

*The combat utility of the U.S. fleet aircraft carrier
in the post-war period¹*

Ben Ho Wan Beng²

Introduction

The fleet aircraft carrier possesses a number of attributes that make it the United States National Command Authorities' platform of choice to deal with a crisis or war. These attributes are namely, territorial independence, mobility that allows it to deploy as a "first-responder" to a troubled spot, and flexibility provided by the vessel's air wing that allows it to handle different and evolving scenarios. Nevertheless, it must be noted that the relatively successful and unencumbered application of American sea-based airpower in the post-war period has been significantly aided by the benign environments in which the carriers have operated. To illustrate, during Operations Desert Storm and Enduring Freedom, U.S. carriers came up against adversaries with few or no anti-access/area-denial (A2/AD) capabilities such as submarines and missiles. In other words,

¹ This paper is adapted from the author's master's degree in strategic studies dissertation on a similar topic at the S. Rajaratnam School of International Studies, Singapore.

² Senior Analyst, S. Rajaratnam School of International Studies, Singapore

American carriers have so far only proven their worth in situations located on the *lower* end of the combat spectrum.

Indeed, they last met an opponent of a substantial standing – the Japanese navy – in 1944, and questions abound over their ability to do so credibly should the opportunity presents itself in the future. The debate over the carrier’s survivability in the face of new threats has raged on from the vessel’s inception in the 1920s till the present day. Critics contend that A2/AD capabilities would render the modern U.S. carrier obsolete. However, uncertainty clouds this issue as American carriers have not been subjected to a credible access-denial threat in combat situations. Nonetheless, it is possible to draw two conclusions based on empirical evidence related to this matter. They are namely, 1) the submarine, especially the diesel-electric variant, poses a genuine challenge to American carriers, if the sub is able to find and track them; and 2) the anti-ship cruise missile (ASCM) constitutes less of a “mission-kill” threat compared to the torpedo.

Brief Literature Review

The debate over the utility of the carrier as a war-fighting platform for the United States has been going on for decades. This discourse became especially prominent after World War Two as critics pointed out that nuclear weapons would make the flat-top obsolescent.³ And as the Soviet Union developed weapons and strategies to deal with American carriers, critics became even vehement that the vessel would become obsolete. Nonetheless, this did not stop the United States Navy (USN) from utilising them in conflicts where there were little or no sea-control challenges, as in the Korean and Gulf Wars. Since the demise of the Soviet Union, the U.S. has been enjoying unparalleled superiority on the high seas. However, the proliferation since of A2/AD weapons has again raised questions over the carrier’s vulnerability. This issue is discussed frequently

³ The U.S. Air Force was unsurprisingly one of the carrier’s most vehement critics; it maintained that atomic weapons coupled with long-range bombers would make the carrier obsolete. See Robert C. Rubel, “The Future of Aircraft Carriers,” *Naval War College Review* 64, no. 4 (Autumn 2011): p. 16. As for individuals, one of the foremost carrier critics the Cold War was Edward Teller, a physicist who helped develop the hydrogen bomb; he argued that the carrier was useless and excessively vulnerable in the nuclear age. See Beatrice Heuser, *The Evolution of Strategy: Thinking War from Antiquity to the Present* (Cambridge: Cambridge University Press, 2010), p. 272.

in opinion-editorials on publications like *The National Interest* and *The Diplomat*, and the length of these arguments are usually not more than a couple of thousand words long.⁴ The debate is also alive in the blogosphere where informed bloggers put forth their varied arguments on sites such as *War is Boring* and *War on the Rocks*. This study therefore seeks to contribute to the existing literature on the issue by synthesising and analysing in a full-length study the arguments put forth by various camps.

Methodology and scope of study

This paper seeks to answer two central research questions: 1) “Why has the U.S. fleet carrier been so useful in the post-war period?”, and 2) “What is the nature of the threats it faces today?” To tackle these issues, this study will use historical examples. And as its title suggests, only examples from the period since the end of World War Two will be discussed. As for the scope of this paper, only the operational aspects of the American *fleet* carrier in potential or actual combat situations will be assessed; in other words, it will not analyse the platform for such purposes as humanitarian assistance and naval diplomacy. Neither will this study delve into the use of *light* carriers, except for comparative purposes. The following section will assess the utility of the American fleet carrier in the post-war period. The section after the next will raise a number of considerations vis-a-vis the vessel’s vulnerability in a future conflict with adversaries possessing decent anti-access capabilities. The conclusion will then sum up this paper.

The Utility of the U.S. Fleet Carrier

Former U.S. president William Clinton once said that whenever a crisis breaks out, the first question that comes to everyone’s mind would be “Where is the nearest carrier?”

⁴ For a recent example of such an article, see Harry J. Kazianis, “America’s Aircraft Carriers, Submarines and Stealth Weapons: All Obsolete?,” *The National Interest*, February 25, 2016, nationalinterest.org/blog/the-buzz/americas-aircraft-carriers-submarines-stealth-weapons-all-15324. See also Michael Carl Haas, “Yes, the Aircraft Carrier Is Still Relevant,” *The Diplomat*, March 4, 2016, thediplomat.com/2016/03/yes-the-aircraft-carrier-is-still-viable.

In the half century after World War Two, Washington employed force in response to some 200 crises and carriers were involved in two-thirds of them.⁵ On the other hand, the U.S. Army and U.S. Air Force (USAF) were involved in 38 and 53 of these incidents respectively.⁶ This contrast came about because the carrier offered a number of unique advantages over other combat platforms. Said esteemed naval analyst Norman Polmar: “(The) survival of the aircraft carrier... can be attributed to... territorial independence, flexibility of striking power, (and) mobility.”⁷ These three attributes will now be explored and an argument will be made that in an environment with little or no A2/AD challenges, the U.S. fleet carrier has proven useful in supporting ground combat as evidenced in such operations as those off the South-west Asia over the past 25 years. In this light, the carrier is still a viable combat platform, insofar as it is operating in a low-threat environment.

Territorial independence

During times when the defence spending is tight and when different branches of the American military vie for the budgetary pie, the aircraft carrier would often be subjected to criticism by other services, especially the air force. This is because the vessel is deemed to be a major competitor for scarce resources owing to its high price tag and because it is seen as taking over some of the USAF’s roles. Nevertheless, even some of the harshest critics of the USN have begrudgingly alluded to some advantages unique to the carrier, the most important of which is arguably its territorial independence that allows it to conduct operations unconstrained by political limitations. For instance, General Ronald Fogelman, the USAF Chief of Staff from 1994 to 1997 and who was known to be a fierce critic of USN expenditure, was cognisant of this attribute when he said: “Aircraft carriers give you the ability to sail into a littoral region and not have to worry about diplomatic clearance... The... crisis during Taiwan’s elections... was an ideal use of... carriers.”⁸ U.S. carrier task forces, with their own logistical infrastructure and force-

⁵ Jeffrey G. Barlow, “Answering the Call: Carriers in Crisis Response Since World War II,” *Naval Aviation News*, January-February 1997, fas.org/man/dod-101/sys/ship/docs/970100-jb.htm.

⁶ Reuven Leopold, *Sea-Based Aviation and the Next U.S. Aircraft Carrier Design: The CVX* (Cambridge, Massachusetts: Center for International Studies, 1998), p. 4.

⁷ Norman Polmar, *Aircraft Carriers: A Graphic History of Carrier Aviation and Its Influence on World Events* (New York: Doubleday, 1969), p. vii.

⁸ Quoted in Leopold, *Sea-Based Aviation*, p. 5.

projection capabilities, make for an ideal tool for intervention. This is especially so in cases where American interests are not aligned with that of allies, and this could result in Washington not having access to air bases.⁹ The carrier's territorial independence would thus come in handy if local issues were to make it difficult for land-based airpower to be deployed.

One of such issues is that of friendly air bases being attacked. According to a RAND report, the U.S. has 28 major air bases on the geostrategically and economically critical Eurasian landmass.¹⁰ Although land bases are closer to potential hotspots, they are also closer to likely adversaries and could be targeted more easily during a conflict, making them more vulnerable than carriers. As a USN officer maintained: "I can't tell you where... our carriers are... but given a few moments of research at Base Ops, I can give you the coordinates of every Air Force runway... and hangar worldwide."¹¹ The proliferation of missiles and their enabling systems such as satellites in the post-Cold War period has led to several nations gaining the capability to target U.S. bases. In 1997, the Congress-commissioned National Defense Panel encapsulated this point when it concluded that: "Precision strikes, weapons of mass destruction, and... missiles... present threats to our forward presence... Widely available... space-based systems providing imagery, communications, and position location will greatly multiply the vulnerability of fixed... forces."¹²

This threat still endures today. In fact, it could even be said that the threat has become more serious with the advent of more advanced weapon technologies over the years. This is arguably why Washington is realigning forces from Okinawa to Guam and setting up a new Marine contingent in Australia – to hedge against American forces in

⁹ Jacquelyn K. Davis, *Aircraft Carriers and the Role of Naval Power in the Twenty-First Century* (Cambridge, Massachusetts: Institute of Foreign Policy Analysis, 1993), p. 34.

¹⁰ Michael J. Lostumbo, et al., *Overseas Basing of U.S. Military Forces: An Assessment of Relative Costs and Strategic Benefits* (Santa Monica, California: RAND Corporation, 2013), p. 20-30.

¹¹ Quoted in James Paulsen, "Is the Days of the Aircraft Carrier Over?" (Air Command and Staff College Research Report, 1998), p. 20.

¹² Quoted in Christopher J. Bowie, *The Anti-Access Threat and Theater Air Bases* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2002), p. 1.

north-east Asia being targeted by China's A2/AD systems during a conflict.¹³ There have been no studies that do not acknowledge the vulnerabilities of land bases to anti-access threats; furthermore, even the most optimistic of such reports say that these vulnerabilities cannot be removed against an adversary which can attack fixed targets.¹⁴ Land installations are also more vulnerable to terrorist attack. Highlighting the vulnerability of ground installations, one author has merit when he contended that driving a food-delivery truck laden with weapons of mass destruction to the Pentagon might be easier than sending the same package to a carrier at sea.¹⁵ Indeed, in the current age where asymmetric warfare is commonplace, potential adversaries who are unable to take on the U.S. directly in a conventional fight may resort to terrorism and other irregular warfare methodologies.

Equally troublesome for America in times of trouble is the refusal of nations to grant over-flight¹⁶ and aircraft deployment rights – an issue which the carrier does not face. The denial of over-flight rights to land-based aircraft could complicate Washington's strategy. During Operation El Dorado Canyon, France, Spain, and Portugal denied over-flight rights to U.S. aircraft taking off from British bases; consequently, the USAF F-111 Aadvarks involved had to be refuelled in mid-air several times, a problem not faced by the carriers involved in the same operation as the ships were situated contiguously in the battlespace.¹⁷ As for the constraint of needing political clearance before U.S. aircraft can operate from foreign bases, a 2013 study contended that: "The attitude of host countries... is difficult to predict, raising... uncertainties regarding the basing of aircraft. The United States can bring enormous pressure to bear on a host country to accept U.S. forces, but success... cannot be guaranteed."¹⁸

¹³ Cheryl Pellerin, "Work: Guam is "Strategic Hub to Asia-Pacific Rebalance," *DoD News*, August 19, 2014, defense.gov/news/newsarticle.aspx?id=122961.

¹⁴ Sam J. Tangredi, *Anti-Access Warfare: Countering A2/AD Strategies* (Annapolis: Naval Institute Press, 2013), p. 68.

¹⁵ Paulsen, *Is the Days of the Aircraft Carrier Over?*, p. 24.

¹⁶ It must be noted that this point applies only to states contiguous to the sea where the carrier is deployed; overflight rights are still needed for aircraft seeking to reach countries situated landward of a coastal state.

¹⁷ Leopold, *Sea-Based Aviation*, p. 4.

¹⁸ Tangredi, *Anti-Access Warfare*, p. 49.

During the Cold War, U.S. defence experts had already envisaged this problem with the publication of such studies as one in 1978 that recommended moving the base at then-troubled Bahrain to then-friendly Iran's Bandar Abbas and which highlighted the significance of Subic Bay as a base.¹⁹ No one could predict then that Teheran would turn on Washington just one year later or that Subic Bay would cease to be a friendly installation one day. These examples are manifest how the fortunes of American allies, and concomitantly that of the U.S. bases they host, could change.

Examples abound of allies being hesitant or unwilling to allow U.S. aircraft to operate from their territory. Even when Iraq was poised to invade Saudi Arabia after taking over Kuwait in August 1990, the House of Saud hesitated before it permitted coalition forces to be deployed on its soil.²⁰ Similarly, the USAF could not operate out of Saudi Arabia and Turkey for Operation Desert Strike²¹, and this made a USN official comment that the air force had been "castrated."²² He then extolled the territorial independence of the carrier in this instance: "With an aircraft carrier, you get 4.5 acres of Americana with no diplomatic restrictions."²³ The phallic reference may sound exaggerated, but it was a fact that American land-based airpower was effectively emasculated when it could not operate out of its Middle Eastern bases for Desert Strike.

The problem of deployment rights is also present in other geostrategically important areas. In the Asia-Pacific region, there have been calls by allies to place constraints on U.S. forces deployed on their territory, and this could complicate Washington's strategy in the region. For example, the people of Okinawa have put pressure on their government to get U.S. forces on the island to relocate elsewhere. Would Japan allow American aircraft based on its soil to deploy against North Korea during a crisis on the Korean Peninsula and risk retaliation by the Korean People's Army? Issues

¹⁹ Paulsen, *Is the Days of the Aircraft Carrier Over?*, p. 23.

²⁰ Davis, *Aircraft Carriers*, p. 34.

²¹ Operation Desert Strike was initiated by the United States in September 1996 in response to the Iraqi military offensive against the city of Irbil in Iraqi Kurdistan.

²² Quoted in Bowie, *The Anti-Access Threat*, p. 3.

²³ *Ibid.*

such as these would place a premium on the territorial independence of carriers in times of conflict.

Since the turn of the millennium, the carrier's territorial independence has allowed U.S. naval airpower to contribute prominently to the wars in south-west Asia. During Operation Enduring Freedom-Afghanistan, carrier planes substituted significantly for shore-based ones due to the lack of suitable installations near the conflict area for the latter to be viable.²⁴ From October 7, 2001 until the end of major combat in mid-March 2002, six carrier groups flew some 4,900 – about 75 per cent – of the 7,500 air strikes carried out against remote and landlocked Afghanistan.²⁵ On the other hand, USAF tactical aircraft contributed less to the war in Afghanistan as they could not begin operations until only after the 10th day when bases in several Persian Gulf nations had been secured; even then, they had to fly at extreme range and generated significantly fewer combat sorties.²⁶ All in all, American carriers have proved to be useful for their territorial independence, and this characteristic – allied with their mobility – essentially allows them to act as “first responders” to any situation.

Mobility

Our ability to deliver... firepower and generate... high aircraft sortie rates can... impact on... a conflict... during the critical early period of a joint campaign, when... U.S.-based forces are just starting to arrive in theater.²⁷

~ Admiral Jay Johnson, U.S. Chief of Naval
Operations
from 1996 to 2000

Owing to their mobility, U.S. carriers are usually the first assets to be deployed to a hotspot, and this attribute has made one analyst describe the USN, and for that matter

²⁴ Benjamin S. Lambeth, *American Carrier Air Power at the Dawn of a New Century* (Santa Monica, California: RAND, 2005), p. 20.

²⁵ *Ibid*, p. 28.

²⁶ *Ibid*, p. 36.

²⁷ Angelyn Jewell, *Carrier Firepower – Realising the Potential* (Alexandra, Virginia: Center for Naval Analyses, 1999), p. 5.

its carriers, as “the... little Dutch boy... (who) can hold a finger in the dike until reinforcements – the U.S. Air Force, U.S. Army, and allied forces – are in place.”²⁸ When the deployment order comes, a carrier group moving at even a moderate speed of 25 knots can cover a significant 600 nautical miles in 24 hours of continuous steaming. To illustrate, a U.S. carrier group near Guam moving at that speed would take just over two days to reach the vicinity of Taiwan in the event of a Taiwan Strait crisis.²⁹ Suffice it to say that it would reach there even sooner at a higher speed.

The carrier’s mobility that enables it to act as a first responder was manifested as early as during the Korean War. From the invasion of South Korea by the North in June 1950 until the Inchon landings in September, American and British carriers provided the sole tactical aviation assets as the number of South Korean-based aircraft was small and the USAF platforms in Japan were too short-ranged to have significant loiter time over targets. In more recent times, during the 1990 Gulf crisis, Army General Norman Schwarzkopf said the *Eisenhower* and *Independence* battle groups were within range of Iraqi targets within 48 hours of the deployment order being given, adding that: “The Navy was the first military force to respond... and... was also the first airpower on the scene. Both of these deterred, indeed, I believe, stopped Iraq from marching into Saudi Arabia.”³⁰ To get such a glowing assessment from a top officer from a rival service undoubtedly attests to the carrier’s unequalled utility in responding first to a crisis. In addition, the aforementioned carriers provided air cover for the deployment of land-based aircraft to Saudi Arabia, as viable shore-based offensive airpower, but still small and with limited sustainability, was available only three weeks after the crisis broke out.³¹ Had Iraq invaded Saudi Arabia within this period, the two U.S. carriers on station would be even more crucial as they were the only assets in theatre that could take the fight to the enemy.

The importance of flat-tops as first responders has been validated by a study comparing capability differences in land- and sea-based aviation. That study asserted that

²⁸ Ibid.

²⁹ According to the author’s calculation, at 25 knots, it would take some 52 hours to cover the distance of about 1,300nm between Guam and the waters off eastern Taiwan, which is derived from Google Maps.

³⁰ Davis, *Aircraft Carriers*, p. 22.

³¹ John Pay, “Full Circle: The U.S. Navy and its Carriers: 1974-1993,” in *Seapower: Theory and Practice*, ed. Geoffrey Till (Portland: Frank Cass, 1994), p. 136.

cutting a USAF tactical air wing (TFW) would not make a difference vis-à-vis land-based aircraft being deployed to a hotspot as arrival is affected by such factors as base access, not the number of planes.³² On the other side of the coin, the removal of a carrier and its air wing would affect the early arrival of U.S. forces at the scene as less carriers would be forward deployed a smaller fraction of the time.³³ Furthermore, substituting a carrier can mitigate the repercussions of striking a TFW off the force structure, but the converse is not true. This is because improving the early arrival of the TFW in theatre would necessitate not only having additional airlift and tanking assets, but also having more bases.³⁴ In any case, having more bases might not necessarily improve early arrival as being able to operate aircraft off them is subjected to the host nation's approval.³⁵

A different aspect of the carrier's mobility was shown during Operations Deliberate Force and Allied Force when Italy-based aircraft were grounded by fog.³⁶ The U.S. carriers on stations were not affected as they circumvented this by simply moving to a location where weather was suitable for flying, thereby reducing the disruption to the air campaign.³⁷ In the same vein, the carrier has, during exercises, shown how its mobility at high speeds can hinder enemy efforts to find it. To illustrate, in May 1991, the *Eisenhower* task force headed for the Norwegian Sea from the Persian Gulf steaming 7,000nm at an average speed of 30 knots. During the exercise that ensued, the *Eisenhower* sprinted ahead of schedule and launched simulated attacks on British air bases earlier than expected, surprising the Royal Air Force as it thought that the carrier was much further away.³⁸ To be sure, current carrier escorts such as the *Burke*-class destroyers and *Ticonderoga*-class cruisers are conventionally powered and would not be able to steam at high speeds for a long time. That said, this could be ameliorated to some extent as the nuclear-powered U.S.

³² Michael W. Smith and Henry L. Eskew, *Cost and Capability Differences in Land-Based and Sea-Based Tactical Aviation* (Alexandria, Virginia: Center for Naval Analyses, 1995), p. 3.

³³ *Ibid*, p. 4.

³⁴ *Ibid*.

³⁵ *Ibid*.

³⁶ Deliberate Force was the 1995 NATO air campaign launched to undermine the military capabilities of the Bosnian Serb Army during the Bosnian War. Allied Force was also an air campaign by NATO, this time in 1999 against Yugoslavia to stop its human rights abuses in Kosovo.

³⁷ Tim Benbow, "Maritime Power in the 1990-91 Gulf War and the Conflict in the Former Yugoslavia," in *The Changing Face of Maritime Power*, ed. Andrew Dorman, Mike Smith, Matthew Uttley (London: Palgrave MacMillan, 1999), p. 118.

³⁸ Leopold, *Sea-based Aviation*, p. 26.

supercarrier is able to refuel its consorts, slowing down only during the replenishment period and without reducing its own operating range.³⁹

Flexibility

Another inherent advantage offered by the carrier to U.S. theatre commanders is that it can conduct a wide variety of operations because of the different types of aircraft embarked on it. To be sure, land bases can accommodate a wide range of aircraft as well, but they simply lack the unique attributes of territorial independence and mobility offered by the large-deck carrier as discussed earlier. The typical carrier air wing (CVW) today consists of 44 F/A-18 Hornet/Super Hornet fighters, five EA-18 Growler electronic warfare aircraft, four Hawkeye airborne early-warning (AEW) platforms, and 19 MH-60 Seahawk helicopters.⁴⁰ Indeed, during its 50-year service from 1962 to 2012, the USS *Enterprise* operated 43 types of aircraft.⁴¹ This ability to accommodate diverse aircraft enables the carrier to carry out a wide range of missions. This was evidenced during Operation Deliberate Force when carrier planes participated in the whole gamut of operations other than strikes: close air support, search-and-rescue, and enforcing the no-fly zone.⁴²

And because the carrier is such a large platform, it can integrate assets from other services, even other nations, into its operations. This is especially crucial today with the stress placed on jointness between the American armed services, and between Washington and her allies. In the current combat environment characterized by fluidity, the capabilities needed in one region or situation may not be the same in another, and that is why the ease by which the CVW can be modified would be useful.⁴³ To illustrate, during

³⁹ Ibid.

⁴⁰ David Barno, Nora Bensahel and M. Thomas Davis, *The Carrier Air Wing of the Future* (Washington, D.C.: Center for a New American Century), p. 8.

⁴¹ Rebecca Maksel, "The Future of Aircraft Carriers," *Air & Space*, January 15, 2015, airspacemag.com/daily-planet/future-aircraft-carriers-180953905.

⁴² Benbow, "Maritime Power," p. 118.

⁴³ Lambeth, *American Carrier Air Power*, p.37.

Operation Restore Democracy⁴⁴, USS *America* and USS *Eisenhower* carried only elements of the 160th Special Operations Aviation Regiment and the aviation component of the 10th Mountain Division respectively – the ships' organic air wings having being temporarily removed.⁴⁵

The carrier has thus proved to be an extremely useful platform for the U.S. National Command Authorities, but it must be noted that the deployments delineated above occurred where anti-access threats were at best marginal. The following section will consider this issue and the counter-arguments made against the advantages offered by the carrier.

Counter-arguments and a caveat

An argument can be made that the territorial independence of the carrier would not count as much because strategic bombers from the continental U.S. (CONUS) can, with the help of aerial refuelling, hit almost any target around the world. This is certainly true, but it ignores the fact that these bombers are the only aerial assets with the range to deploy to any hot spot and hence the *types* of missions carried out will be limited only to strike. Take the case of a hypothetical conflict with Iran where none of America's Middle Eastern allies want to be involved. Without regional base access, the only shore-based airpower available to the U.S. would be its heavy bombers from Diego Garcia or CONUS. The U.S. heavy bomber force currently consists of B-1 Lancers, B-52 Stratofortresses and B-2 Spirits, of which the first two, both non-stealthy and hence more vulnerable, predominate in numbers. Besides outnumbering the stealthy B-2s, the B-1s and B-52s have a larger payload and would account for most of the bomber sorties generated; however, they will be bereft of enabling capabilities such as air superiority, Suppression of Enemy Air Defences, and intelligence, surveillance and reconnaissance (ISR).⁴⁶ Without these capabilities, the missions would be less effective and more dangerous. That is where a

⁴⁴ This was the 1994 intervention in Haiti to remove the military regime installed by the 1991 coup overthrew the elected President Jean-Bertrand Aristide.

⁴⁵ Ibid.

⁴⁶ Leopold, *Sea-based Aviation*, p. 11.

carrier air wing, which can take on different missions, can come in and provide the aforementioned enabling capabilities for USAF heavy bomber missions.

The same line of reasoning applies for the carrier-versus-cruise missile-armed platform debate. It is certainly true that U.S. submarines and surface ships in international waters can fire their Tomahawk land-attack cruise missiles (TLAMs) at targets without constraints; but the *type* of missions these vessels can undertake is limited. Like strategic bombers, these USN assets can only carry out strike missions with their Tomahawks. To compound matters, the number of TLAMs they carry is limited, which makes their continual contribution to a campaign without at-sea replenishment doubtful. For instance, the 122-cell vertical launch system (VLS) of the *Ticonderoga*-class cruiser do not solely consist of Tomahawks. Ditto the 90- or 96-cell VLS of the *Burke*-class destroyer. Additionally, the surface ships of the Surface Action Groups lack air cover, making them vulnerable to attack. The cruise-missile payload of the *Los Angeles*- and *Virginia*-class attack submarines currently in service are even smaller with each class having a 12-cell VLS for TLAMs.⁴⁷ The *Ohio*-class cruise-missile submarine packs a much heavier punch with its 154 Tomahawks, but there are only four of them currently available. Nevertheless, even this seemingly high figure pales in comparison to the payload of the *Nimitz*-class carrier, which is said to be equivalent to 4,000 Tomahawks.⁴⁸ All in all, the limited Tomahawk payloads of these alternatives to carriers would render them being able to contribute to a campaign for only a short duration. Furthermore, the type of missions these assets can undertake are considerably limited compared to that of carriers.

The air wing of the American fleet carrier also makes it a much suitable candidate for power projection over its light counterpart. That the supercarrier carries a variegated and *large* air wing is an attribute not enjoyed by its smaller counterpart, and this could be decisive in a conflict. During the Falklands War, the lack of a ship-borne AEW aircraft contributed to heavy losses suffered by the British task force, whose air cover was

⁴⁷ The navy is considering bringing forward the plan to begin production of the Virginia Payload Module (VPM) which will be fitted onto Block V *Virginia*-class boats by 2019. Boats with the VPM will be able to fire a total of 40 Tomahawks, which is a substantial increase from the current 12. See "Navy Wants 28 More Tomahawks on Virginia-Class Submarines Sooner" by Kris Osborn at military.com/daily-news/2015/03/16/navy-wants-28-more-tomahawks-on-virginia-class-submarines-sooner.html.

⁴⁸ Geoffrey Till, *Seapower*, (London: Routledge, 2013), p. 127.

provided by two “light” carriers. Owing to their small size, the two carried 20-odd Harrier fighters and Sea King helicopters each. One analyst even said that had the task force consisted of a supercarrier, the war might be concluded in a matter of days⁴⁹ His argument may seem exaggerated, but it does allude to the flexibility and concomitantly, decisive combat potential, offered by the American carrier’s large and variegated air group. And even though the small-deck carrier can embark helicopters fitted with AEW capabilities, they cannot match fixed-wing aircraft in such crucial attributes as range and endurance. In fact, the sole USN ship-borne helicopter – the Seahawk/Knighthawk – currently does not have AEW capabilities. A task force based around the light carrier would therefore severely lack long-range aerial-surveillance coverage, rendering it much more vulnerable to enemy attack.

In addition, these small-deck carriers can carry only about 20 fixed-wing aircraft – either the AV-8 Harrier currently or the upcoming F-35B Lightning. With such a small aircraft contingent, the task force commander would be in a dilemma: compromise on defence and the vulnerability of his ships increases; allocate more assets to defence and fewer will be deployed for the carrier’s *raison d’être* – power projection. Though a two small-carrier task force has almost the same number of tactical aircraft compared to a supercarrier, it is worth noting that the fixed-wing assets on the light flat-top are simply not as capable as those on its heavier counterpart. This is because the light carrier can only operate Vertical/Short Take-Off and Landing (VSTOL) aircraft whose performance is generally inferior compared to that of aircraft deployed on large carriers. To illustrate, Lockheed Martin attributes the VSTOL F-35B with a combat radius of some 450nm, while the carrier variant, the F-35C, 600nm.⁵⁰ All in all, the lack of an AEW platform and the limited performance of aircraft deployed on the small-deck carrier actually make the latter more vulnerable to anti-access threats compared to the supercarrier. As such, light carriers arguably cannot do the job as well as their larger counterparts, especially in demanding circumstances.

⁴⁹ Leopold, *Sea-Based Aviation*, p. 34.

⁵⁰ “F-35 Lightning II Program Status and Fast Facts,” *f-35.com*, [f35.com/assets/uploads/downloads/13567/f-35fast_facts4q2015.pdf](https://www.f35.com/assets/uploads/downloads/13567/f-35fast_facts4q2015.pdf).

Staying on the small-versus-large carrier debate, critics of the supercarrier have often maintained that it would be more cost-effective to have more light flat-tops rather than one heavy one. To illustrate, one prominent carrier critic castigated the approximate US\$12.9 billion commonly cited for building the new *Ford*⁵¹ and contended that for every one supercarrier, at least three light ones can be procured in its place.⁵² This is true at first glance when the *America*-class light carrier, with a unit cost of US\$3.5 billion, is considered.⁵³ However, the US\$12.9 billion for the *Ford* is not merely its unit cost, but also includes US\$3.3 billion for detailed design/non-recurring engineering purposes, which is the *one-time* cost to research, develop, design and test a new item.⁵⁴ Indeed, the unit cost of the *Ford* is stated at US\$9.6 billion.⁵⁵ As the *Ford* programme matures, the unit cost would arguably be reduced. Nonetheless, doing the math based on the unit cost of \$9.6 billion figure, building three *Americas* actually costs *more* than getting one *Ford*. Simple cost comparisons therefore ignore the critical issue of operational effectiveness, and as discussed above, the small carrier simply cannot do the job of its larger counterpart.

Inasmuch as the unique advantages offered by fleet carriers make them an attractive policy instrument for the U.S. president, it must be noted that their deployments in the examples discussed earlier occurred in relatively low-threat milieus. Such permissive environments, which were characterized by factors like the absence of an integrated air-defence system and sea-denial threats, gave the carriers nearly complete freedom to project their airpower. During the first Gulf War, there were serious reservations over the deployment of U.S. carriers to the confined waters of the Persian Gulf owing to Iraq's not insignificant sea-denial capabilities. The Iraqi navy, though bereft of major surface combatants or submarines, nevertheless had 13 missile boats armed with Styx ASCMs and six captured Kuwait craft with Exocet ASCMs.⁵⁶ Additionally, Baghdad

⁵¹ Ronald O'Rourke, *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress* (Washington, D.C: Congressional Research Service, 2015), p. 4.

⁵² Henry J. Hendrix and J. Noel Williams, "Twilight of the Superfluous Carrier," *Proceedings*, Vol. 137/5/1299 (May 2011), usni.org/magazines/proceedings/2011-05/twilight-superfluous-carrier.

⁵³ *Defense Acquisitions: Assessments of Selected Weapon Programs* (Washington, D.C: United States Government Accountability Office, 2014), p. 91.

⁵⁴ O'Rourke, *Navy Ford (CVN-78) Class Aircraft Carrier Program*, p. 3.

⁵⁵ *Ibid.*

⁵⁶ Benbow, "Maritime Power," p. 111-112.

had 400 air-launched Exocets and 50 aircraft to launch them.⁵⁷ Fortunately for the Coalition, the Iraqi sea-denial threat was nullified as the missile boats were poorly deployed and also because these vessels were destroyed early in the conflict by Allied airpower.⁵⁸ Suffice it to say that Iraqi forces were even weaker 12 years later that two of the four American flat-tops involved in Operation Iraqi Freedom operated in the Persian Gulf without undue worry over their safety.

An even more fortuitous situation existed for U.S. carriers during Operation Enduring Freedom-Afghanistan. American projection of carrier airpower against the Taliban regime was conducted in the face of virtually no opposition. Afghanistan, being a landlocked nation, has never had a navy. The Taliban did not have an air force either and what surface-to-air systems it possessed were mostly short-range ones.⁵⁹ Lastly, the generous use of mid-air refuelling which contributed substantially to the reach of U.S. carrier airpower in Enduring Freedom was only made possible by the benign combat environment. Aerial tankers are prized assets that are vulnerable to enemy attack. In a more contested milieu than the one during the Afghan war, they would definitely be afforded less freedom of action. To be sure, the lack of range issue could be alleviated by “buddy” tanking whereby carrier Hornets refuel other Hornets. However, this reduces the availability of the aircraft for combat missions, and as such is a luxury that the carrier strike group would be unable to afford during a high-intensity conflict.

In sum, since the end of World War Two, carriers in general, and for that matter American ones, have not faced decent opposition for the most part. On the one occasion when they did during the Falklands War, it was a close-run thing indeed for British flat-tops. The U.S. carrier seems to revel in the role of a flat-track bully that dominates an inferior adversary who cannot really fight back. The vessel has not taken on a credible opponent since 1944, and the real issue is would it be able to do so should the opportunity present itself in the future. The next section will make some considerations regarding this issue.

⁵⁷ Ibid, p. 112.

⁵⁸ Till, *Seapower*, p. 271.

⁵⁹ Martin Van Creveld, *The Age of Airpower* (New York: Public Affairs, 2011), p. 265.

The U.S. Fleet Carrier in an A2/AD Environment

Admiral James L. Holloway III once said during his tenure as the U.S. Chief of Naval Operations from 1974 to 1978 that in a potential conventional war with the Warsaw Pact, 30 to 40 per cent of American carriers would be sunk.⁶⁰ This assertion would have surprised the U.S. naval community as Holloway was a decorated *carrier aviator* who saw service in the Korean and Vietnam conflicts. In the same vein, Admiral Hyman Rickover was asked during a 1982 congressional hearing about how long American carriers would survive in a war and he replied: “48 hours.”⁶¹ In the ensuing period till the present day, several senior American naval officers have made similar hard-hitting statements. One of the harshest of such critics in recent years is Captain (retired) Henry J. Hendrix, who argued that the carrier is “in danger of becoming like... battleships: big, expensive, vulnerable.”⁶² Statements like these have raised questions over the viability of the mainstay of the United States Navy in a high-intensity conflict, and this section will draw some conclusions regarding this issue from a fresh perspective.

Three major anti-access/area-denial challenges are viewed as jeopardising the carrier’s survivability – indeed of all surface combatants – and these threats are namely, submarines, anti-ship cruise missiles, and anti-ship ballistic missiles (ASBMs). The ASBM has created voluminous debate since reports of the Chinese DF-21D first surfaced last decade. What is known about this weapon, at least from open sources, is that it has only been tested once on stationary targets, not moving ones, and not at sea.⁶³ Specifics of the missile are also vague. To illustrate, the U.S. Department of Defense could only ascribe a range of “exceeding 1,500km” to the weapon.⁶⁴ In fact, some analysts have even questioned whether the “carrier killer” will be used in the first place as its flight pattern,

⁶⁰ Ibid, p. 275.

⁶¹ David W. Wise, “The U.S. Navy’s Big Mistake – Building Tons of Supercarriers,” *War is Boring*, May 27, 2015,

medium.com/war-is-boring/the-u-s-navy-s-big-mistake-building-tons-of-supercarriers-79cb42029b8.

⁶² Henry J. Hendrix, *At What Cost A Carrier?* (Washington, D.C: Center for a New American Century, 2013), p. 3.

⁶³ Kyle Mizokami, “Five Chinese Weapons of War America Should Fear,” *National Interest*, May 7, 2014, nationalinterest.org/feature/five-chinese-weapons-war-america-should-fear-10388.

⁶⁴ Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People’s Republic of China 2015*, p. 39.

which is similar to that of a nuclear-tipped intercontinental ballistic missile, could be construed as the opening salvo of a nuclear strike and lead to a global conflict.⁶⁵ Bearing these considerations in mind, this paper will not discuss the DF-21D as to do so would be purely speculative. It will, however, assess two mature weapon systems – submarines and ASCMs – based on related empirical evidence. The examples to be discussed will be limited to those of the Chinese and Iranians mainly because they are the most likely adversaries of the U.S. in a future high-intensity conflict because they are regarded as strategic competitors

A caveat

Forecasting the outcome of a future conflict based on what is stated on paper such as weapon specifications is risky business. One reason for this is that governments are generally reluctant to reveal everything about their militaries, and may hide or embellish certain details. This is especially so in authoritarian societies such as China and Iran, and esteemed strategist Edward Luttwak has alluded to this conundrum. As James R. Holmes, an associate professor with the Naval War College, wrote:

Luttwak... observed... (that) weapons are like “black boxes”. Until used in combat, no one knows for sure whether they will perform as advertised. Battle, not technical specifications, is the true arbiter of military technology’s value. Accurately forecasting how ships, planes, and missiles will perform amid the stresses and chaos of combat thus verges on impossible. This is especially true... when conflict pits an open society against a closed one.⁶⁶

Luttwak was referring to the American-Soviet naval competition, but his statement is just as applicable to any dynamic involving Washington and Beijing or Teheran. His argument holds water because the ever-ubiquitous “fog of war” is said to

⁶⁵ Robert Farley, “Should America Fear China’s ‘Carrier-Killer’ Missile?,” *National Interest*, September 22, 2014, nationalinterest.org/feature/should-america-fear-chinas-carrier-killer-missile-11321.

⁶⁶ James R. Holmes, “The Sino-Japanese War of 2012,” *Foreign Policy*, August 20, 2012, foreignpolicy.com/2012/08/20/the-sino-japanese-naval-war-of-2012.

rear its ugly head during every conflict – witness the Iran Air Flight 655 tragedy in July 1988 where the much-vaulted Aegis air-defence system of the USS *Vincennes* mistakenly identified an airliner for a hostile warplane. A high-intensity conflict involving American carriers would probably not be exempted from the fog of war. Nevertheless, by referencing history, reasoned extrapolations can be made. As one scholar argued: “The future cannot be known at all... despite its... ambiguities, historical experience remains the only available guide to both the present and to the range of alternatives inherent in the future.”⁶⁷

In this light, through an assessment of past training exercise performance and “dramatic incidents” such as fires⁶⁸, it is possible to draw some conclusions about threats to the U.S. carrier. Simply put, this essay will contend that the submarine and its traditional weapon, the torpedo, poses a graver threat to the carrier compared to the anti-ship cruise missile. And this is because the torpedo is more likely to bring about a mission kill of the carrier compared to the ASCM.

The submarine threat

Even in the open ocean, NATO fleet exercises demonstrate time and again that a proportion of SSKs will get through the screen.

~Commander Richard Compton-Hall, Royal Navy (Retired)⁶⁹

⁶⁷ Quoted in Williamson Murray and MacGregor Knox, “The Future Behind Us,” in *The Dynamics of Military Revolution 1300-2050*, ed. Williamson Murray and MacGregor Knox (Cambridge: Cambridge University Press, 2001), p. 176.

⁶⁸ James R. Holmes, “India’s Aircraft Carrier Challenge,” *The Diplomat*, October 8, 2012, thediplomat.com/2012/10/indias-aircraft-carrier-challenge.

⁶⁹ Roger Thompson, *Lessons Not Learned: The U.S. Navy’s Status Quo Culture* (Annapolis: U.S. Naval Institute Press, 2007), p. 15.

U.S. Navy exercises with diesel submarine since the mid-1990s have often proved humbling.

~John Benedict, National Security Analysis Department,
John Hopkins University Applied Physics Laboratory⁷⁰

As these statements by two noted authorities show, the diesel-electric submarine (SSK) is said to pose a grave danger to the U.S. carrier. This is because the platform, which is quieter than its nuclear-powered counterpart (SSN), is seemingly often able to slip detection by the carrier's escorts and get to a close enough position to be able to attack the ship. It is a *fact* that there have been numerous instances of American carrier groups being surprised by SSKs, friendly or otherwise, during either training exercises or regular deployments. The most famous of such cases is arguably the 2006 incident of a Chinese *Song*-class SSK surfacing at a distance within firing range of the USS *Kitty Hawk* battle group.⁷¹ The argument goes that if a relatively inferior sub like the *Song* was able to penetrate the carrier's screen, a more capable one such as the *Kilo*-class SSK, which is owned by several governments not exactly friendly with Washington, would find the endeavour easier.

Two of the America's likely adversaries in a future conflict, Iran and China, possess attack submarines that could threaten USN carriers. According to *The Military Balance 2016*, Iran's current submarine force is rather small. It comprises three *Kilos* and an assortment of smaller attack and midget submarines, of which not much is known of their capabilities.⁷² As these smaller vessels lack the range to be ocean going⁷³, it is unlikely that U.S. carriers will encounter them; hence the *Kilo* will be probably the flat-tops' main sub-surface threat in any future conflict with Iran. As for the People's Liberation Army Navy (PLAN), it has five SSNs and 60 SSKs, all of which are ocean

⁷⁰ Ibid.

⁷¹ For more instances of American carriers being surprised by SSKs, refer to Thompson's *Lessons Not Learned*.

⁷² International Institute of Strategic Studies, *The Military Balance 2016* (London: Routledge, 2016), p. 328.

⁷³ For example, the Iranian navy's midget submarine based on the North Korean *Yono* is believed to have a submerged range of only 55nm, in Anthony H. Cordesman and Aaron Lin, *The Iranian Sea-Air-Missile Threat to Gulf Shipping* (New York: Rowman & Littlefield, 2015), p. 123. To be sure, the Iranian midget submarine could lie in wait for an enemy naval force in the Strait of Hormuz. That being said, during times of tension and possible conflict, it is tactically imprudent for the CSG to get itself reined in in the narrow waterway.

going.⁷⁴ Of these, the more modern ones are two *Shang* SSNs, 12 *Kilos*, and 12 *Yuan* SSKs.⁷⁵ This study will now discuss the threat posed by Iranian/Chinese submarines by analysing 1) in the event of a conflict, how likely they are able to locate the American carrier and, 2) if they are able to do so, to what extent could they successfully damage or sink the ship.

Enemy subs are likely to be forward deployed in a cordon to intercept the American carrier strike group (CSG) as it transits to the conflict zone. Owing to their limited speed, SSKs will act essentially as mobile minefields and in this capacity, the Iranian *Kilos* will have a tall order just finding the CSG. This is because the northern Arabian Sea is a vast area of real estate for three relatively slow-moving vessels, which are submerged most of the time, to cover. Furthermore, the Islamic Republic's ocean-surveillance repertoire is still fledging, given that it does not have satellites for that purpose or AEW platforms; the *Kilos* hence cannot count on exogenous direction to interdict the carrier. Compounding the problem, Iranian subs are believed to lack maintenance while their crew lack realistic training.⁷⁶ They would therefore need a great dose of luck to be "at the right place and time" to even contact the American carrier at all. Nevertheless, one expert maintained that in spite of these weaknesses, the threat posed by Iranian subs cannot be ignored.⁷⁷

As for the issue of Chinese subs finding U.S. carriers, Peter Howarth maintained in a 2006 book that in the event of a Taiwan contingency:

The PLA Navy's most promising course would be to deploy its quiet *Kilo*- and *Song*-class SSKs to stake out the chokepoints between the chain of islands along the East Asian continental shelf and lie in wait for carrier... groups as they make their way into the semi-enclosed areas off the China coast.⁷⁸

⁷⁴ *The Military Balance 2016*, p. 329.

⁷⁵ *Ibid.*

⁷⁶ Cordesman and Lin, *The Iranian Sea-Air-Missile Threat*, p. 22.

⁷⁷ *Ibid.*

⁷⁸ Peter Howarth, *China's Rising Sea Power: The PLA Navy's Submarine Challenge* (London: Routledge, 2006), p. 103.

China's considerable progress in the anti-access arena in the ensuing years since that study was published means that U.S. carrier groups would be reluctant to operate in the "semi-enclosed areas off the China coast", which is the area within or around the First Island Chain. As such, they are likely to operate beyond that – in the Philippine Sea and beyond (refer to map below).



Source: globalsecurity.org/military/world/china/plan-doctrine-offshore.htm

The area to be covered is vast, even for the numerically large Chinese submarine force. Indeed, PLAN boats would stand a greater chance of contacting American carriers if Chinese ocean-surveillance capabilities, which seemed to have progressed in recent years through the launching of several satellites for this purpose, are harnessed to their full potential. And if a carrier is discovered, an SSK would find it difficult to track continuously the American vessel's movement unless the sub's position relative to the carrier is optimal at first contact. In other words, the SSK, owing to its limited speed, is simply in no position to play catch-up with the carrier group. Indeed, the *Kilo* has a top submerged speed of only 17 knots and this for a limited duration; on the other hand, the *Nimitz*-class supercarriers can make 30 knots or more. Though it can be argued that SSNs possess the speed to do so, it must be noted that only the PLAN's *Shangs*, with a top

speed of 30 knots⁷⁹, is capable of matching the CSG as the other Chinese SSN in service, the *Han*, can only make up to 25 knots.⁸⁰ Furthermore, Chinese SSNs would be caught between a rock and a hard place: move at slower speeds to reduce detection but risk losing contact with the target, or move faster and risk being discovered. All in all, the “tyranny of geography” could mean that Chinese subs would find it difficult to establish contact with an American carrier without exogenous elements such as direction provided by satellites. To compound matters, Chinese boats lack towed-array sonar that would enable them to detect targets from a much greater distance compared to hull sonar.⁸¹ In addition, PLA-N submariners lack operational proficiency, even though steps like increased patrols have been taken in recent years to remedy this problem.⁸²

And if an enemy submarine is able to get into an optimal position relative to a U.S. carrier, can the sub track its target without being detected? The decline of the discipline of anti-submarine warfare (ASW) in the USN since the end of the Cold War does not bode well for this issue. Indeed, James R. Holmes maintained that ASW has been a “subsidiary function (of the USN) for a generation” as a result of the USN’s focus on power projection since 1992.⁸³ The fortunes of the carrier-borne S-3 Viking ASW plane in the post-Cold War period manifested this de-emphasis on ASW. The aircraft was a valuable sub-hunter for the carrier battle group as it enabled area-ASW coverage.⁸⁴ During the Cold War, the aerial anti-submarine defence of an American carrier task force consisted of two components: area- and local-ASW efforts. The latter, currently the only form of aerial ASW practised by CSGs, involves helicopters deployed in a 25-75 nm zone around the flattop. As for area ASW, it involves fixed-wing sub-hunters like the Viking patrolling an area of around 75-150 nm ahead of the carrier. Area-ASW coverage from

⁷⁹ “Type 093 Shang-class Nuclear Attack Submarine Specifications,” *GlobalSecurity.org*, globalsecurity.org/military/world/china/type-93.htm.

⁸⁰ Howarth, *China’s Rising Sea Power*, p. 103.

⁸¹ Ronald O’Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities – Background and Issues for Congress* (Washington, D.C: Congressional Research Service, 2016), p. 75.

⁸² *Ibid*, p. 76.

⁸³ James R. Holmes, “Relearning Anti-Submarine Warfare,” *The Diplomat*, October 30, 2014, thediplomat.com/2014/10/relearning-anti-submarine-warfare.

⁸⁴ Ben Ho Wan Beng, “U.S. Navy: Time to Bring Back the S-3 Viking?” *The Diplomat*, November 9, 2015, thediplomat.com/2015/11/u-s-navy-time-to-bring-back-the-s-3-viking.

the air has not been carried out since the standing down of the S-3 as an anti-submarine platform in the 1990s, and this has essentially removed a critical layer of defence for the carrier group.

Indeed, from the 1990s, the aircraft's main missions shifted to surface warfare and mid-air refuelling. In 2009, the Viking was retired altogether, leaving the Seahawk helicopter as the sole carrier-borne ASW platform, and eroding the carrier group's ASW capabilities. Indeed, hunting subs is merely just one of the Seahawk's repertoire of missions. And even though the USN has in recent years become cognisant of this decline and has taken steps accordingly to remedy it, including the full integration of advanced ASW systems such as the SQQ-89A(V)15 Combat System, the Multi-Functional Towed Array, and the P-8 Poseidon maritime patrol aircraft.⁸⁵ That said, this issue of ASW deficiency on the part of the United States Navy simply cannot be resolved in a short period of time, and the frequent instances by which American carriers have been surprised by submarines from other countries, whether allied or otherwise, attest to the fact ASW performance is a genuine cause for concern for the USN.

So, assuming an enemy submarine is able to sneak into position to attack the American carrier, what is the likelihood of their ordnance achieving critical hits? At this juncture, it is appropriate to establish the terms "mission kill" and "platform kill". Simply put, platform kill occurs when the ship attacked is sunk, while a mission kill involves the ship being unable to perform its primary task(s). The *raison d'être* of the aircraft carrier is its air wing and the ability to conduct flight operations is indispensable in this aspect. Making its flight deck inoperable would be one way to bring about the mission kill of a carrier. Another would be to reduce the ship's speed and manoeuvrability as it must be able to maintain a steady course and speed for the launch and recovery of aircraft. For America's adversaries, achieving a mission kill of its carriers may just be enough for a major military and political victory.

The hostile submarine can attack the American carrier with either its torpedoes or if it has them, ASCMs. A hit from the former is arguably the more damaging of the two. As Peter Howarth contended: "Large armoured warships are inherently difficult to sink

⁸⁵ Jeff W. Benson, "A New Era in Anti-Submarine Warfare," *Proceedings*, August 27, 2014, news.usni.org/2014/08/27/opinion-new-era-anti-submarine-warfare.

or disable with hits above the waterline, unless the missiles manage to penetrate a vital area of the ship such as its magazine or combat information centre.⁸⁶ Similarly, as Norman Friedman argued, underwater weapons are “inherently far more lethal than their above-water counterparts, because they can flood and thus sink a ship”.⁸⁷ Also toeing this line is then U.S. Chief of Naval Operations Gary Roughhead who maintained in 2011: “I would argue that you can put a ship out of action faster by putting a hole in the bottom [with a torpedo] than by putting a hole in the top.”⁸⁸ A torpedo hit, which is below the waterline, will create a hole in the carrier’s hull and this might slow the ship down or make it list. A wake-homing torpedo – a weapon owned by some of America’s most likely adversaries – is even more dangerous as it tracks the wake created by the target and is likely to hit the propeller system or its vicinity upon impact. This is an outcome that would adversely degrade the carrier’s speed and mobility – two factors that would affect its ability to conduct flight operations. All in all, attaining torpedo hits on an American carrier has a decent chance of bringing about its mission kill – if the resultant damage is not properly contained.

To be sure, U.S. carriers are currently equipped with soft-kill counter-torpedo capabilities in the form of the SLQ-25 Nixie decoy and the Acoustic Device Countermeasure Mark 2 Mod 4.⁸⁹ That being said, American flat-tops currently do not possess a hard-kill counter-torpedo system, as the Torpedo Warning System and the Countermeasure Anti-Torpedo will reach initial operational capability only in 2019.⁹⁰ What is worth nothing is that these capabilities have not been tested under combat situations whatsoever, and it remains to be seen how effective they are in the heat of battle.

As a matter of fact, there have not been instances in the post-war era of American warships being hit by torpedoes. There were, however, a few incidents of fires involving USN assets, and this will be elaborated in the next segment on the cruise-missile threat.

⁸⁶ Howarth, *China’s Rising Sea Power*, p. 99.

⁸⁷ Quoted in *Ibid.*

⁸⁸ Wise, “The U.S. Navy’s Big Mistake.”

⁸⁹ *U.S. Navy Program Guide 2015*, p. 57, *navy.mil*, www.navy.mil/strategic/top-npg15.pdf.

⁹⁰ *Ibid.*

Bearing this in mind, it can perhaps be argued that in any future conflict, the United States Navy would be more used to handling topside hits rather than those involving parts of the ship below the waterline. This is because the USN would undoubtedly have drawn up a list of “Lessons Learned” after each incident of fire and take appropriate measures in such areas as damage control that will be implemented in the future. Although it can be argued that the USN has had *some* experience in dealing with hits around the waterline when they handled damage to a number of mined assets in the 1980s and 1990s, it must be emphasized that the mine is a different weapon together compared to the torpedo. In fact, the largest of these ships mined – the 19,500-tonne USS *Tripoli* – set off a device containing about 135kg of explosives and yet its structural integrity was compromised.⁹¹ The amount of explosives in the torpedoes owned by America’s potential adversaries is much higher and the damage these weapons can cause is likely to be significantly higher. To illustrate, the Type 53 torpedo used by the Iranians and Chinese has a 300kg warhead.⁹² China also has the Type 65 wake-homing torpedo with a 500kg warhead.⁹³ Moreover, there is a fundamental difference between a torpedo and mine strike as the former usually involves the weapon exploding under the target ship’s keel, seriously jeopardising its structural integrity as a consequence. Tellingly, the Type 53 and 65 torpedoes are both “keel busters”. On the other hand, the naval mine, while damaging in its own right, simply cannot inflict the same amount of damage on a target ship compared to a torpedo, *ceteris paribus*. All in all, American ship crew might not be able to handle a torpedo hit as well as one from a missile considering the USN’s lack of experience in dealing with the former; in this light, the submarine-launched torpedo constitutes a genuine threat to the U.S. carrier.

As Iranian submarines are believed to lack the capability to fire ASCMs, they can only attack the carrier with torpedoes. On the other hand, China seems to stress the centrality of ASCMs in attacking ships. Said an instructor at the Chinese navy’s submarine academy, who wrote a textbook for fire-control personnel: “Under modern

⁹¹ The amphibious-assault ship hit a LUGM-145 device during Operation Desert Storm, in Edward J. Marolda, Robert John Schneller, *Shield and Sword: The United States Navy and the Persian Gulf War* (Annapolis: Naval Institute Press, 2001), p. 249.

⁹² Cordesman and Lin, *The Iranian Sea-Air-Missile Threat*, p. 111.

⁹³ Norman Friedman, *The Naval Institute Guide to World Naval Weapon Systems* (Annapolis: Naval Institute Press, 2006), p. 731.

combat conditions, the main combat method for attack submarines is to fire anti-ship missiles from underwater to attack enemy surface ships.”⁹⁴ If this doctrinal emphasis on missiles were to be strictly followed in a war, Chinese submarines might actually be rendered more vulnerable. This is because the launch of a missile underwater is a noisy affair – even more so than that of a torpedo – as the “flaming datum” would give away the position of the submarine, making it more susceptible to counter-attack if there are enemy forces in the vicinity. To exacerbate matters, the submarine will have to be operating at a shallow depth in order to launch its missiles, and this accentuates its vulnerability.

What is worth noting is that by using ASCMs, PLAN submarines might have a *lower* chance of hitting and crippling an American carrier. Modern Chinese boats like the *Kilo* and *Shang* have six torpedo tubes each and this means usually a maximum of five ASCMs will be loaded into the tubes and fired. This is because it is typical, indeed prudent, for the submarine to have at least a torpedo loaded and ready for firing in case any sub-surface threat appears. A salvo of a handful of missiles, though dangerous in its own right, hardly constitutes the saturation attack which the Aegis systems on the carrier’s escorts are built to handle. Having said that, China is in the process of commissioning three upgraded *Shangs* armed with a vertical launch system each for launching missiles⁹⁵ – a development that could significantly complicate CSG defence. The number of tubes in the upgraded *Shang*’s VLS is currently unknown. However, if one were to assume a conservative number of eight⁹⁶, that would mean that the sub is capable of launching at least a dozen ASCMs at its target, and this would be an ominous development for the USN indeed.

⁹⁴ Quoted in Dennis M. Gormley, Andrew S. Erickson, and Jingdong Yuan, *A Low-Visibility Force Multiplier: Assessing China’s Cruise Missile Ambitions* (Washington, D.C.: National Defense University Press, 2014), p. 51.

⁹⁵ Franz-Stefan Gady, “China’s ‘New’ Carrier Killer Subs,” *The Diplomat*, April 6, 2015, thediplomat.com/2015/04/chinas-new-carrier-killer-subs.

⁹⁶ The later Los Angeles-class and Virginia-class submarines have a 12-cell VLS each.

The ASCM threat

The saturation attack where many ASCMs are simultaneously fired at a target has been commonly cited as the harbinger of the U.S. carrier's demise. The argument goes that a few "leakers" evading the CSG's defences are all it takes to devastate the force. American warships, and indeed that of any other nation, have not been subjected at all to missile attacks of such nature in the post-war era; so, going by the "black box" argument, it would be difficult to assess whether such attacks will overwhelm the CSG's defence. Nonetheless, the failure of Aegis during the Flight 655 case and ineffectiveness of the Phalanx Close-In Weapon System during the 1987 USS *Stark* incident shows that much-touted military technology could disappoint even during relatively peaceful conditions, let alone in the heat of battle.⁹⁷ It is therefore not inconceivable that a CSG is overwhelmed by a saturation attack involving ASCMs. In addition, there were a number of serious fires involving U.S. flat-tops in the post-war period and it is reasonable to infer from these blazes what would be the likely aftermath of ASCM hits on a modern carrier. This is because these fires bear a similarity to ASCM hits in that both involve the ship's topside.

The conflagration that engulfed the USS *Enterprise* in January 1969 is often cited as evidence of the U.S. carrier's ability to take punishment and still continue fighting. The fire occurred when nine 500-pound bombs were set off on its flight deck and the explosive power of the blast was said to be equivalent to that of six Russian cruise missiles.⁹⁸ In spite of heavy casualties – 27 dead and 300 wounded – the catapults and arresting gear of "Big E" remained relatively undamaged and she resumed flight operations within hours.⁹⁹ In fact, all that was needed to do so was to simply remove the debris from the accident.¹⁰⁰ In other words, the ship sustained the equivalent of half a dozen ASCM hits, but did not become a mission kill. If one were to infer from this case, it can be maintained that the ASCM does not create as well the conditions for a mission kill compared to the torpedo. However, it must be stressed that this extrapolation does not take into account

⁹⁷ Armin Krishnan, *War as Business: Technological Change and Military Service Contracting* (Farnham, Surrey: Ashgate Publishing, 2013), p. 60.

⁹⁸ Howarth, *China's Rising Sea Power*, p. 99.

⁹⁹ *Ibid.*

¹⁰⁰ Paulsen, *Is the Day of the Aircraft Carrier Over?*, p. 22.

the fact that at the point of impact, the missile could be moving at speeds of between Mach 2 and 3, or more. Indeed, the Chinese Kh-31P/YJ-91 is reportedly capable of making Mach 3.5.¹⁰¹ The question is thus: “Would the kinetic energy sustained from travelling at such high speeds allow the missile to penetrate the carrier’s armour and hit vital spaces like its magazines?” Witness the sinking of HMS *Sheffield* during the Falklands conflict where a *subsonic* Exocet penetrated the destroyer’s hull, but did not detonate. Nevertheless, the missile caused fires that doomed the ship.

All in all, the uncertainty of war means that it is difficult to predict the course of a conflict. Conclusions based on factors like weapon specifications could be invalidated as military platforms are “black boxes” whose performance can only be assessed by actual combat. Having said that, the fact that the SSK has often penetrated the layered defence of the CSG means it poses a credible threat to the carrier, as long as the boat is able to contact, track and attack its target. This is especially so if the SSK uses as its primary weapon the torpedo that is more likely to bring about a mission kill compared to the ASCM.

Going forward, Beijing has always treated submarines as a key component of their “counter-intervention” strategy against a modern adversary.¹⁰² To this end, China is seriously investing in its underseas fleet and their submarines now outnumber that of America as a result, though their quality is still inferior.¹⁰³ As a senior USN official said: “We know they (the PLAN) are out experimenting and... want to be in this world of advanced submarines.”¹⁰⁴ The key issue is to what extent can the Chinese catch up with the Americans in the realm of undersea warfare? Opined Owen R. Cote perceptively: “The Chinese are still far from that position, but... it would... be a mistake to assume that they won’t eventually get there if they decide to try.”¹⁰⁵ In fact, the case of the Soviet *Akula*-class submarine, whose acoustic technologies appeared years before the West’s

¹⁰¹ Gormley *et al*, *A Low-Visibility Force Multiplier*, p. 22.

¹⁰² O’Rourke, *China Naval Modernization*, p. 75.

¹⁰³ Andrea Shalal, “China submarines outnumber U.S. fleet: U.S. admiral,” *Reuters*, February 25, 2015, reuters.com/article/us-usa-china-submarines-idUSKBN0LT2NE20150225.

¹⁰⁴ *Ibid*.

¹⁰⁵ Owen R. Cote, *Assessing the Undersea Balance Between the U.S. and China* (Cambridge, Massachusetts: MIT Security Studies Program Paper, February 2011), p. 28.

projection¹⁰⁶, shows that Washington must not rest on its laurels with regard to Chinese submarines.

As for the ASCM, though deadly in its own right and provided it does not penetrate the carrier's vital spaces such as its magazines, it is less likely to bring about a mission kill of the ship. The 1969 *Enterprise* incident, which has been likened to the ship being struck by multiple missiles, bears some testimony to this assertion. New integrated fires systems incorporating new technologies such as the laser, which has witnessed advances recently and which if brought to maturation, might just alleviate the ASCM threat. One of the key shortcomings of the CSG's defence is the finite number of surface-to-air missiles its constituents can carry, rendering it susceptible to being overwhelmed by a saturation attack. Said an expert on the laser as a ship-borne weapon:

A laser would give a ship a weapon with a deep (some observers say unlimited) magazine capacity. Lasers could permit Navy surface ships to more effectively defend themselves against adversaries with more weapons and decoys than can be handled by the ships' onboard supplies of interceptor missiles and CIWS ammunition.¹⁰⁷

Whether the laser will prove to be a viable weapon remains to be seen. And if this eventuality comes to pass, the onus will be on America's potential adversaries to come up with a counter in yet another episode in the dialectical realm of warfare.

Conclusion

Rounding up this paper, the U.S. fleet carrier has offered a number of unique advantages over other platforms in situations location on the *lower ends of the combat spectrum*. In essence, the National Command Authorities will always place a premium on forces which are not subjected to local constraints, can deploy quickly to the troubled spot, and, can adapt to different scenarios – attributes that are unique to fleet carriers. Nevertheless, it must be stressed that American carrier deployments in the post-war

¹⁰⁶ Polmar, *Submarines*, p. 210.

¹⁰⁷ Ronald O'Rourke, *Navy Shipboard Lasers for Surface, Air, and Missile Defense: Background and Issues for Congress* (Washington, D.C: Congressional Research Service, 2015), p. 3.

period have taken place in environments that were relatively free of A2/AD threats. With such challenges, would the vessel be given carte blanche to project its airpower? Would its survivability be seriously questioned by the submarine and other anti-ship systems? In fact, is the carrier still useful in the 21st century?

The first two questions cannot be answered accurately as the modern U.S. carrier has yet to operate in a contested environment. The third, however, can be addressed with a fair amount of certainty, and the answer is “yes.” Conflict between major powers has been infrequent in the post-war period, and if this trend persists – and several experts have argued that it is likely to be the case – the U.S. carrier will not face credible A2/AD systems like those owned by major powers.¹⁰⁸ On the other hand, the high occurrence of lower-intensity conflicts is likely to continue, and the U.S. fleet carrier has, despite criticism, already proven its worth in such situations.

That said, an area where both sides on this debate can agree on is that the U.S. CVW since the end of the Cold War has been relatively short-ranged. The current Super Hornet air wings are optimized to conduct strikes between 200-450nm from their mother ships without aerial refuelling.¹⁰⁹ In stark contrast, during the Cold War, the A-6 Intruder bomber could conduct unrefuelled missions of 600nm.¹¹⁰ Fortunately, America’s enemies had not exploited this shortcoming so far as they lacked credible anti-access capabilities. And with potential adversaries such as China and Iran making progress in the anti-access arena, the recent talk is of extending the reach of U.S. carrier aviation through the now defunct Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) aircraft with “longer legs” than the Super Hornet and the Lightning.¹¹¹ The UCLASS

¹⁰⁸ One of the chief proponents of the “conflict between major powers is obsolete” thesis is political scientist John Mueller who wrote the 1989 book *Retreat from Doomsday: The Obsolescence of Major War*. In the same vein, international relations luminary Graham Allison concluded that a Sino-U.S. war in the next decade is “unlikely” in a 2014 *Atlantic* article entitled “Just How Likely Is Another World War?”.

¹⁰⁹ Thomas P. Ehrhard and Robert O. Work, *The Unmanned Combat Air System Carrier Demonstration Program: A New Dawn for Carrier Aviation?* (Washington DC: Center for Strategic and Budgetary Assessments, 2007), p. 2.

¹¹⁰ *Ibid*, 21.

¹¹¹ Sam LaGrone, “Pentagon to Navy: Convert UCLASS Program Into Unmanned Aerial Tanker, Accelerate F-35 Development, Buy More Super Hornets”, *USNI News*, February 1, 2016,

initiative is just one of the several developments made vis-à-vis the CVW – the carrier’s raison d’être – throughout the decades. Several of these developments have meant that the flat-top has managed to stay relevant, though the ship itself remains largely unchanged. As James R. Holmes argued: “Age... does not spell obsolescence... a carrier hull is a container for whatever sensors or weaponry engineers install in it, and an airstrip for whatever aircraft it’s equipped to operate.”¹¹²

The issue of the carrier’s utility in the future is therefore largely dependent on whether its “Sunday Punch” would be relevant for the current and future politico-military environment. Washington believes that access to the Indo-Asia-Pacific littoral would be critical in the coming years and this is reiterated in a revised version of 2007’s *A Cooperative Strategy for 21st Century Seapower* released in March 2015.¹¹³ The document also recognizes the CSG as embodying the navy’s “preeminent strike capability”.¹¹⁴ As the Indo-Asia-Pacific is largely a maritime domain, the American fleet carrier would have a crucial role to play in any major regional contingency there. Perhaps only a war in that area – with China – could the issue of how the U.S. supercarrier would fare in high-intensity combat be answered. And the question of “What would be the doctrinal role of the vessel in such a conflict?” would profoundly shape this issue. Robert C. Rubel posited that in a contested environment, the carrier might be useful as a support vessel for either the submarine or the littoral combat ship.¹¹⁵

Similarly, another possible role for the flat-top is to provide air cover, ISR, and other enabling missions for its Tomahawk-carrying escorts in high-end combat with a

news.usni.org/2016/02/01/pentagon-to-navy-convert-uclass-program-into-unmanned-aerial-tanker-accelerate-f-35-development-buy-more-super-hornets.

¹¹² James R. Holmes, “The US Navy is Big Enough: A Zombie Idea That Won’t Die,” *Real Clear Defense*, March 10, 2015,

realcleardefense.com/articles/2015/03/10/the_us_navy_is_big_enough_a_zombie_idea_that_wont_die_107725-3.html.

¹¹³ *A Cooperative Strategy for 21st Century Seapower*, www.navy.mil/local/maritime/150227-CS21R-Final.pdf, p. 9.

¹¹⁴ *Ibid*, p. 19.

¹¹⁵ Robert C. Rubel, “The Future of Aircraft Carriers,” *Naval War College Review*, Vol. 64, No.4 (Autumn 2011): p. 24.

near-peer competitor.¹¹⁶ This is likely as the U.S. CVW's "retreat from range"¹¹⁷ since the end of the Cold War does not seem to be alleviated anytime soon, given that there are no long-range carrier strike aircraft in the developmental stage. Moreover, the 900nm range of the latest Tomahawk variant¹¹⁸ enables power projection from much further out compared to carrier aviation. In other words, the carrier would not be the main player in this situation – its Tomahawk-armed escorts, ironically, would. Were that to happen, the carrier-escort nexus would have come full circle since World War Two.

Prior to 1942, the flat-top played a supporting role to the battlefleet. Carrier planes were to serve as scouts to find enemy battleships and attack them if possible so as to "soften" them for the friendly battleline to deliver the coup de grace. This did not transpire as the carrier supplanted the battleship as the "Queen of the Waves" during the course of the Second World War. The flat-top has held that title since and its primacy as *the* capital ship has been largely unchallenged – until recent years with the upsurge in A2/AD prowess of America's potential adversaries. Indeed, the talk now is of "missile carriers" – platforms with a copious inventory of long-range cruise missiles – eclipsing flat-tops as the premier U.S. naval power-projection asset.¹¹⁹ This does not mean, however, that the cruise-missile platform will replace the carrier as numero uno. This is because the flat-top offers a number of unique advantages that the missile carriers will never possess, as mentioned earlier in this paper. What is likely, therefore, is that the Tomahawk shooters will partake significantly in "first day(s) of war" operations, with carriers playing only a supporting role in the background. Once the enemy's metaphorical "A2/AD door" has been kicked down with the softening of enemy defences, the carrier would once more take centre stage.

¹¹⁶ Jon Solomon, "The Large-Deck Carrier: Part 2," *Information Dissemination*, November 18, 2014, informationdissemination.net/2014/11/the-large-deck-carrier-part-2.html.

¹¹⁷ For a comprehensive study of how the U.S. CVW's striking reach has atrophied over the years, see Henry J. Hendrix, *Retreat from Range: The Rise and Fall of Carrier Aviation* (Washington, D.C: Center for a New American Century, 2015).

¹¹⁸ "Tomahawk Cruise Missile," *navy.mil*, www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1300&ct=2.

¹¹⁹ Philip, E. Pournelle, "The Rise of the Missile Carriers", *Proceedings*, Vol. 139, No. 5 (May 2013), p. 34.

In the final analysis, there are numerous issues surrounding the utility of the American fleet aircraft carrier, and this lively debate is set to go on. What could end it is arguably the litmus test of high-intensity conflict involving that venerable platform. But with many thousands of lives undoubtedly at stake, the author vehemently hopes such issues will *never* be raised in real life.

Bibliography

A Cooperative Strategy for 21st Century Seapower, www.navy.mil/local/maritime/150227-CS21R-Final.pdf.

Barlow, Jeffrey G. "Answering the Call: Carriers in Crisis Response Since World War II." *Naval Aviation News*, January-February 1997.
fas.org/man/dod101/sys/ship/docs/970100-jb.htm.

Barno, David; Bensahel, Nora and Davis, M. Thomas. *The Carrier Air Wing of the Future*. Washington, D.C: Center for a New American Century, 2014.

Benbow, Tim. "Maritime Power in the 1990-91 Gulf War and the Conflict in the Former Yugoslavia." In *The Changing Face of Maritime Power*. Edited by Andrew Dorman; Mike Smith; Matthew Uttley, 107-124. London: Palgrave MacMillan, 1999.

Benson, Jeff W. "A New Era in Anti-Submarine Warfare." *Proceedings*, August 27, 2014
news.usni.org/2014/08/27/opinion-new-era-anti-submarine-warfare.

Bowie, Christopher J. *The Anti-Access Threat and Theater Air Bases*. Washington, D.C: Center for Strategic and Budgetary Assessments, 2002.

Cordesman, Anthony H. and Lin, Aaron. *The Iranian Sea-Air-Missile Threat to Gulf Shipping*. New York: Rowman & Littlefield, 2015.

Cote, Owen R. *Assessing the Undersea Balance Between the U.S. and China*. Cambridge, Massachusetts: MIT Security Studies Program Paper, February 2011.

Davis, Jacquelyn K. *Aircraft Carriers and the Role of Naval Power in the Twenty-First Century*. Cambridge, Massachusetts: Institute of Foreign Policy Analysis, 1993.

Defense Acquisitions: Assessments of Selected Weapon Programs. Washington, D.C: United States Government Accountability Office, 2014.

Ehrhard, Thomas P. and Work, Robert O. *The Unmanned Combat Air System Carrier Demonstration Program: A New Dawn for Carrier Aviation?* Washington D,C.: Center for Strategic and Budgetary Assessments, 2007.

"F-35 Lightning II Program Status and Fast Facts," *f-35.com*,

[f35.com/assets/uploads/downloads/13567/f-35fast_facts4q2015.pdf](https://www.f-35.com/assets/uploads/downloads/13567/f-35fast_facts4q2015.pdf).

Farley, Robert. "Should America Fear China's 'Carrier-Killer' Missile?" *The National Interest*, September 22, 2014, nationalinterest.org/feature/should-america-fear-chinas-carrier-killer-missile-11321.

Friedman, Norman. *The Naval Institute Guide to World Naval Weapon Systems*. Annapolis: Naval Institute Press, 2006.

Gormley, Dennis M.; Erickson, Andrew S.; and Jingdong Yuan. *A Low-Visibility Force Multiplier: Assessing China's Cruise Missile Ambitions*. Washington, DC.: National Defense University Press, 2014.

Gady, Franz-Stefan. "China's 'New' Carrier Killer Subs." *The Diplomat*, April 6, 2015, thediplomat.com/2015/04/chinas-new-carrier-killer-subs.

Hendrix, Henry J. and Williams, J. Noel. "Twilight of the Superfluous Carrier," *Proceedings* (May 2011), usni.org/magazines/proceedings/2011-05/twilight-uperfluous-carrier.

Hendrix, Henry J. *At What Cost A Carrier?* Washington, D.C: Center for a New American Century, 2013.

Hendrix, Henry. J. *Retreat from Range: The Rise and Fall of Carrier Aviation*. Washington, D.C: Center for a New American Century, 2015.

Ho, Ben Wan Beng. "U.S. Navy: Time to Bring Back the S-3 Viking?" *The Diplomat*, November 9, 2015, thediplomat.com/2015/11/u-s-navy-time-to-bring-back-the-s-3-viking.

Holmes, James R. "The Sino-Japanese War of 2012." *Foreign Policy*, August 20, 2012, foreignpolicy.com/2012/08/20/the-sino-japanese-naval-war-of-2012.

Holmes, James R. "India's Aircraft Carrier Challenge." *The Diplomat*, October 8, 2012, thediplomat.com/2012/10/indias-aircraft-carrier-challenge.

Holmes, James R. "Relearning Anti-Submarine Warfare," *The Diplomat*, October 30, 2014, www.thediplomat.com/2014/10/relearning-anti-submarine-warfare.

Holmes, James R. "The US Navy is Big Enough: A Zombie Idea That Won't Die." *Real Clear Defense*, March 10, 2015,

realcleardefense.com/articles/2015/03/10/the_us_navy_is_big_enough_a_zombie_idea_that_wont_die_107725-3.html.

Howarth, Peter. *Chinese's Rising Sea Power: The PLA Navy's Submarine Challenge*. London and New York: Routledge, 2006.

International Institute of Strategic Studies. *The Military Balance 2016*. London: Routledge: 2016.

Jewell, Angelyn. *Carrier Firepower – Realising the Potential*. Alexandria, Virginia: Center for Naval Analyses, 1999.

Krishnan, Armin. *War as Business: Technological Change and Military Service Contracting*. Farnham, Surrey: Ashgate Publishing, 2013.

LaGrone, Sam. "Pentagon to Navy: Convert UCLASS Program Into Unmanned Aerial Tanker, Accelerate F-35 Development, Buy More Super Hornets.", USNI News, February 1, 2016, news.usni.org/2016/02/01/pentagon-to-navy-convert-uclass-program-into-unmanned-aerial-tanker-accelerate-f-35-development-buy-more-super-hornets.

Lambeth, Benjamin S. *American Carrier Air Power at the Dawn of a New Century*. Santa Monica, California: RAND, 2005.

Leopold, Reuven. *Sea-Based Aviation and the Next U.S. Aircraft Carrier Design: The CVX*. Cambridge, Massachusetts: Center for International Studies, 1998.

Lostumbo, Michael J.; McNerney, Michael J.; Peltz, Eric; Eaton, Derek; Frelinger, David R.; Greenfield, Victoria A.; Halliday, John; Mills, Patrick; Nardulli, Bruce R.; Pettyjohn, Stacie L.; Sollinger, Jerry M.; and Worman, Stephen M. *Overseas Basing of U.S. Military Forces: An Assessment of Relative Costs and Strategic Benefits* (Santa Monica, California: RAND Corporation, 2013.

Maksel, Rebecca. "The Future of Aircraft Carriers," *Air & Space*, January 15, 2015, airspacemag.com/daily-planet/future-aircraft-carriers-180953905.

Marolda, Edward J. and Schneller, Robert John. *Shield and Sword: The United States Navy and the Persian Gulf War*. Annapolis: Naval Institute Press, 2001.

- Mizokami, Kyle. "Five Chinese Weapons of War America Should Fear," *National Interest*, May 7, 2014, nationalinterest.org/feature/five-chinese-weapons-war-america-should-fear-10388.
- Murray, Williamson and Knox, MacGregor. "The Future Behind Us." In *The Dynamic of Military Revolution 1300-2050*. Edited by Williamson Murray and MacGregor Knox, p. 175-194. Cambridge: Cambridge University Press, 2001.
- Office of the Secretary of Defense. *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2015*.
- O'Rourke, Ronald. *China Naval Modernization: Implications for U.S. Navy Capabilities – Background and Issues for Congress*. Washington, D.C: 2016.
- O'Rourke, Ronald. *Navy Shipboard Lasers for Surface, Air, and Missile Defense: Background and Issues for Congress*. Washington, D.C: Congressional Research Service, 2015.
- O'Rourke, Ronald. *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress*. Washington, D.C: Congressional Research Service, 2015.
- Paulsen, James. "Is the Days of the Aircraft Carrier Over?" Air Command and Staff College Research Report, 1998.
- Pay, John. "Full Circle: The U.S. Navy and its Carriers: 1974-1993." In *Seapower: Theory and Practice*. Edited by Geoffrey Till, 124-147. Portland: Frank Cass, 1994
- Pellerin, Cheryl. "Work: Guam is "Strategic Hub to Asia-Pacific Rebalance." *DoD News*, August 19, 2014, defense.gov/news/newsarticle.aspx?id=122961.
- Polmar, Norman. *Aircraft Carriers: A Graphic History of Carrier Aviation and Its Influence on World Events*. New York: Doubleday, 1969.
- Polmar, Norman. *Submarines of the Russian and Soviet Navies, 1718-1990*. Annapolis: Naval Institute Press, 1991.
- Pournelle, Philip, E. "The Rise of the Missile Carriers", *Proceedings*, Vol. 139, No. 5 (May 2013): p. 30-34.
- Rubel, Robert C. "The Future of Aircraft Carriers." *Naval War College Review* 64, No.4 (Autumn 2011): p. 13-27.

- Shalal, Andrea. "China submarines outnumber U.S. fleet: U.S. admiral." *Reuters*, February 25, 2015, [reuters.com/article/us-usa-china-submarines-idUSKBN0LT2NE20150225](https://www.reuters.com/article/us-usa-china-submarines-idUSKBN0LT2NE20150225).
- Smith, Michael W. and Eskew, Henry L. *Cost and Capability Differences in Land-Based and Sea-Based Tactical Aviation*. Alexandria, Virginia: Center for Naval Analyses, 1995.
- Solomon, Jon. "The Large-Deck Carrier: Part 2." *Information Dissemination*, November 18, 2014, informationdissemination.net/2014/11/the-large-deck-carrier-part-2.html.
- Tangredi, Sam J. *Anti-Access Warfare: Countering A2/AD Strategies*. Annapolis: Naval Institute Press, 2013.
- Till, Geoffrey. *Seapower: A Guide for the Twenty-First Century*. Routledge: London, 2013.
- Thompson, Roger. *Lessons Not Learned: The U.S. Navy's Status Quo Culture*. Annapolis: U.S. Naval Institute Press, 2007.
- "Tomahawk Cruise Missile," www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1300&ct=2.
- "Type 093 Shang-class Nuclear Attack Submarine Specifications." globalsecurity.org/military/world/china/type-93.htm.
- U.S. Navy Program Guide 2015*, *navy.mil*, www.navy.mil/strategic/top-npg15.pdf.
- Van Creveld, Martin. *The Age of Airpower*. New York: Public Affairs, 2011.
- Wise, David W. "The U.S. Navy's Big Mistake – Building Tons of Supercarriers." *War is Boring*, May 27, 2015, medium.com/war-is-boring/the-u-s-navy-s-big-mistake-building-tons-of-supercarriers-79cb42029b8#.n7e2m9yjq.