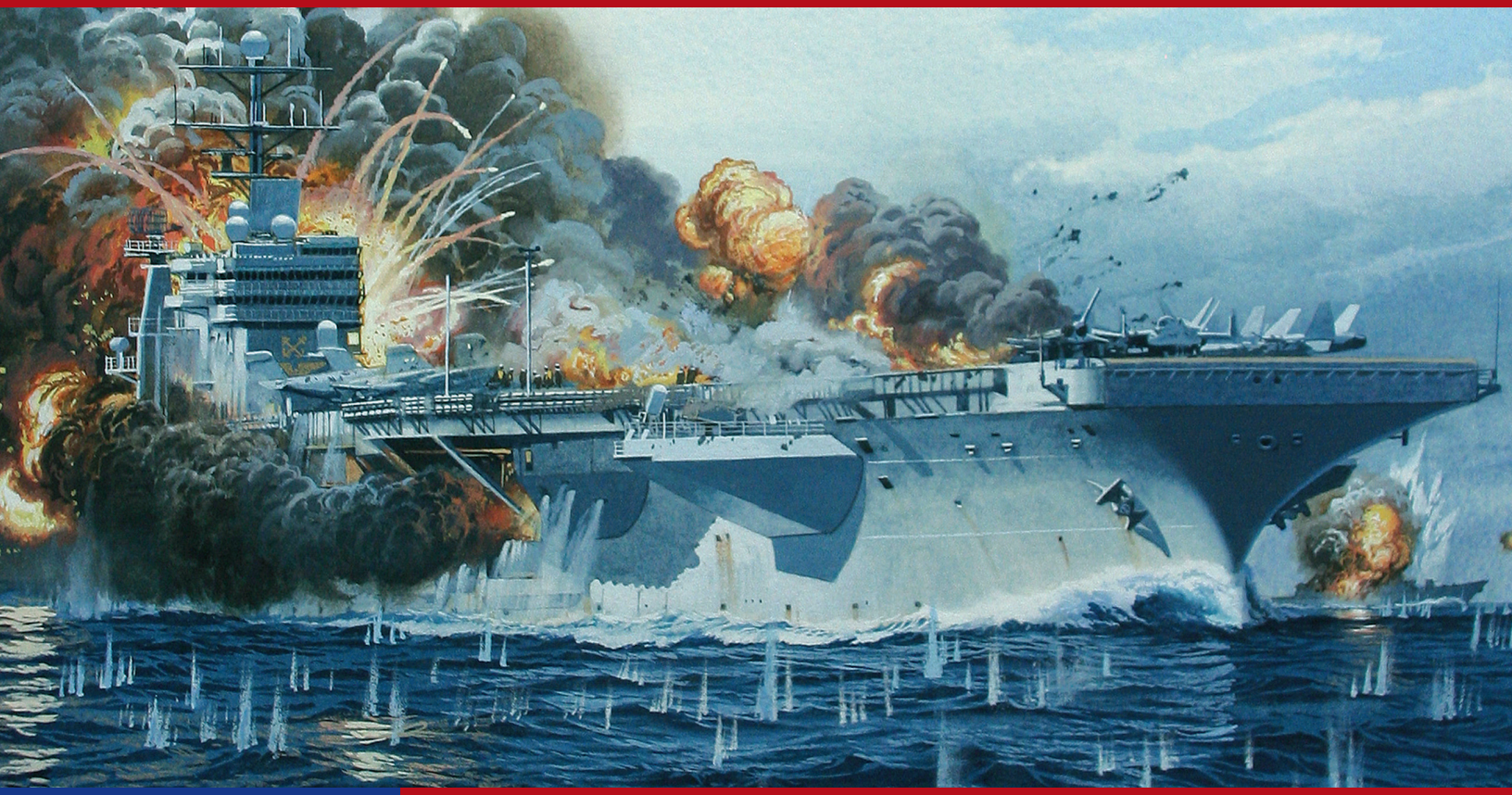

MARCH 2013

DISRUPTIVE DEFENSE PAPERS

At What Cost a Carrier?

By CAPT Henry J. Hendrix, USN (Ph.D.)

Center for a New American Security

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About the Author

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About the Series

As U.S. spending on defense declines, hard choices will need to be made to ensure the health of U.S. Armed Forces and their ability to promote and defend America's interests. The Disruptive Defense Papers are designed to be hard-hitting arguments dealing with controversial issues in U.S. defense policy. The opinions in these papers are those of the authors, as CNAS does not take institutional positions.

About the Cover

Tom Freeman, an award winning artist, was inspired to paint "Carrier Killer" based on his concern that U.S. aircraft carriers were growing increasingly vulnerable to anti-ship ballistic cruise missiles. The painting was featured on the May 2009 cover of the U.S. Naval Institute's Proceedings Magazine. CNAS is grateful to Mr. Freeman for his permission to use the painting for this report.

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The queen of the American fleet, and the centerpiece of the most powerful Navy the world has ever seen, the aircraft carrier, is in danger of becoming like the battleships it was originally designed to support: big, expensive, vulnerable – and surprisingly irrelevant to the conflicts of the time. This outcome has become more likely as the Navy continues to emphasize manned carrier aircraft at the expense of unmanned missiles and aircraft. If the fleet were designed today, with the technologies now available and the threats now emerging, it likely would look very different from the way it actually looks now – and from what the United States is planning to buy. The national security establishment, the White House, the Department of Defense and Congress persist despite clear evidence that the carrier equipped with manned strike aircraft is an increasingly expensive way to deliver firepower and that carriers themselves may not be able to move close enough to targets to operate effectively or survive in an era of satellite imagery and long-range precision strike missiles.

This report explores the evolution of the aircraft carrier, its utility, power, costs and vulnerabilities, and then suggests a different course for U.S. naval forces, one that emphasizes far greater use of unmanned aircraft – generally described as UCAVs, for "unmanned combat aerial vehicles" – as well as submarines in combination with long-range precision strike missiles. While the carrier's end may be in sight, its story is a long one, beginning a little more than 100 years ago, in the waters off Great Britain.

A Carrier Revolution in Military Affairs

During the 1920s and 1930s, restrictive treaties and constrained military budgets resulted in military technological advancements that subsequently shaped the strategic environment in World War II. Long-term investments in armor, diesel engines and radios gave rise to a form of mobile tank warfare the world had never before seen. Concepts of trench warfare so recently learned were brushed aside in Czechoslovakia, Poland, Belgium and France. Advances in airframe design, supercharged engines, navigation, ordnance and analog computers made strategic bombing possible in Europe and Asia. Metallurgy, battery design and the aforementioned advances in diesel engines also greatly improved submarine effectiveness, but perhaps no other combination of technology with tactics saw such advances during the interwar period as those associated with the aircraft carrier.[1]

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By the end of World War I, nearly every great power had exercised some marriage between naval and air power. The United States had deployed a robust wing of naval float planes to Europe. The Germans had developed zeppelins to fly over the North Sea, and the British developed an aircraft carrier, the *HMS Furious*.[2] During the war, aircraft from the *Furious* bombed and destroyed two German zeppelins in their hangar near Tondern. American naval officers noted the Tondern strike

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with interest, consequently pushing to convert the coal supply ship *Jupiter* into an American aircraft carrier. This first carrier, renamed the *USS Langley*, was slow and carried very few aircraft on its 500-foot flight deck, but it provided the experience required to make the next two American carriers, the converted treaty cruisers *Lexington* and *Saratoga*, real weapons of war.[3]

For much of the next two decades the American Navy experimented with its carriers, at first using them to launch aircraft to spot the splashes of battleship shells in and around their targets, providing corrections and improving accuracy. Other times the carriers were used as a scout force for the battleships, flying their aircraft ahead of the main battle line to provide the optimal opportunity to win decisively in a dreadnought battle. However, audacious innovators such as Admirals Edward Eberle and Joseph Reeves soon began to use aircraft carriers and their air wings as the prime instruments in power projection and sea control missions.[4] Eberle emphasized the strike potential of the carrier's aircraft, rather than just using them as a scout force in support of the battleship. Reeves went even further, detaching the carriers from the battleships to act alone as a power projection force. Their tactics were shaped by the vastness of the ocean and the difficulty in finding targets sailing upon it. Strikes from the sea could originate along any axis of approach. The fiscally constrained environment of the interwar period helped to create an era of innovation and experimentation. In brief, when dollars were short, people innovated with what they had.

A Grand Debate

Now, flash-forward 70 years. After the disasters and victories of World War II, the aircraft carrier took center stage in American naval strategic thought and force structure design.[5] Such constancy has not been witnessed upon the world's oceans since the age of sail. Some would say that this speaks to the unmatched adaptability of the carrier design, while others see hubris and a lack of strategic innovation.[6] However, the evolution of airborne anti-ship technologies that began with kamikaze aircraft in World War II and progressed through the massive Soviet anti-ship cruise missiles began to challenge the carrier's effectiveness. The U.S. decision to dispatch two carrier strike groups near Taiwan in 1996 in response to Chinese provocations taught the People's Republic of China a valuable lesson: It needed to be able to hold U.S. power at a distance if it were to regain a margin of supremacy within its historical sphere of influence in the western Pacific. Shortly thereafter, the People's Liberation Army Navy began to invest in new anti-ship cruise and ballistic missiles. The rapid development of these systems and the perception that they might effect, at a minimum, a mission kill against their chosen targets has led to a new debate about the utility of the aircraft carrier.

Recent critics of the aircraft carrier cite the combined challenges of rising costs and increased vulnerability. There are also questions regarding the future utility of the platform as competing capabilities force the big decks to operate at ever-increasing ranges from their targets.[7] Proponents of the carrier quickly responded that the most recent threat to the carrier, China's DF-21 missile, can be defeated by crippling its target detection to

weapon impact "kill chain." The director of the Air Warfare Requirements Division and the program executive officer for aircraft carriers (two rear admirals) published an article arguing that cutting the carrier force would lead to a decrease in the U.S. maritime presence and that large deck carriers are necessary to meet the nation's strategic objectives in the 21st century. They also argued that only carriers possess the global reach, sustained firepower and proof of purpose to influence the global arena and maintain the U.S. position in the world.[8] The issues raised by this debate deserve deeper consideration.

At What Cost a Carrier?

If it is true that when money gets tight, people get smarter, then the United States needs some very smart people right now. By the end of 2011, the nation's debt exceeded its gross domestic product for the first time since World War II, not an enviable strategic position to be in. The current debate regarding debt ceilings, continuing resolutions and sequestration have led many to view the nation's defense needs with scrutiny.[9] No one can doubt the diplomatic power of carriers, for presidents, it seems, are always asking where they are. Allied nations and the U.S. combatant commanders persistently request additional naval presence to shore up their interests. In 2009 the U.S. deputy chief of naval operations for resources announced that there was a "presence deficit" of naval platforms across the globe, and no platform is requested more than the carrier. The question nonetheless remains: "Can the United States afford the carrier?" That suggests, in turn, the question "What is the carrier's value?" These statements also raise the question of what is the relative character of naval presence.[10]

Consider naval presence, for the moment, as distinct from power projection. The idea that naval presence has value is well established. Combatant commanders throughout the world constantly bargain to increase the number of naval ships operating within their areas of responsibility, and none has ever argued for a decrease. Assigning a quantifiable value to naval presence has always been difficult, and it is also difficult to design war games to test the idea that routine deployments prevent conflict. However, analysts have begun to lay the theoretical framework of a broader argument that persistent presence, even with low-end platforms, encourages conflict avoidance.[11] Others have taken the argument further, advancing a construct within power-law theory that recognizes a logarithmic relationship between the number of consistent military interactions and casualties: The higher the number of interactions, the fewer casualties over time.[12] It is clear that presence has value, which may be hard to express in financial terms. However, value could be suggested analytically by comparing platforms and relative equivalencies.

Carrier strike groups are expensive to buy and to operate. Factoring in the total life-cycle costs of an associated carrier air wing, five surface combatants and one fast-attack submarine, plus the nearly 6,700 men and women to crew them, it costs about $6.5 million per day to operate each strike group. When considering the demands by presidents, allies and combatant commanders for forward-deployed naval presence, wise spenders must question the cost and method of meeting these demands. Given that the aircraft carrier is the benchmark for current naval presence missions, for the purposes of discussion, assume it has a presence value of 1.00 on a sliding scale where a riverine detachment, on the low end, has a value of 0.01. This means that the current acquisition cost of 1.00 presence is $13.5 billion, which raises the question of whether an alternative combination can achieve this level of presence at a lower cost. What is the presence value of a destroyer? Can one assign it a 0.2 presence value? Would spending $10 billion on five destroyers to create a 1.00 naval presence value at an operating cost of $1.8 million per day be a better investment? What about

a littoral combat ship? Does its presence, bearing the Stars and Stripes, not assert American interests near a 0.10 presence score at a cost of $500 million apiece? Would not a $5 billion investment in 10 littoral combat ships, at a combined operating cost of $1.4 million per day – ships that could be present in many places simultaneously – not meet U.S. presence requirements more economically?

Proponents will counter that these platforms would fall short in their ability to transition to power projection missions during wartime, when the ability of the carrier to sortie a large number of tactical aircraft really comes into play.

The Nimitz-class carriers can generate approximately 120 sorties a day. The Ford-class carriers, with the new electromagnetic aircraft launch system (EMALS), are projected to launch around 160 sorties per day, a 33 percent increase in launch capacity. This seems very impressive until one realizes that the *USS George H.W. Bush*, the last Nimitz carrier, cost $7 billion and the *USS Gerald R. Ford* is coming in at $13.5 billion. In the end, the nation is paying nearly 94 percent more for a carrier that can only do 33 percent more work.[13] Even factoring in projected savings from reduced manning and lower maintenance costs, this investment is still not a good use of U.S. taxpayer money, especially given what U.S. sortie requirements are and what they are projected to be.

After World War II, the Strategic Bombing Survey team calculated that it took 240 tons of bombs to drop one bridge spanning a river. By 1965 in Vietnam that number had only come down to 200 tons, but shortly thereafter, American investment in precision strike weapons really began to pay off. By 1999 only 4 tons of bombs were needed to accomplish the mission, regardless of the weather at the target. Couple this fact with the observation by Colin Powell – former secretary of state, national security adviser and chairman of the Joint Chiefs of Staff – that modern warfare plays out under "Pottery Barn rules" (if you break it, you own it and you will pay to replace it). Reconstruction in Iraq and Afghanistan has cost the American taxpayer more than $109 billion since 2002.[14] Future wars should be characterized by smaller target lists that emphasize discreetly interrupting capacities, not destroying them. Think power relay stations rather than power generation plants, and you begin to get the picture. Arguments that the United States will need to generate expanded sortie capacity above and beyond what it has now run counter to current technological and political trends. Should the United States find itself in a position where massive destructive power is necessary, the capabilities that populate its ballistic submarine force will be waiting in the wings.

Ultimately, analysis cannot end with aircraft sortie rates, because these do not accurately measure the cost-effectiveness of the carrier weapon system. That can be measured by examining the 44 strike-capable aircraft that are launched off carriers. What is the cost-effectiveness of carrier-based strike aircraft?

The United States is emerging from a decade of continuous combat operations in Iraq and Afghanistan. The military has had F/A-18 Hornets that were built in 2000 retire from the force having exceeded the programmed nearly 8,600-hour life of their airframe.[15] These aircraft were purchased at an approximate cost of $50 million apiece.[16] Initial training for each of the five pilots who would fly them for 1,700 hours each during the life of the aircraft conservatively cost $2 million. Fuel, spare parts and maintenance cost $60 million over the life of the aircraft, leading to an estimated total life-cycle cost of $120 million each, on the high side. That is what the United States puts into the system, but what does it get out? More specifically, how much of an aircraft's life is spent in combat? While there, how many bombs does it drop?

The first fact that needs to be understood in answering these questions is that piloting an aircraft onto the deck of an aircraft carrier is hard. The aircraft is going fast, the carrier is speeding over the ocean to create wind across the deck, and although the ship appears large to an observer standing on it, it looks incredibly small from the air. Couple that with the carrier pitching, yawing and rolling, and you have the most incredible challenge that a naval aviator will face in his or her career. Every month the pilot has to go airborne a number of times to maintain qualification in this difficult task, and then the pilot has to go up and qualify all over again, at night.

Add to this that pilots have to demonstrate their abilities in a number of warfare areas beyond taking off and landing; formation flight, anti-air and strike qualifications are just a few. In any given month, the average F/A-18 squadron has to fly a little more than 500 hours, or about 32.5 hours per pilot, to maintain warfare readiness, and that is just during the 12-month home cycle. Once deployed, squadron flight hours increase to approximately 650 hours per month, or 38 hours per pilot.[17] One-third of these hours are expended maintaining the currency and qualifications of the pilot. In the end, over the full extent of its airframe life, the average F/A-18 Hornet will log just 20 percent of its 8,600 hours in combat. Much of this time involves transiting to and from the operating area, with 30 minutes per flight, at most, being dedicated to the mission at hand, providing support to forces on the ground in most cases. The effectiveness of that support can best be measured in ordnance expended.

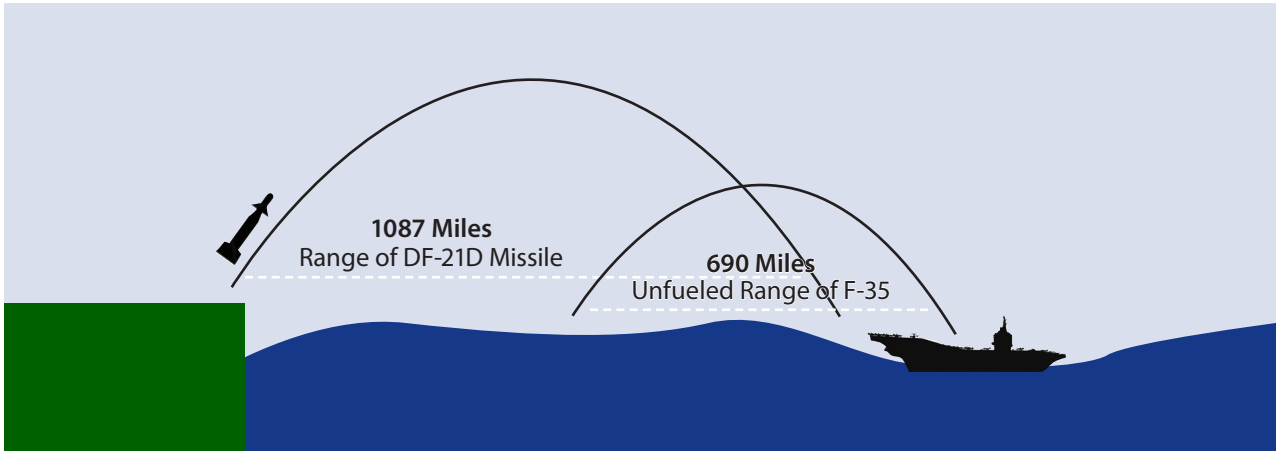
Ascertaining the actual number of weapons expended in combat is difficult at best as there are no unclassified reports detailing this information for current and recent activities in Afghanistan and Iraq. However, logic suggests that weapons dropped in combat must be replaced in the inventory. Available budget documents reveal that the Department of the Navy has purchased approximately 18,000 air-to-ground weapons since Fiscal Year 2002. Taking into account that perhaps 2,000 of these weapons were intended to build up inventories, the data suggests that the U.S. naval services have expended approximately 16,000 air-to-ground weapons in the past 10 years.[18] While this number seems impressive at first glance, when divided across the approximately 1,000 air-to-ground strike-capable aircraft in the Navy's inventory, that works out to an average of just 16 weapons per aircraft during the decade.

To achieve the same return on investment as the Tomahawk, Hornets would have needed to fly nearly four times the number of sorties and drop 100,000 air-to-ground weapons.

Including the previously stated life-cycle cost of an F/A-18 Hornet, that works out to $7.5 million per bomb. That is quite substantial when compared with the precision-strike Tomahawk cruise missile, which each cost a conservative $2 million. To achieve the same return on investment as the Tomahawk, Hornets would have needed to fly nearly four times the number of sorties and drop 100,000 air-to-ground weapons.

Manned aviation supporters could counter that aircraft would have dropped more ordnance if there had been more targets, and that is exactly the point. Modern warfare generates fewer targets, and the military has become much more careful about how it attacks them. To be sure, some manned

FIGURE 1: MISSILE VS. F-35 FLIGHT RANGE



aviation will be required to perform close-air support missions, where requirements for eyes-on accuracy will exceed the capabilities of long-range precision-guided munitions during major ground combat operations for some time to come. For this reason, the United States will have to maintain aircraft carriers of some size and capacity to deliver close-air support in the absence of land bases. But the massive launch capacity incorporated within the Ford-class aircraft carrier design is not required; more efficient methods of attack are.

However, platform efficiency is not the biggest challenge facing the carrier. Platform survivability is. Submarines, surface ships, aircraft, air-launched anti-ship cruise missiles and swarming small craft each pose threats to U.S. naval forces, including aircraft carriers, but no weapon has captured the imagination of American naval strategists like the DF-21D missile.[19] Using a maneuverable re-entry vehicle (MaRV) placed on a CSS-5 missile, China's Second Artillery Division states that its doctrine will be to saturate a target with multiple warheads and multiple axis attacks, overwhelming the target's ability to defend itself.[20] The MaRV warhead itself would use a high explosive, or a radio frequency or cluster warhead that at a minimum could achieve a mission kill against the target ship.[21] While the United States does not know the cost of this weapons system, some analysts have estimated its procurement costs at $5 million to $11 million.[22] Assuming the conservative, high-end estimate of $11 million per missile gives an exchange ratio of $11 million to $13.5 billion, which means that China could build 1,227 DF-21Ds for every carrier the United States builds going forward. U.S. defenses would have to destroy every missile fired, a tough problem given the magazines of U.S. cruisers and destroyers, while China would need only one of its weapons to survive to effect a mission kill. Although U.S. Navy and Air Force leaders have coordinated their efforts to develop the means to operate in an anti-access/area denial (A2/AD) environment by disrupting opposing operations,[23] the risk of a carrier suffering a mission kill that takes it off the battle line without actually sinking it remains high.

The inefficiency of manned aviation, with its massive fiscal overhead of training, pilot currency and maintenance, is rapidly outpacing its utility. The idea that the United States needs a large sortie capability inexorably drives decisionmakers to large carriers. These maritime juggernauts are expensive and hence need to be defended by an ever-larger ring of exquisite technologies in order to launch a historically

New Hornets operating from the legacy large carriers would allow the United States to meet its obligations in the near term while investment in UCAVs would begin the Navy's pivot toward the new strategic environment.

shrinking number of very expensive aircraft from ever-increasing distances that may or may not drop their bombs. This raises the question of who is shaping whom within the current strategic environment.

The U.S. Navy must be ready to support the nation's interests. It must commit itself to developing the reliable means to conduct precise, limited strikes on strategic targets such as leadership facilities, power relay stations or water treatment plants. After 100 years, the carrier is rapidly approaching the end of its useful strategic life. As arrows shot by English longbowmen at Agincourt supplanted knights in armor on the battlefields of Europe and were in turn overtaken by muskets and cannon, the one constant in warfare is change. To continue to invest in aircraft carriers at this stage, to believe that the *USS Ford*, with a service life of 50 years, can see the carrier through to a 150-year life unchallenged upon the high seas smells of hubris. Advancements in surveillance, reconnaissance, global positioning, missiles and precision strike all signal a sea change in not only naval warfare, but all forms of warfare.

The United States, always an innovating nation, must break out of its ossified force structure and not only get ahead of the strategic curve, but actively seek to redefine the curve. The nation must plan a graceful transition that stops building carriers, plans a path for those already built to see them through their service life and creates new means of operational effectiveness in the future.

The Way Forward

All these factors indicate that a turn toward UCAVs is long overdue. The advent of A2/AD technologies is pushing U.S. carrier strike groups farther from their targets, and the combat radius of the F-35, or Joint Strike Fighter (JSF), is simply not going to solve that problem (see Figure 1). One solution would be to cancel the always-troubled JSF now while simultaneously extending production of the lower-cost Hornets. That would allow the Navy to invest the nearly $70 million cost differential between the JSF and the F/A-18 in accelerating the development and production of a UCAV that could operate both from large carriers and from smaller, less expensive, light amphibious carriers. New Hornets operating from the legacy large carriers would allow the United States to meet its obligations in the near term while investment in UCAVs would begin the Navy's pivot toward the new strategic environment.

The new UCAVs would be flown only when operationally needed. UCAV pilots would maintain their currency in simulators, reducing personnel and operational costs and extending their airframes' lives by decades. This posture would allow the slowly declining number of carriers that would remain in the inventory until the *USS Ford* retires in 2065 to remain effective. Designing the still-evolving UCAV to operate from the decks of light amphibious carriers as well as carriers would give the United States flexibility. Once on station, the UCAV's range and endurance would be limited only by the availability of tankers to refuel it and the need to change the lubricating fluids periodically. The UCAV would not be a low-performance drone. On approaching enemy air defenses the UCAV would be able to execute

microsecond-timed maneuvers at G-levels that would exceed human performance parameters in order to successfully reach its target.

It is not clear how quickly the Navy will develop an operational UCAV. While the experimental X-47B platform shows promise, the Navy appears to be concerned that operational units built from an evolution of this design, which is extremely stealthy, will be plagued by high cost, limited endurance and low payload capacity. Other advocates have pushed for adapting currently weaponized unmanned aerial vehicles (UAVs) such as the Predator for maritime use. That would keep costs low but would come up short in terms of range and weapons-carrying capacity. There must be some middle ground that emphasizes moderate stealth, carrying capacity and cost with long range in order to address the A2/AD challenge. So far, naval aviation seems to be stressing the need to rapidly develop a manned F/A-XX platform to follow the JSF.[24] It would be far better to develop a reliable UCAV platform capable of operating off both large and amphibious carrier flight decks.[25] Given the increasing lethality of anti-air and A2/AD technologies, the U.S. Navy must accelerate its movement toward UCAVs, or it will surely regret its hesitance.

A parallel path forward should include the maturation and extension of the U.S. inventory of conventional missiles. The current Tomahawk missiles are deployed on Navy cruisers, destroyers, fast-attack submarines and, more recently, on four modified Ohio-class submarines. These guided-missile submarines, known as SSGNs and each carrying up to 155 Tomahawks, represent the most effective path forward in strike warfare. Super quiet, the Ohio SSGNs can penetrate enemy waters unseen, positioning themselves to unleash massive waves of precision strike weapons to take down critical nodes of enemy infrastructure, weakening resolve and resistance from the strategic center outward. Stealthy submarines, loaded with low-cost precision cruise and ballistic strike missiles capped with conventional warheads, provide the United States with an elegant "one target + one missile = one kill" solution.

Money is tight, and as the nautical saying goes, the enemy has found our range. It is time to change course.

By pursuing the combination of paths described above – slowly divesting from carriers; building a transition bridge with UCAVs that can carry weapons, sensors and airborne electronic warfare systems while operating from large carriers and light amphibious carriers; and creating a smooth expansion of undersea precision strike capacity – the United States would be able to invest in larger numbers of less exquisite "influence squadrons" to maintain naval presence in regions of interest.[26] These organized squadrons of amphibious ships, littoral patrol corvettes, coastal patrol boats and riverine squadrons would provide utility across the spectrum of engagement by emphasizing payloads over platforms while allowing the Navy to operate forward dynamically.[27]

An innovative culture has characterized the U.S. Navy throughout its history. The carrier had its day, but continuing to adhere to 100 years of aviation tradition, even in the face of a direct challenge, signals a failure of imagination and foreshadows decline. Money is tight, and as the nautical saying goes, the enemy has found our range. It is time to change course.

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(April 2009), http://www.usni.org/magazines/proceedings/2009-04/buy-fords-not-ferraris.

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