the key focus of U.S. strategy. The Navy, anxious to be part of the Eisenhower's "New Look" nuclear-weapon based strategy, invested heavily in the A-3 Skywarrior, an 84,000-pound aircraft capable of carrying a nuclear weapon 1,800 nm into Soviet territory, and the 78,000-ton *Forrestal*-class supercarrier, a ship large enough to support the new aircraft. These investments raised the average range of the carrier air wing to 1,200 nm.

Average unrefueled air wing ranges remained high, in excess of 900 nm, for the next 40 years. The numbers actually are more impressive when the development of organic tanking – carrier aircraft giving gas to other carrier aircraft in flight – is factored in, and these capabilities served the nation well during conflicts in Vietnam and Desert Storm where distant targets and long dwell periods were required. However, the end of the Cold War and the subsequent euphoria that emerged gave rise to a sense of invulnerability. The A-12 Avenger II was canceled due to cost overruns, and the Cold War A-6 Intruders, F-14 Tomcats, and S-3 Vikings were all retired, taking their longer ranges with them. Left in their places were F/A-18s, aircraft designed to be a short-range, light attack fighter, and the increasingly expensive and limited-range Joint Strike Fighter. By 2006, the average unrefueled range of the carrier air wing had shrunk to just under 500 nm, and organic tanking had all but gone away. The F/A-18E/F had been tasked with the tanker role, but its impact was limited to tanking four aircraft out to 1,000 nm. In addition, naval aviation has recently begun to worry that the tanker configuration is placing excessive strain on the aircraft's wings, shortening its service life.

PAYLOAD CAPACITY

Payload capacity, the amount of ordnance carried, remains the one bright spot among the original defining characteristics of the carrier air wing. In the beginning, small aircraft could carry only a minimum amount of ordnance; the average payload capacity of the *Langley*'s air wing was only 610 pounds in 1922. This rose slowly to 1,800 by 1943 when the *Essex*-class air wing was first deployed. During the Cold War, however, payload capacity expanded ten-fold, peaking at 13,750 pounds during the 1960s and remaining above 11,000 pounds through the present day. Payload capacity has been amplified by the advent of precision strike capabilities. Whereas in the past, up to and through the Vietnam era, an entire air wing might be launched to perform an "Alpha Strike" to take down a single target, precision strike guidance systems allows a single F/A-18E/F Hornet to launch with four bombs and hit four targets. Today, lighter bombs have higher effectiveness than larger dumb bombs of the past, as modern weapons can be targeted against very specific structural weak points in order to initiate a structure's collapse.

LOW OBSERVABILITY

The introduction of radar surveillance and targeting in conjunction with the rapid move from surface to air artillery to missiles designed to target aircraft proved a strong and increasingly effective threat against aircraft. The large numbers of aircraft – small and large, low altitude and high altitude – caused aircraft designers to investigate methods to first distract and then diminish the effectiveness of search and fire control radars, the emitters that actually help to guide missiles toward their targets. The initial technique was to launch distractions from the aircraft, small strips of aluminum called chaff, to confuse missiles homing on a radar return. Later, as missiles became more discriminate, the defensive initiative swung toward decreasing the size of the overall radar return given off by the aircraft. This initiative was quickly branded as "stealth."

"Stealth" had its beginning within Lockheed's "Skunk Works" shop and found its first manifestation in the SR-71 "Blackbird" spy plane and later in the "Have Blue" demonstrator. The latter aircraft quickly evolved into the F-117 "Nighthawk" attack aircraft. This initial attempt at stealth focused on building an aircraft with unique faceted panels set at angles in order to reflect radar energy away from the aircraft and away from the radar transmitter. This approach focused on the frontal aspect of the aircraft as it approached enemy targets. Later aircraft designs, including the B-2 bomber, the A-12 Avenger II, the F-22, and the F-35, pursued all-aspect stealth designs that sought to wrap radar energy around the aircraft and thus minimize the amount of energy available to return. These later designs also took up other aspects of the aircraft's overall "signature" as well, seeking to decrease its thermal signature, for instance.

The success of stealth can be seen in its employment. F-117s were used almost exclusively during the initial attacks on Baghdad during Operation Desert Storm to take down the Iraqi air defense network. Later, during the Yugoslavia air campaign, the B-2, flying from the United States, joined F-117s to attack heavily defended positions. This trend continued during operations in Afghanistan and Iraq, as stealth became the default attack platform during initial stages of combat when enemy air defense systems remained nominally active and effective.[118]

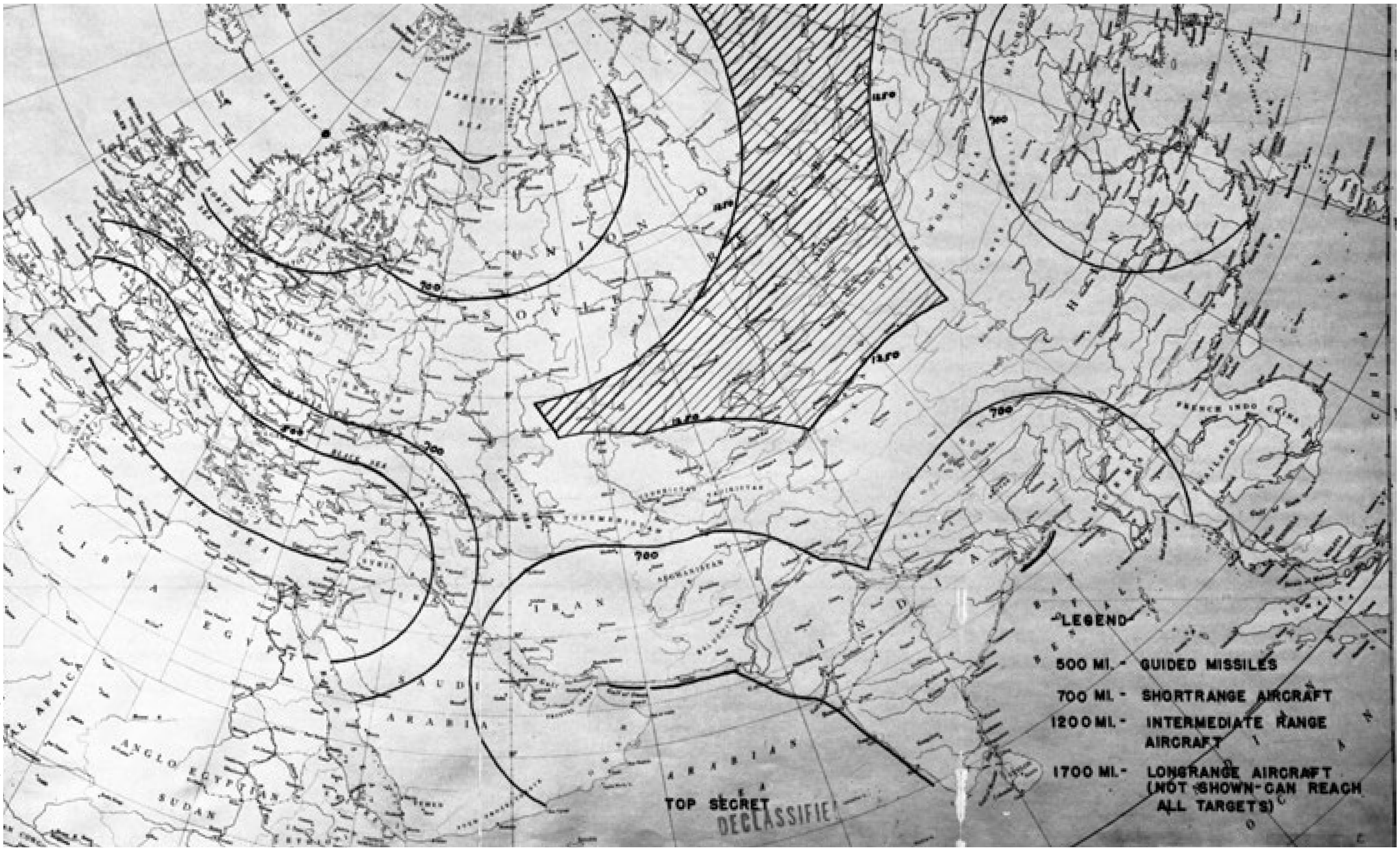
Today stealth is approaching an advanced state wherein marginal decreases in the aircraft's overall signature are coming only with significant increases in its cost.[119] However, low observability has had, and continues to exert, a significant impact on aircraft design and operational employment within the carrier air wing. Such is the density of sensors and weapons within the modern anti-access/area-denial environment that older, non-stealthy aircraft are not expected to survive penetration.[120] Only low observable platforms enjoy any chance of success.

PERSISTENCE

Unmanned aircraft introduced a new capability to aviation that is only now becoming apparent and valued by planners and strategists: the ability to persist over an area of interest, serving in many ways as a lower altitude satellite. The Navy has had aircraft with long endurance profiles, such as the A-3 Skywarrior, the E-2 Hawkeye, and the S-3 Viking, but the long war against terrorism in Iraq and Afghanistan has brought persistence, a combination of range and endurance that provides an ability to gaze at an area with an unblinking eye for a prolonged period of time, into the forefront. An unmanned platform, untethered to the physiological requirements of the human body and limited only by the amount of fuel and the need to change lubricating fluids, can orbit above an area of interest, developing intelligence on patterns of movement and operations. In addition, armed persistent assets can orbit while awaiting tasking, enabling quicker responses as targets are established. Persistence also has an inverse effect upon naval aviation maintenance, circumventing the risk of structural damage or malfunctions that most often accompany the jarring evolutions of takeoff and landing. Persistence promises to be a paradigm-altering characteristic in the future as rapidly maturing unmanned systems are introduced and explored, and appears to be a naturally accompanying extension of the original range and payload capacity characteristics and a possible offset to requirements for mass.[121]

Summary

The end of the Cold War brought about a period of rapid reevaluation of the strategic environment. The assumptions that had been the bedrock of the U.S.-Soviet Union confrontation – non-permissive environments and contested supremacy – gave way to their opposites. American preponderance was assumed and access to the global commons at sea, in the air, and in space, was assured. Given the new security environment, radical changes were made within the national defense portfolio that had significant implications with regard to positioning and operating naval forces. Range and the deep strike mission were allowed to atrophy as carriers moved closer to shore and their



Naval History and Heritage Command

The planned ranges for long, intermediate, and short ranged aircraft to be launched from the new class of super carriers. Note that "short range" in the 1950s was considered to be 700nm. Today, the longest ranged fighter/attack aircraft on the carrier cannot reach this range unrefueled.

land-based targets. Short-range, light attack aircraft replaced older, long-range aircraft as time passed, and the carrier itself became optimized, at great cost, to launch increasing numbers of aircraft each day, even as the overall size of the carrier air wing decreased due to the rising price of individual airplanes.

These assumptions held, but only for a while. By the mid-1990s other nations, led by China, noted the methods by which Americans waged war and began to develop weapons systems aimed at pushing Americans back and denying them access to the global commons. These anti-access/area-denial weapons, an interconnected series of sensors, aircraft, ships, and missiles, seek to take advantage of the United States' decision to cede range and the deep strike mission capability and push American ships and aircraft back beyond their operating ranges, thus protecting their leaders from U.S. power projection and regime change strategies that have dominated modern American wars. These investments by China, Russia, Iran, and North Korea effectively negate American post-Cold War assumptions and re-impose the non-permissive environments and contested commons that have characterized most of human history.

To assure its continued role as a strong guiding power within the global international system of governance that it has labored to build over the past 70 years, the United States in general and the Navy in particular will need to reinvest and "buy back" range for its carrier air wings in order to present a credible deep strike capability to its competitors. An emphasis also must be placed on an initiative to grow the size of the carrier air wing from its present complement of 60-plus aircraft to its historic average of 80-plus planes per air wing. Range and mass have characterized the carrier air wing since its inception in the early 1920s for a reason. The present era can only be viewed as an aberration and rejection of the lessons learned during the Fleet Problems of the 1930s, the war in the Pacific during the 1940s, and the Cold War competition of 1950–1990. The ability to project power from long range to end wars quickly has been and must remain the strategic focus of the nation and its Navy.

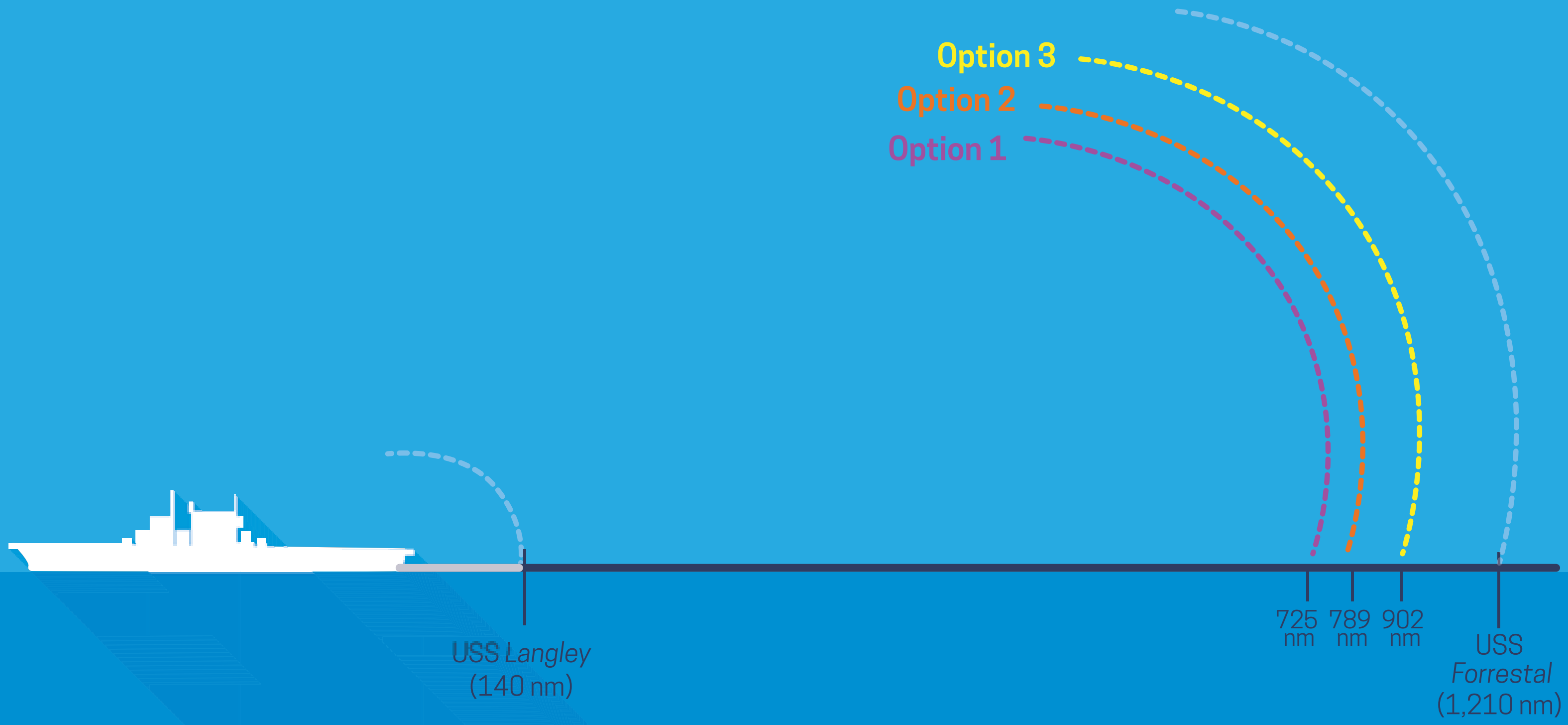
Today the combination of the F/A-18E/F Super Hornets and the F-35C Lightning II Joint Strike Fighter represents the immediate future of the carrier air wing, which will be comprised of two squadrons (24 aircraft) of Super Hornets and two squadrons (20 aircraft) of Joint Strike Fighters, along with accompanying E-2D Hawkeyes, EA-18G Growlers, CV-22 carrier onboard delivery aircraft, and helicopters for a 62 aircraft air wing. Such an air wing is not capable of upholding the nation's interests in the face of rising competitors. However, options exist that include truncating or canceling the acquisition of the Joint Strike Fighter, extending the production of the venerable and effective Super Hornet, and accelerating the development and introduction of a viable unmanned combat aerial vehicle capable of spanning the vast distances imposed by anti-access/area-denial systems. The nation should aggressively investigate these options and select a viable path forward. Today's carriers and their accompanying air wings, with their shrinking ability to project mass and power at great distance, represent 25 years of actively forgetting critical historical lessons. History, like the enemy, does not forgive.

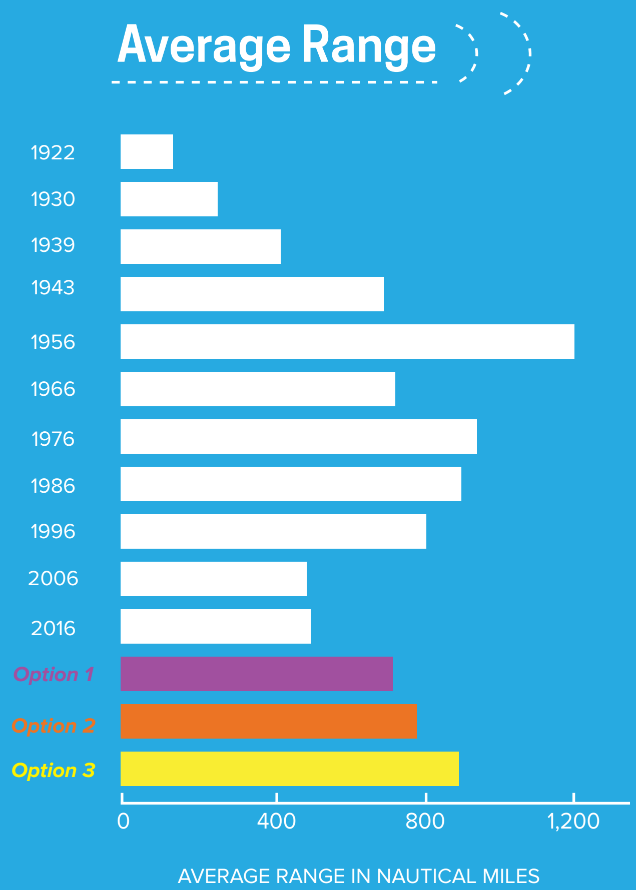
TODAY'S CARRIERS AND THEIR ACCOMPANYING AIR WINGS, WITH THEIR SHRINKING ABILITY TO PROJECT MASS AND POWER AT GREAT DISTANCE, REPRESENT 25 YEARS OF ACTIVELY FORGETTING CRITICAL HISTORICAL LESSONS. HISTORY, LIKE THE ENEMY, DOES NOT FORGIVE.

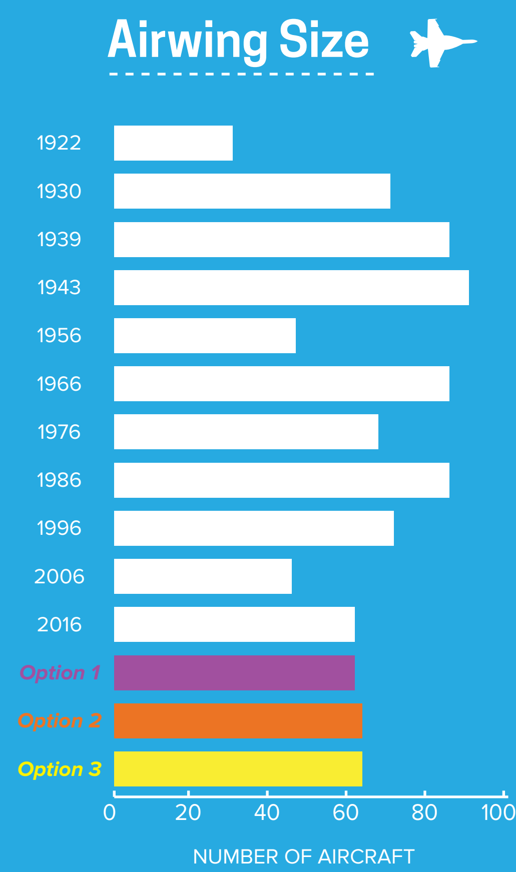
2025

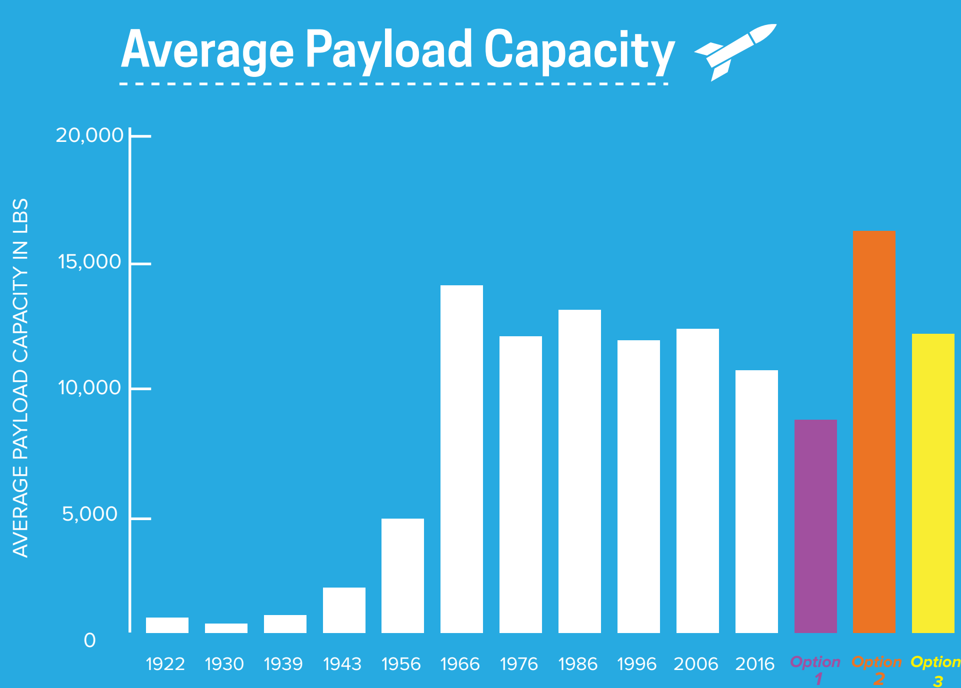
OPTIONS

Air Wing Averages (unrefueled)




Average Range
1922
1930
1939
1943
1956
1966
1976
1986
1996
2006
2016
Option 1
Option 2
Option 3
0
400
800
1,200
AVERAGE RANGE IN NAUTICAL MILES


Airwing Size
1922
1930
1939
1943
1956
1966
1976
1986
1996
2006
2016
Option 1
Option 2
Option 3
0
20
40
60
80
100
NUMBER OF AIRCRAFT


Average Payload Capacity
AVERAGE PAYLOAD CAPACITY IN LBS
20,000
15,000
10,000
5,000
0
1922
1930
1939
1943
1956
1966
1976
1986
1996
2006
2016
Option 1
Option 2
Option 3

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116. Given the size of the option one and two carrier air wings (62 aircraft), there is not requirement for a large 100,000-ton supercarrier. Something along the lines of the 80,000-ton *Forrestal*-class carrier or even the 45,000-ton *Midway*-class carrier could support the smaller modern air wings more efficiently and at a lower cost than the new *Ford*s.

117. 400 F-35Cs cost $52B at $130M each. Three squadrons of twelve F/A-18E/Fs across ten air wings at $85M apiece equals $30.6B. Six squadrons of 16 UCAV at $175M each to fill deploying carriers only costs $16.8B for a total of $47.4B, a net savings to the taxpayer, who could use the money to buy replacements for the Ohio Class Ballistic Missile Submarines that a due to retire.

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