Regaining the High Ground Against China: A Plan to Achieve US Naval Aviation Superiority This Decade

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The Center for Defense Concepts and Technology at Hudson Institute

Hudson Institute’s Center for Defense Concepts and Technology examines the evolving field of military competition and the implications of emerging technologies for defense strategy, military operations, capability development, and acquisition. The center focuses on a comprehensive view: connecting strategy with new operational concepts; assessing the weapons and systems needed to implement new concepts; and evaluating the necessary commitment of resources.

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CHAPTER 1. INTRODUCTION: AN INCREASINGLY CONTESTED AIRSPACE

The US Navy and Marine Corps face growing challenges ranging from great powers China and Russia to regional threats such as Iran and North Korea, all of whom seek to undermine their neighbors’ stability and revise geopolitical relationships in their favor. Despite the impact of the COVID-19 pandemic and resulting economic downturn, each of these potential adversaries continued to improve its military capabilities, especially the number and reach of precision missiles able to strike US allies and slow or prevent intervention by US naval forces. Supported by commercial and military surveillance networks in every domain, weapons based on adversary territory could threaten US and allied ships, troop formations, and aircraft hundreds of miles away. The People’s Republic of China (PRC) fields the most capable of these networks, as shown in Figure 1.¹

To complement their traditional militaries, US adversaries also support or direct sub-conventional or “gray-zone” operations by paramilitary forces, criminal organizations, terrorists, and proxies. Gray-zone operations have proved an effective approach for aggressors to gain influence and territory without the cost and international condemnation that can accompany a military campaign. And because gray-zone forces are inexpensive and can melt into the local population, their efforts are sustainable in ways a formal military deployment is not.²

By combining long-range precision fires with sub-conventional forces and activities, opponents such as the PRC, Russia, and Iran

Photo: CF-5 FLT 218 piloted by CDR Ted Dyckman on the USS George Washington on August 18, 2016. (Todd R. McQueen)
could hinder US military operations in their regions and compel US ground troops and ships to operate at greater distances from potential conflict. Although the DoD is fielding long-range hypersonic missiles to overcome the impact of Chinese and Russian precision weapon and sensor networks, few ships will carry them until the late 2030s. Long-range ground-based hypersonic weapons that will arrive in the mid-2020s will be too costly to buy in large numbers and may not be acceptable to some US allies who would need to host them. As a result, the US military will increasingly rely on airpower for the reach needed to deter or counter aggression.

However, in confrontations against major powers like the PRC a large portion of the Air Force’s fighter and bomber inventories will likely be consumed protecting allied airspace and attacking enemy sensors, missile batteries, and military facilities ashore. Some Air Force bombers may be available to counter PLA naval forces, but only the B-1 is equipped to use anti-ship missiles. The bulk of maritime operations in the Taiwan Strait and South and East China Seas will therefore likely fall to the Navy.

Multiple assessments during the last several years have explored how the Navy’s fleet should change to better address the PRC threat. This study will address the largely ignored US Navy and Marine Corps aviation portfolio and how it should evolve by the early 2030s to enable naval forces to counter Chinese belligerence.
Exploiting the Sea as Maneuver Space

Naval aviation has a storied history of commanding the seas during World War II and the Cold War, but as threats to sea control abated following the Soviet Union’s dissolution, naval air forces shifted to projecting power through strike operations ashore. Although Navy and Marine Corps aviators flying into Kosovo or Iraq faced some Soviet-era air defenses, their carriers were able to safely operate close to adversary coastlines, allowing frequent sorties with moderate need for aerial refueling.6

The uncontested maritime conditions of post-Cold War regional conflicts are unlikely to recur against even a regional power like Iran, and certainly not against major powers China and Russia. Aircraft carriers and airfields will face salvos of ballistic and cruise missiles within 2,000 nm of China’s mainland or Chinese-controlled maritime features and People’s Liberation Army Air Force (PLAAF) bombers could extend that range to more than 3,500 nm. Figure 2 summarizes the throw weight of weapons potentially facing US forces in a confrontation against China in 2030, but likely underestimates the threat posed by the PLA, which has consistently modernized and grown its capacity faster than US intelligence community projections.

The number of weapons facing US forces will make sustained offensive operations difficult within about 1,500 nm of China. For

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**Figure 2: Projected 2030 PLA strike capacity vs. range**

![Figure 2: Projected 2030 PLA strike capacity vs. range](image-url)

Source: Authors.7

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**PLA strike aircraft in 2030**

<table>
<thead>
<tr>
<th>System</th>
<th>Total Aircraft</th>
<th>Aircraft Employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>JH-7A/A2</td>
<td>180</td>
<td>90</td>
</tr>
<tr>
<td>J-10B/C</td>
<td>160</td>
<td>80</td>
</tr>
<tr>
<td>H-6K/N</td>
<td>205</td>
<td>102</td>
</tr>
<tr>
<td>JH-XX</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>H-20</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 3: The number of weapons that could be destroyed by US naval air defenses at sea and ashore per 2-minute salvo attack

The figure assumes incoming weapons need to be defeated with a 90 percent likelihood of success and assumes IFPC, SM-class, and ESSM missiles have a 70 percent probability of kill; RAM missiles have a 90 percent probability of kill; and EW/HPM has a 50 percent probability of kill. Lasers are assumed to have an 80 percent probability of kill with a 10 second dwell time on target and 2 seconds to slew between targets. FFGs and DDGs are assumed to apportion VLS cells as follows: 10 percent SM-3, 25 percent SM-6, 15 percent SM-2, 40 percent ESSM, 5 percent Tomahawk, 5 percent VL ASROC. Additionally, each DDG/FFG has a SLQ-32(V)6 EW system. Each EAB has one IFPC Inc-1 interceptor system and an EW system equivalent to 1/3 the capacity of a SLQ-32(V)6.

Source: Authors.

example, using the estimates of Figure 2, a force of ships and troop formations operating in and around the southern Philippines—about 1,000 nm from China—could be attacked by up to 360 anti-ship ballistic missiles, plus daily raids of about 5,000 air-delivered 2,000-lb precision guided munitions (PGM). The context for such a confrontation would likely be a larger and longer conflict, which suggests only a portion of these weapons would be devoted to US forces in and around the Philippines during any given day. If 10 percent of the PLA’s weapons were allocated to these missions, US ships and Marines around the Philippines would have to counter up to 500 air-delivered weapons per day plus about 36 land-based missiles. In the worst case, all the PLA weapons allocated would be employed in one salvo.

If the naval force in this example consisted of two Marine Expeditionary Advance Bases (EAB), four guided missile frigates (FFG), and four guided missile destroyers (DDG), an even distribution of PLA attacks would assign three ballistic missiles per target and about 50 PGMs delivered per day by aircraft. As shown in Figure 3, US naval forces in this situation may be able to counter the initial salvos of ballistic missiles and air-launched PGMs with a combination of “hard-kill” surface-to-air interceptors and “soft-kill” electromagnetic warfare (EW) or high-power microwave (HPM) systems that disrupt weapon guidance.9

As their interceptor magazines ran out, ships and EABs would fall back to EW/HPM systems, which may have sufficient ca-
capacity to defeat subsequent PLA strikes. However, these energy weapons can only engage weapons after they cross the horizon, limiting the number of incoming weapons per salvo that can be defeated. Faced with sustained attacks from PLA aircraft, naval forces would likely need to withdraw or attempt to hide in terrain or civilian activity, preventing them from contributing to the fight.

The situation does not improve with larger naval units and force packages. For example, a carrier strike group (CSG) of a carrier and seven DDGs will have substantial defensive capacity, as shown in Figure 4. This capacity would be sufficient to address an initial salvo of about 536 weapons described above in and around the Philippines.

It is unlikely, however, that the PLA would limit its weapons expenditure to 10 percent of its inventory if it were engaging a US CSG, and follow-on attacks by PLA air forces would be likely. As a result, the CSG would see larger initial salvos or sustained salvos that would exceed its defensive capacity once the CSG’s escorts depleted their vertical launch system (VLS) magazines. Sensor countermeasures, often touted by Navy leaders as protecting carrier operations closer to China, are unlikely to defeat the PLA’s robust and overlapping surveillance network over the Western Pacific unless carriers also restrict maneuvers and flight operations, reducing their relevance.

To enable sustained offensive operations, US naval forces will need to shrink and dilute enemy weapons salvos to within the capacity of their air defenses. As suggested by Figure 2, positioning US forces more than 1,500 nm from China would shrink the total number of weapons they could face to about 360 ballistic missiles overall and 2,200 air-delivered PGMs per day. Assuming only a portion of those weapons are employed against ships and EABs in the context of a theater-wide confrontation against US and allied forces, the defenses described in Figures 3 and 4 could be sufficient if naval forces also dilute salvos as described below.

Dispersal, as described in the Navy Distributed Maritime Operations (DMO) and Marine Expeditionary Advanced Base Operations (EABO) concepts, is already being pursued by naval forces to dilute PLA missile salvos. Distributing ships and troop formations would create more targets for PLA attacks and could reduce the number of weapons reaching each unit to within the capacity of passive defenses like hardening and active defenses such as surface-to-air interceptors and EW systems.
Navy and Marine forces could further dilute PLA attacks by employing camouflage and decoys across multiple portions of the electromagnetic spectrum (EMS), including radiofrequency (RF) transmitters that mimic US radars and radios, infrared (IR) emitters that simulate signatures from US vehicles, ships, or planes, and—for ground vehicles or systems—visual decoys. Perfect decoys are expensive and difficult to create. However, reducing EMS emissions from real systems and obscuring both real and decoy systems using visual and IR camouflage or RF jammers could enable real and decoy forces to look sufficiently alike that attackers are compelled to engage both or spend time further assessing the targeting picture.

Naval forces may not need to remain 1,500 nm from Chinese territory throughout a confrontation. Operating at sea also affords US naval forces the ability to close with enemy forces as the threat environment or risk calculation of US leaders change. However, the analysis above highlights the characteristics needed in naval forces to dissuade aggression by Beijing. With a viable ability to impact events in the East and South China Seas under stressing conditions, US naval forces can help dissuade or deter a range of PRC aggressive acts.

**A Crowded Carrier Deck**

After 30 years of flying strike missions from carriers sailing in permissive waters close to shore, US naval air forces will need new approaches for employment, basing, and fleet composition to be relevant in conflicts up to 1,500 nm from the enemy. The most important of these changes will be to move some missions and aircraft from carriers to other ships or shore in order to maximize the reach and capacity of naval airpower as described below.

During the more than 100 years of carrier aviation, Navy and Marine air forces tended to increase their reliance on specialized aircraft against improving threats and deploy more multi-mission planes when threats abate. For example, Figure 5 shows how the Navy reduced the percentage of air defense, attack, and other specialized aircraft in carrier air wings (CVW) following the Cold War and increasingly relied on multi-role strike fighters. This approach managed maintenance and logistics costs by reducing the variety of airframes on the carrier, and multi-role F/A-18 Hornets and F/A-18E/F Super Hornets were sufficient against regional powers such as Iraq or Yugoslavia. However, the trade-offs between range, speed, and payload in multi-role aircraft

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**Figure 5: Composition of US CVWs over time**

![Figure 5: Composition of US CVWs over time](image-url)
result in CVWs that are less suited for the contested environments naval forces face today. In addition to lacking the reach for long fights from areas where CSGs can defend themselves, the speed, maneuverability, and signatures of multi-role aircraft may be insufficient to defeat opposing fighters or air defenses.

Historical trends would suggest that naval aviation should field growing numbers of specialized aircraft in the face of intensifying threats from the PLA and other militaries. However, carrier space constraints will require that the Navy and Marine Corps achieve a more diverse airpower portfolio by leveraging aircraft that can fly from other ships or shore to accomplish their missions.

Figure 2 shows the greatest threat to naval forces in the Western Pacific comes from PLA aircraft that can launch large salvos of cruise missiles and bombs, rather than long-range missiles launched from the Chinese mainland. To address PLA bombers and cruise missile equipped ships, US naval forces will need to "kill the archer before it launches its arrows." But unlike the Cold-War Outer-Air Battle tactic, in which carrier-based fighters would intercept Soviet bombers, naval forces today will need to use a combination of shore, sea, and airborne air defense systems to attack PLA platforms due to extreme ranges of modern anti-ship missiles (ASM). Assuming they field anti-ship versions of weapons like the DH-10 cruise missile or the US Navy’s BGM-109 Tomahawk, PLA ships and aircraft will need to be engaged 1,000 nm away from naval forces, creating too large an area to cover with the CVW’s fighter capacity alone.

Offensive operations will demand a similar approach. To impact events in the South or East China Sea from 1,500 nm away, naval aircraft will need to travel at least 1,000 nm and then use standoff weapons to attack PLA ships, aircraft, or forces ashore on islands or maritime features. Submarines and surface combatants could help sustain strikes through periods when carriers need to reposition or move out of range, but they will need to be reloaded outside the theater.

Strike fighters with standoff weapons like the Long-Range Anti-Ship Missile (LRASM) should be able to attack targets about 900 nm from their host carrier without refueling. However, aircraft and weapons may need to fly circuitous routes to avoid threat sensors, coordinate attacks, or loiter until a target is detected. And air-to-air missiles to counter enemy bombers or...
torpedoes for attacking submarines lack the LRASM's standoff range. Carrier-based strike fighters will therefore almost always need aerial refueling to engage enemy launch platforms. As shown in Figure 6, the Navy retired its dedicated aerial fueling aircraft shortly after the Cold War ended. Today, CVWs rely on “buddy-tanking,” in which an F/A-18E/F with wing-mounted tanks refuels other aircraft, trading strike fighter capacity to achieve greater range. Once carrier aircraft reach areas where Air Force and allied aircraft are operating—likely 1,000 nm from carrier operating areas, they could leverage Air Force aerial refueling tankers. Operating Air Force tankers near carriers would be inefficient due to the CVW's relatively small aggregate fuel demand.16

The Navy is addressing the need for CVWs to operate from longer range by fielding the MQ-25A Stingray tanker unmanned air vehicle (UAV). One MQ-25A can deliver approximately 15,000 lbs. of fuel at 500 nm, considerably more than a F/A-18E buddy tanker configuration and enough to enable 2 F-35Cs or F/A-18E/Fs to reach about 1,000 nm from the carrier and return.17 However, to employ all its available aircraft for a strike mission approximately 1,000 nm away (exclusive of the range of their weapons), CVWs would need to include 15 MQ-25As, rather than 5-9 as the Navy currently plans.18

The need to find and track enemy ships and bombers will further increase refueling demands. As Figure 6 shows, since

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**Figure 7: The Navy’s planned CVW after MQ-25A is added**

<table>
<thead>
<tr>
<th>Squadron Type</th>
<th>Description</th>
<th>Planned/Noted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three V(F)A squadron</td>
<td>Each with 10 F/A-18E/F aircraft</td>
<td>Planned 44</td>
</tr>
<tr>
<td>One V(F)A squadron</td>
<td>14 F-35C aircraft</td>
<td>Planned 5-7</td>
</tr>
<tr>
<td>One VAQ squadron</td>
<td>5-7 E/A-18G aircraft</td>
<td>Planned 5</td>
</tr>
<tr>
<td>One VAW squadron</td>
<td>5 E-2D AEW&amp;C aircraft</td>
<td>Planned 5-9</td>
</tr>
<tr>
<td>One VUQ detachment</td>
<td>5-9 MQ-25A utility/tanker aircraft</td>
<td>Often 1-2 onboard CVN</td>
</tr>
<tr>
<td>One VRC detachment</td>
<td>2-3 CMV-22 multimission aircraft</td>
<td>Often 2-3 onboard CVN</td>
</tr>
<tr>
<td>Two HSM/HSC squadrons</td>
<td>3-11 MH-60R/S helicopters</td>
<td>Often 2-3 onboard CVN</td>
</tr>
</tbody>
</table>

the 1950s CVWs have incorporated a changing array of intelligence, surveillance, and reconnaissance and targeting (ISR&T) and airborne early warning and control (AEW&C) planes. Today, E-2D Advanced Hawkeye AEW&C aircraft provide most organic CVW airborne sensing, complemented by the passive radiofrequency (RF) sensing capabilities of EA-18G Growler EW aircraft and passive infrared and RF sensors on strike fighters. However, because they have similar endurance limitations as strike fighters, ISR&T aircraft will require refueling to surveil the wider and deeper threat axes around naval forces operating at standoff ranges of 1,500 nm or more from China.\textsuperscript{19} 19

The increasing demand for aerial refueling will crowd an already full carrier deck. In theory, Nimitz-class aircraft carriers can host about 100 F/A-18 A-D sized aircraft, but recent deployments showed that support equipment, larger airframes, and the need for space to move planes around safely have constrained CVWs to about 67 aircraft.\textsuperscript{20} As shown in Figure 7, the Navy’s planned CVW after the MQ-25A is fielded will likely be at its maximum size, even without adding MQ-25As to address growing refueling requirements or other emerging needs like increased ISR&T.

Restoring the Relevance of Shore-based Naval Aircraft

The Navy could free up space on carriers for strike fighters and tankers by shifting a larger share of specialized missions currently performed by CVWs—such as ISR&T, EW, and anti-submarine warfare (ASW)—to aircraft operating from shore or from other ships. Today, land-based ISR&T and maritime patrol and reconnaissance aircraft (MPRA) already conduct a portion of the Navy and Marine Corps’ detection and tracking missions, taking advantage of the longer endurance possible with larger airframes that are not constrained by the carrier’s dimensions.

As shown in Figure 8, the land-based naval aviation fleet shrank to a minimum during the early 2010s before growing again with the introduction of the P-8A Poseidon and several new UAVs.

Figure 8: Inventory of land-based Navy and Marine Corps ISR&T and maritime patrol and reconnaissance aircraft

![C2 and ISR aircraft inventory](https://www.history.navy.mil/content/history/museums/nnam/explore/collections/aircraft/) and [https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/](https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/).
The slowly expanding naval UAV portfolio includes the Navy’s high altitude long endurance (HALE) MQ-4C Triton and the Marine Corps’ medium altitude long endurance (MALE) MQ-9 Reaper, as well as small UAVs such as the RQ-21A Blackjack and MQ-8C Firescout that can be launched from ships or shore.

The Navy and Marine Corps’ ability to leverage land-based aircraft for CVW missions is currently constrained by aircraft survivability and endurance. ASW provides a good example. Because the CVW’s MH-60R helicopters cannot search more than 100 nm from their ships, P-8As perform most ASW tracking, relying on cueing from intelligence satellites or seabed sonar arrays such as the Sound Surveillance System (SOSUS) and Fixed Distributed System (FDS). P-8As then use active or passive sonobuoys to track submarines and can engage them using air-launched Mk-54 torpedoes.

P-8As must remain within line-of-sight of sonobuoys to communicate with them, and Mk-54 torpedoes are not standoff weapons, requiring P-8As to operate near likely enemy submarine operating areas such as chokepoints or the maritime approaches around US naval forces. However, flying slow, high-signature P-8As above chokepoints relevant to a confrontation with China—such as the Luzon, Ryuku, or Kyushu Straits—would place them within weapons range of PLA fighter aircraft and air defense systems on ships or Chinese-controlled maritime features. P-8As would be more survivable if they operate only episodically within reach of enemy fighters or air defenses, which would reduce their utility in chokepoint ASW.

The Navy could address the vulnerability of P-8As by using them to defend the fleet operating in open ocean. As suggested by Figure 9, the P-8As range of about 4,500 nm would enable it to conduct 6-to-8-hour missions around naval forces in the Philippine Sea from commercial or civil airfields in Compact of Free Association states, southern Japan, or the Marianas. If those airfields were attacked during a conflict, P-8As could fly from bases further away in locations such as northern Australia at the expense of mission time, which would shrink to 2-to-4 hours. P-8As could conduct longer missions with aerial refueling, but...
Air Force tankers may not be available and MQ-25As do not carry enough fuel to substantially increase P-8A mission duration.

AEW&C is another mission where survivability and endurance pose challenges to shifting carrier missions ashore. As slow, high-signature aircraft, E-2Ds are too vulnerable to operate within range of PLA fighters or air defenses. Combined with its range limitations, the E-2D’s vulnerability will result in Hawkeyes surveilling the area around naval forces in open ocean rather than the hundreds of miles of airspace between the fleet and China. However, operating locally around naval forces would help with fleet air defense, and E-2Ds could support 2-to-3-hour missions over the Philippine Sea from airfields in the Compact of Free Association states or Marianas. E-2Ds could also extend their missions by refueling from MQ-25As.

Insufficient range and survivability will similarly prevent shore-based EA-18G Growlers from supporting offensive naval EW or ISR&T missions against peer competitors like China. Their lack of stealth makes EA-18Gs vulnerable against PLA fighters and air defenses, which will be exacerbated if EA-18Gs use their jamming capabilities. Moreover, with an unrefueled combat radius of about 400 nm, EA-18Gs would significantly reduce the fuel available for strike fighters if they supported missions 1,000 nm or more from the carrier. The EA-18G’s limited range will also demand substantial refueling to reach naval forces in open ocean from airfields in the Marianas, Compact of Free Association states, or Japan.24

**Holistically Reassessing Naval Aviation**

Simultaneously addressing the range limitations of CVWs and the need for more specialized aircraft providing ISR&T, refueling, ASW, and EW will require a dramatic rebalancing of the naval aviation portfolio. Despite improving threats, carriers will remain the most survivable and productive airfields in contested areas during conflict, and Navy or Air Force strike fighters will necessarily remain constrained in range due to their size. To enable offensive operations from inside a theater like the Western Pacific and complement bombers coming from outside the theater, carriers will need to prioritize strike fighters and the tankers that will enable them to reach enemy targets.

Maximizing the offensive capacity at range of carriers will require that other missions such as ISR&T, ASW, EW be done by aircraft from other ships or shore. This shift creates an opportunity for the Navy and Marine Corps to embrace new technologies and reduce their dependence on manned platforms for many aviation missions. All the aircraft that can enable this transition are available today and could be fielded in their new roles by 2030. The question is whether Navy leaders are willing to make hard choices to move away from comfortable but ineffective approaches and embrace new capabilities that are more likely to succeed. The next chapter will describe new operational concepts naval aviation should pursue, followed by chapters detailing the force structure implications and implementation of these changes.
CHAPTER 2. NEW APPROACHES TO NAVAL AIRPOWER

The Navy is unlikely to have the funding or time to field by 2030 a new class of carrier-based attack or fighter aircraft with dramatically longer range. F/A-18E/Fs, F-35As and their successors will therefore need aerial refueling to reach enemy weapons platforms from areas where carriers are defensible and able to sustain air sorties.

An alternative to being constrained by carrier size and operating areas would be conducting offensive air operations from land bases, as the Air Force does. However, land bases are attractive and vulnerable targets that are likely to be among the first attacked during a confrontation with a high-end military like the PLA. In response, the Air Force is implementing Agile Combat Employment, a new concept that operates tailorable force packages from multiple operating locations across a theater of operations like the Western Pacific.²⁵

An aircraft carrier, despite its space constraints, provides a more survivable airfield than land bases due to its mobility and, more importantly, its organic defenses and those of its accompanying escorts. Although land bases can be protected, their fuel supplies, aircraft, and C2 facilities are often unhardened and dispersed, diluting the effectiveness of air defense.

Photo: MQ-4C Triton aircraft at the Naval Base Ventura County, Point Mugu. The insignia of Unmanned Patrol Squadron (VUP)-19, the Navy’s first unmanned patrol squadron, can be seen behind them. (Northrop Grumman Corporation)
systems. Carriers also incorporate the weapons magazines and maintenance capabilities to sustain air operations, whereas prepositioned support capabilities on austere airfields are designed to sustain relatively small or short-duration missions.

The Navy could better contribute to joint campaigns by concentrating its relatively short-range strike fighters on carriers, rather than distributing them to austere airfields where they will compete with Air Force aircraft or flying them from distant land.

Figure 10: Estimated US Navy fleet circa 2030, which informs this study’s operational concepts

Source: Authors.
bases where they will require extensive tanking to achieve short times on station.

To maximize the ability of carriers to support strike-fighter operations, naval forces will need to move aircraft other than strike fighters and tankers—and their missions—to alternative ships or shore. Fortunately, new operational concepts and technologies are creating opportunities to make this shift while also improving the fleet’s ability to counter Chinese aggression through adaptability, disaggregation, and establishing decision-making advantages, as described below.

The following concepts are designed for use during the early 2030s, and therefore rely predominantly on current or modified versions of existing aircraft or platforms and systems that already have been demonstrated. The naval vessel fleet is assumed to be comprised of the ships likely to be operational during the early 2030s based on the FY 2023 shipbuilding plan, as depicted in Figure 10.

**Gaining Decision Superiority**

The range and survivability constraints of today’s naval aircraft reduce the options available to US commanders and enable

![Figure 11: Forecast-centric vs. Decision-centric planning approaches](image)
adversaries like the PLA to build comprehensive plans and systems for combat, placing US commanders at a decision-making disadvantage. New aircraft like those associated with the Navy’s Next-Generation Air Dominance (NGAD) program could temporarily mitigate its limitations, but restoring naval airpower’s flexibility and reach will require fundamentally changing its force design from centering on manned aircraft to instead focus on compositions incorporating manned and unmanned systems.

Emerging concepts such as Mosaic Warfare from the Defense Advanced Research Projects Agency (DARPA) and Decision-Centric Warfare from the Hudson Institute seek to regain decision-making advantage by combining machine-enabled approaches to command and control (C2) with more disaggregated forces that can adopt a wider variety of configurations. As depicted in Figure 11, this approach stands in contrast to forecast-centric US planning processes such as the Joint Capability Integration and Development System or Joint Operational Planned and Execution System, which attempt to forecast future needs and efficiently allocate resources to develop programs or implement operations that are most likely to succeed in projected situations.

In its approach of “expanded maneuver,” the US Joint Staff’s Joint Warfighting Concept (JWC) also embraces the centrality of adaptation to military success. US forces employing the Joint Warfighting Concept would exploit the interoperability and integration provided by Joint All-Domain C2 (JADC2) to connect and manage operations by a growing variety of units that would disaggregate, reaggregate, and recompose to increase their flexibility and impose uncertainty on the opponent.

New operational concepts for naval aviation will need to reverse the predictability of today’s force to implement the JWC and help the US military gain a decision-making advantage. In part, providing commanders more options will require rebalancing the naval aviation portfolio to increase the reach of land- and sea-based aircraft as well as provide more platforms that are either risk-worthy or survivable and therefore do not need to be defended. But changes to the aviation fleet will only expand options for commanders if naval forces are tactically employed in ways that exploit their new characteristics. The concepts below are designed to address the carrier capacity constraints described in Chapter 1 while improving the adaptability of naval forces and creating decision superiority for US commanders.

Posturing for More Flexible Operations

Navy’s current land-based aircraft have more schedule flexibility because they are not tied to the carrier’s maintenance and training cycles but are arguably more limited in deployment location because of support requirements. Although the P-8A is based on the widely used Boeing 737 jetliner, its sonobuoys, weapons, and repair parts are not broadly available, making non-US Navy airfields useful only for fuel and basic airframe maintenance. The E-2D and MQ-4C are more specialized and require dedicated support to be established at any operating location.

Rather than attempting to vary deployment schedules, which creates costs and industrial or organizational inefficiencies the Navy cannot afford, the proposed posture would increase flexibility by changing deployment locations. As shown in Figure 12, Pacific-based carriers on the US West Coast and Japan, augmented when needed by East Coast carriers, would form a two-CSG “maneuver force” that would deploy to the Indo-Paci-
The proposed posture would also expand operating locations for shore-based aircraft such as P-8As, E-2Ds, and MQ-4Cs by prepositioning support equipment to airfields in the Western Pacific under the ongoing Pacific Deterrence Initiative (PDI). The US Navy could coordinate with these NATO fleets to ensure a continuous CSG presence in the Mediterranean or North Atlantic. The French CVN Charles de Gaulle and Italy’s carrier Cavour. Because airfields that could host P-8As and E-2Ds will be rela-
tively large and require specialized support capabilities, they will need to be outside the range of most PLA missiles and aircraft, such as in the Marianas, Compact Free States, or Australia. Marines could operate MQ-9s and F-35Bs from austere airfields at EABs in the Philippines, Japan, or other islands, using short-range air defenses and frequent relocation to reduce the threat from PLA air attacks.35

The proposed posture would enable aircraft from shore or other ships to combine with CVWs in executing the operational concepts below. Although this will potentially constrain carrier operations by relying on land-based specialized aircraft, carriers could recompose their CVWs to be more self-sufficient when operating independently in areas like the Indian or Atlantic Oceans.

Enabling Mission Command
Naval forces are largely organized around a hierarchical command, control, and communications (C3) architecture. Commanders of independently steaming ships, troop formations, and naval groups such as CSGs maintain localized C2 of their subordinate units and troops in the field or at sea, with theater commanders managing operations from Maritime Operations Centers (MOC) at a fleet headquarters. In this hierarchical structure, local commanders rely on MOCs for intelligence, planning, and direction—a dependency that would increase during conflict.36

Peer adversaries China and Russia will attempt to degrade or deny beyond-line-of-sight (BLOS) communications during a conflict using EW or physical attacks.37 These efforts would likely focus first on communication satellites in geosynchronous orbit (GEO) such as the Multi-User Objective System (MUOS) or Advanced Extremely High Frequency (AEHF) constellations that connect deployed naval forces throughout a theater with each other and headquarters. Enemy EW operations would then target BLOS datalinks such as Link-16 that are often relayed or managed by airborne communication nodes.

Naval forces will need to implement C3 approaches that address the likelihood of contact with theater headquarters being
degraded or lost, leaving local commanders to execute C2 of their forces without the benefit of a MOC’s planning staff and intelligence. This study’s proposed C3 concept would address contested communications by adapting C2 relationships to communications availability, rather than attempting to build networks that support a desired C2 structure under all conditions. The resulting C3 architecture would be categorized as heterarchical, as shown in Figure 13, rather than the hierarchical ones that predominate today.38

Under a heterarchical C3 architecture, command devolves to subordinate leaders who are best positioned to manage operations locally when communications are lost with headquarters. This approach is consistent with the concept of mission command.39 But unlike mission command, where C2 structures are established ad hoc, heterarchical C3 structures would use decision support tools and communication management systems to establish and refine command relationships with the goal of continuing the operation while maximizing the options available to junior commanders who no longer have access to the MOC’s planning staff.

For example, when contact is lost with the theater commander and MOC (purple dots in Figure 13), command will devolve to subordinate leaders (blue dots in Figure 13) with the network capabilities and ISR&T and communication relay platforms to continue operations, such as commanders of Expeditionary Sea Bases (ESB), surface action groups (SAG), amphibious ready groups (ARG), or CSGs. Network management systems such as the DARPA DyNAMO program would identify which units (black dots in Figure 13) are still in contact, allowing subordinate commanders to use decision support tools like the DARPA Adaptive Cross-Domain Kill Chains (ACK) program to build courses of action (COA) to carry on the mission with the units available. Network management systems would then align network bandwidth and connectivity to execute the COA.40 If units are in communication with multiple field commanders, decision support and network management tools would help commanders determine which force package the units are best used in, based on the level and types of communication available and the efficacy and nature of the COAs each commander could execute with or without the unit. In the absence of machine-assisted tools, these kinds of negotiations rely on instinct or educated guessing that would likely be more predictable to an adversary.

Heterarchical C3 architectures will still need local communications between field commanders and their units to manage operations, even when theater-wide satellite systems such as MUOS are unavailable. Low earth orbit (LEO) satellite constellations, including those deployed by private companies, will create more options to maintain at least local over-the-horizon (OTH) communications despite adversary counter-space operations. Rather than being stationary targets like their GEO counterparts, LEO satellites orbit the earth approximately every 90 minutes, spending 5 to 15 minutes per orbit in range of naval forces during which they can support communications between units within the satellite’s footprint. By operating as a constellation, LEO architectures can achieve continuous coverage over relevant areas and gracefully degrade to more episodic coverage as satellites are lost to adversary attacks.41

Because stationary GEO satellites are vulnerable to electromagnetic or co-orbital attack and LEO constellations could be degraded through numerous physical and electromagnetic means, naval commanders ashore or at sea will need to leverage UAVs that, in addition to supporting AEW&C or ISR&T, can act as relays for OTH communications within naval groups or between field commanders and theater headquarters. As shown in Figure 14, the Navy’s existing MQ-4C orbit from Guam, carrier-based MQ-25As, Marine Corps MQ-9s flying from EABs, and steerable stratospheric balloons could act as relays to provide OTH communications. Over shorter distances, RQ-21 Blackjack or MQ-8C FireScout UAVs from medium unmanned surface vessels (USV) and DDGs, respectively, could help naval SAGs, ARGs, and CSGs remain connected.
Focusing ISR&T on the Customer

Naval forces conduct ISR&T mostly with systems organic to Navy or Marine Corps units, including shipboard sensors like the SPY-6 radar or manned aircraft such as the E-2D and UAVs including the MQ-4C, MQ-9, and RQ-21. They are complemented by commercial and government space-based sensors, but unlike those for communications, surveillance satellites do not directly connect to ships or ground units and instead provide their ISR data to the intelligence community (IC). The IC is responsible for sharing satellite-provided targeting information to operational forces when needed, which risks data being late or unavailable due to contested OTH communications.42

The proposed ISR&T concept centers on ensuring sensor data can be delivered directly to naval forces in support of a heterarchical C3 architecture and mission command. Some improvements
in this direction are already planned. The US Space Development Agency (SDA) LEO architecture, shown in Figure 15, is expected to incorporate Link-16, which will allow targeting information from its IR sensors to be provided directly to ships or EABs. Recent demonstrations also established methods for transmitting commercial satellite imagery from Hawkeye 360, MAXAR, and BlackSky directly to Army and Navy satellite communication terminals in the field. The MQ-4C will also be able to communicate directly with deployed ships or EABs using Tactical Targeting Network Technology (TTNT) after planned upgrades during the mid-2020s. These efforts should all be accelerated.

Extending AEW&C Across a Theater

In contrast to ISR&T, which is provided by multiple platforms, AEW&C today is almost exclusively conducted by E-2Ds with support from air search radars on guided missile cruisers (CG) and DDGs. Their radar range will require E-2Ds to operate within about 200 nm of carriers, which will also help protect E-2Ds from enemy fighters. And as shown in Figure 14, one benefit of operating farther from China is E-2Ds could fly to their stations from islands such as Compact of Free Association states or the Marianas to free up space on the carrier deck for strike fighters and MQ-25A tankers.
CGs and DDGs make themselves more vulnerable to detection and classification by operating their radars at high power, which should drive CSGs to adopt tactics where surface combatant escorts rely on passive sensors such as the SLQ-32 EW system until air defense actions are required. Although more secure, passive sensors often have shorter detection ranges than active radar, because they depend on the target’s emission strength, frequency, and atmospheric conditions that are not within US forces’ control.

The result of E-2Ds operating farther from the enemy and CSG escorts relying on passive sensors will be hundreds of miles of unmonitored airspace between naval forces and PLA airfields. To gain visibility over this area, the proposed AEW&C concept would employ space and UAV-based passive sensors to detect and track incoming aircraft between fleet formations and enemy air bases. This concept would incorporate the satellite architectures identified above for ISR&T as well as the UAVs, including stratospheric balloons, shown in Figure 14, which could support AEW&C along with ISR&T and communications.

From satellites, naval forces would rely on electronic intelligence (ELINT) sensors because they provide wider coverage compared to EO/IR sensors, enabling earlier detection of what could be fast-moving air threats. Government ELINT satellites share the limitation discussed above of being processed and disseminated by the IC to operational forces, but as noted above commercial ELINT providers like Hawkeye 360 could provide direct satellite downlinks to operating forces, allowing space-based ISR&T to support AEW&C.

From UAVs, naval forces would rely on both ELINT and IR sensors for AEW&C. The MQ-9 already carries ELINT sensors, and the ongoing MQ-4C upgrade to Integrated Functional Capability (IFC-4) will afford it an ELINT capability. Stratospheric balloons could carry similar ELINT systems. Unlike overhead satellite IR sensors that have a relatively narrow field of view, IR sensors on UAVs would achieve wider coverage by looking horizontally across the airspace. To support extended AEW&C, MQ-9s, and stratospheric balloons could be equipped with IR search and track (IRST) sensors like those already employed by strike fighters such as the F/A-18E/F IRST-21 pod or Legion pods carried by F-15Es. MQ-4Cs have an infrared search capability, but would require a software upgrade and some physical modifications to enable it to look for airborne targets.

**Sustaining Land and Maritime Strike**

Ultimately, naval forces need to attack opposing ships and littoral targets—or imply the ability to do so—to deter or defeat an adversary. Naval counter-air operations, although necessary for protecting Navy and Marine Corps units at sea and ashore, are largely in support of land and maritime strike.

Aircraft with direct-attack munitions or gravity bombs conducted the bulk of Navy and Marine Corps strike operations during and since the Cold War due to the relatively low lethality of enemy air defenses, the higher cost of long-range missiles, and the control possible with air attacks. But in response to proliferating and improving air defenses, the preferred mode of strike and surface warfare (SUW) evolved during the last two decades to standoff attacks using long-range missiles such as the ship-launched Tomahawk and air-delivered missiles like LRASM or AGM-158 Joint Advanced Surface Strike Missile (JASSM) that can engage targets hundreds of miles away. Depending on the threat environment, low-observable aircraft like the B-2 or B-21 bombers could still conduct strikes with less-expensive short-range weapons, but the growing prevalence of IR, passive RF, and overlapping radar sensors inside contested areas will likely require even stealthy aircraft to employ standoff missiles.

The need for aircraft to increasingly use standoff weapons results in comparable costs for ship-, air- and ground-launched strike and anti-ship attacks. As depicted by Figure 16, a notional force of six nuclear attack submarines (SSN), two SAGs, and a CVW can deliver hundreds of missiles against targets 1,000 or more nm away. However, each component of the
To exploit the ability of submarines to more closely approach the adversary’s coast compared to SAGs or carriers, commanders would devote SSN-launched missiles to strikes against inland targets, while their torpedoes would be employed against PLAN ships. Because missile launches will tend to reveal submarines’ location, commanders will either need to use SSN-launched missiles early during a conflict or sparingly over the course of a confrontation so submarines can evade ASW forces between launches. Torpedo attacks would be less detectable but occur over much shorter ranges than missile engagements. They are therefore not included in Figure 16, and are assumed to occur mostly in highly contested areas where ASM engagements are difficult to execute.

SAGs will need to remain 1,000 to 1,500 nm from enemy force concentrations and disperse so they shrink and dilute weapons salvos to within their air defense capacity. As a result, their targets will be limited to Chinese ships and islands or maritime features. SAGs would not substantially increase their vulnerability by launching missiles, allowing commanders to employ their weapons more flexibly than SSNs, but with the same constraint of needing to reload outside the conflict area. To sustain SAG offensive capacity, SAGs would rotate small combatants such as Littoral Combat Ships (LCS), corvettes (DDC), or the Navy’s planned large USV (LUSV) to secure resupply and rearming anchorages. Large surface combatants would need to limit their loadout of strike or anti-ship missiles such as the Tomahawk to allow sufficient capacity for surface-to-air interceptors in support of the distributed counter air concept described below.

Assuming sufficient refueling to travel 1,000 nm from the carrier, CVW strike fighters would, like surface combatants, be limited initially to attacking ships and littoral targets because carriers would need to remain 1,000 to 1,500 nm from enemy force concentrations. Longer-range aircraft such as F-35Cs using the new Adaptive Engine Transition Program (AETP) or the future NGAD fighter would not necessarily change the range at which strike operations would occur but could obviate the need for substantial mission refueling and thereby increase the total number of aircraft that could operate at long range. As the ASM threat abates, CSGs and SAGs could more closely ap-

Figure 16: Strike capacity associated with SSNs, SAGs, and CVWs that could be deployed in a 2030 conflict with China

To allow more flexibility in using the 40 missiles carried by their Virginia Payload Modules, Block V Virginia-class SSNs would likely operate outside the First Island Chain of Japan, Taiwan, and the Philippines, where PLA ASW forces will likely respond more slowly after launches. Overall, the facilities needed for reloading submarines will result in them leaving combat for a week or more when their weapons are expended, incentivizing field commanders to manage their use of submarine-launched weapons to avoid a lack of SSNs for torpedo attacks inside highly contested areas.

DDGs  DDC/LUSV  CVW  SSN

0  20  40  60  80  100  120  140  160

Number of weapons delivered

Initial salvo from 8 SSN; 1 VPM
Initial salvo of 2 SAGs (each with 2 DDG, 5 MUSV, and 6 DDC/LUSV)
Subsequent salvos delivered per day by 2 SAGs
Weapons delivered by CVW per day (44A/C in CVW; 2 strike weapons per A/C)

Source: Authors.  

Naval force brings strengths and weaknesses and tends to be most useful in certain situations and time periods during a confrontation. The proposed strike concept would leverage these differences.
proach and contribute to attacks ashore. As shown in Figure 16, the total number of weapons a CVW could launch per day is less than what two SAGs could launch, but the CVW could launch the same number of weapons every day and be rearmed in theater, in contrast to the need for surface combatants to seek a remote anchorage to reload their VLS cells.

The Navy could extend strike and SUW reach of CVWs by pursuing an MQ-25 variant capable of carrying weapons in its existing internal mission bay and with communications systems able to send and receive targeting data. These changes would not impact the ability of MQ-25s to support aerial refueling but could provide CVWs a platform able to launch weapons from more than 1,500 nm away without refueling. However, the net effect of using MQ-25s for strike instead of refueling would be to decrease the CVW’s strike capacity, since each MQ-25 could otherwise refuel two strike fighters to weapons-release range.

For the above reasons, the sustained strike and surface warfare concept proposed by this study would use most SSN-launched missiles against shore facilities and ships early in the conflict, followed by staggered torpedo attacks against ships that remain underway. SSNs would take turns rotating out of theater to reload. SAGs and CVWs would sustain fires against adversary naval forces and maritime features as the conflict progressed, which will be constrained by the need to devote significant missile inventory and sortie generation to air defense against PLA bombers. If conflict continues, CVWs would conduct the bulk of offensive operations as VLS missile inventories dwindle and surface combatants focus on short-range air defense around naval forces.

**Distributed Counter-Air Operations**

As with surface and strike warfare, engaging enemy bombers and attack aircraft before they are in weapons range would require engagements up to 1,000 nm from naval forces. Attempting to maintain air patrols at that range would be unsustainable—even with the participation of all CVW fighters and MQ-25A tankers. Longer-range aircraft such as AETP-equipped F-35Cs or the future NGAD would not substantially change this dynamic because they would only add about 25-30 percent of range, or about ½ hour of time in a counter-air patrol. Rather than attempting to unsuccessfully reprise the Cold War’s Outer Air Battle tactic, the proposed counter-air concept would use distributed shipboard, land-based, and airborne launchers to attempt intercepting enemy aircraft and establish robust defenses against incoming ASMs.

Distributed counter-air operations would rely on ELINT and IR sensors in the extended AEW&C concept to monitor the airspace between naval forces and PLA bases. MQ-9s flying from EABs in the First Island Chain and MQ-4Cs from Guam or Japan would be complemented, when possible, by stratospheric balloons and satellites to detect incoming aircraft via their radar and radio emissions. AEW&C would be managed by E-2Ds orbiting near the CSG, which would use its radar to support ASM defense. The E-2D commander would communicate with balloons, MQ-4Cs, and MQ-9s up to 600 nm away using line-of-sight communications that are less susceptible to jamming.

As shown in Figure 17, the distributed counter-air concept would use EABs as the outer layer of offensive counter-air (OCA) operations. Although the Marine Corps intends EABs to be used primarily for reconnaissance and counter-reconnaissance, an important secondary function for them would be challenging PLA access across the First Island Chain. F-35Bs episodically conducting OCA sweeps and ground-based air defenses with missiles such as SM-6 would not present a high-capacity threat but would require the PLA to devote fighters to suppressing EABs or escorting bombers, either of which would reduce the number of aircraft available for anti-ship missions. This “virtual attrition” was a significant factor in defenders overcoming bombing during historical campaigns such as Operation Rolling Thunder during the Vietnam War and Allied attacks against German industry during World War II. F-35B operations ashore would be supported by amphibious assault ships (LHA/D) at
sea, which would usually remain outside contested waters and infrequently approach islands hosting EABs to drop off or pick up aircraft. If access to EABs is disrupted due to political or military action, LHA/Ds could return Marine forces to sea, but the distributed concept would endure using the remaining counter-air layers.

Surface combatants would constitute the second OCA layer in the distributed counter-air concept, arrayed along threat axes not covered by EABs and from which they could still conduct land and maritime strikes. Using cueing from the E-2D-led AEW&C network, SAGs would engage incoming aircraft with medium- and long-range surface-to-air missiles (SAM) such as the SM-2 or SM-6 using a “silent SAM” tactic in which they energize their radars, if necessary, just before attacking to avoid alerting the target early.

CVW OCA sweeps would complement surface combatants 800-1,000 nm from carriers. The AEW&C network would provide cueing to allow vectoring fighters already airborne in combat
air patrols (CAP) or ready on carrier decks to intercept incoming bombers. Fighters could employ long-range AAMs such as the AIM-260 Joint Advanced Tactical Missile to destroy aircraft or their launched missiles. CVWs could perform periodic sweeps of contested airspace to engage high-value enemy assets and dislocate enemy air operations. When possible, F-35Cs would perform OCA sweeps to leverage their lower signatures to reduce the risk of counter-detection by incoming bombers or their escort aircraft.

The distributed counter-air concept assumes that despite maritime strike and OCA operations, some enemy ships and aircraft will be able to launch weapons. The concept therefore includes defensive counter-air (DCA) operations to defeat ASMs. E-2Ds conducting AEW&C would manage DCA operations using their own radars and cueing from the extended AEW&C network described above. However, many ASMs do not emit EM radiation and those that do emit may not activate their radar seekers until they are close to targets. Against non-emitting missiles, E-2Ds could receive cueing from IR sensors, such as those of the Space Force’s Hypersonic and Ballistic Tracking and Sensing System (HBTSS), the SDA LEO architecture of Figure 15, or IRST systems on UAVs.

The first line of ASM defense would be an EA-18G DCA CAP about 200 nm from the carrier to jam or deceive the guidance systems of incoming ASMs, supported by four to five EA-18Gs in the CVW. Weapons the EA-18G is unable to defeat would be engaged by surface combatants or a strike fighter DCA CAP around 150 nm from the carrier. The DCA CAP would require four strike-fighters, as noted in Figure 15, and would be comprised mostly of F/A-18E/Fs carrying the maximum number of AAMs due to minimal concerns for counter-detection so far from enemy forces.

Against subsonic ASMs, DCA aircraft and ships would use short-range AAMs such as the AIM-9X Sidewinder or short-range SAMs like the Evolved Sea Sparrow Missile (ESSM), respectively. To defeat high supersonic or hypersonic ASMs, strike fighters and surface combatants would need to use faster and longer-range missiles such as the Missile Defense Agency’s Glide-Phase Interceptor or the Navy’s existing SM-6.

The distributed counter-air concept could also support Air Force operations. In addition to defending bases ashore, naval strike-fighters supported by MQ-25A tankers could escort Air Force bombers coming from outside the theater when local airfields are unable to sortie land-based fighters.

Disaggregating Electromagnetic Warfare (EW)

Naval aviation’s primary EW platform today is the EA-18G, which largely is used to conduct electronic attack (EA) against enemy air defenses in support of strikes ashore or for passive detection of enemy aircraft. During the wars in Iraq and Afghanistan, EA-18Gs jammed mobile communication networks to prevent improvised explosive device detonation, and in the years since, its passive sensing capabilities have been employed to locate targets without resorting to active radars that expose US forces to counter-detection.

The EA-18G’s relatively short range and lack of survivability will relegate its use against peer adversaries mostly to ASM defense, in concert with shipboard EW systems like the SLQ-32. The AEW&C concept above will augment or replace the EA-18G’s role in passive RF sensing, but naval forces will need new approaches to conduct offensive EW such as jamming enemy air defenses and communications. As shown in Figure 18, new technologies are creating an opportunity to improve upon the EA-18G by disaggregating EW capabilities onto a wide array of missiles such as the Miniature Air Launched Decoy-X (MALD-X) and UAVs, including small UAV/missile hybrids called air-launched effects (ALE) and attritable long-range jet-propelled UAVs derived from the Air Force Skyborg program. These smaller platforms could still leverage some of the systems developed for the AN/ALQ-249(V)1 Next Generation Jammer that will be carried by EA-18Gs starting in the mid-2020s.
Disaggregating EW capabilities will help provide more options to commanders. Compared to only five to six EA-18Gs per CVW, a naval force could deploy hundreds of ALE and Skyborg UAVs from a variety of land-based, shipboard, and airborne launchers. The Army’s ALE program consists of large and small vehicles intended to provide aircraft the ability to deliver EW effects—including passive sensing, decoy operations, and jamming—more than 50 nm away for the small vehicles and 150 nm for the large. The Skyborg program is developing or equipping larger vehicles such as the MQ-20 Avenger, as well as smaller, attritable vehicles such as the RQ-58 Valkyrie and UTAP-22 Mako that can fly 1,500 and 3,000 nm, respectively, during a mission following a rocket-assisted launch. Although ALE are expected to be expendable due to their relatively small size and cost, the RQ-58 and UTAP-22 are intended to be recoverable at sea or ashore like the target drones upon which they are based.64

Skyborg UAVs and ALE could jam enemy radars to obscure incoming weapons. However, their nature as attritable or expendable systems offers a wider variety of tactics and effects. EW UAVs could simulate strike fighters to confuse enemy sensors or stimulate passive or inactive air defense systems, causing them to reveal their location. ALE or Skyborg-borne radars could illuminate opposing targets to support bistatic sensing operations or enable semi-active weapon homing. And sensors

Figure 18: Disaggregated EW concept
on ALE and Skyborg UAVs could be used to localize targets for later operations, or for weapons in the same salvo, as shown in Figure 18.

The disaggregated EW concept would shift operational responsibilities for much of the offensive naval EW mission to the Marine Corps, consistent with the reconnaissance and counter-reconnaissance mission intended for stand-in forces and the goal of providing naval commanders more options and complicating enemy planning.\(^6^5\) The concept would primarily deploy Skyborg UAVs like the RQ-58 and UTAP-22 from launchers on amphibious transport docks (LPD) and from bases ashore. With about half of Marines in the Indo-Pacific ashore with Marine Littoral Regiments (MLR), LPDs will be used in part for MLR resupply and support but could also rebalance their aviation and vehicle capacity to carry more than 30 RQ-58s each.\(^6^6\)

ALE UAVs could be launched from the whole range of fixed or rotary-wing naval aircraft, but their shorter range compared to Skyborg UAVs would put the launch platform at risk when it cannot exploit terrain as the Army intends in its approaches for multi-domain operations. More survivable aircraft such as the F-35 or B-21 Raider bomber could deploy ALE but would have to reduce their weapons capacity to do so. The disaggregated EW concept addresses this challenge by using risk-worthy UAVs like the Marine Corps’ MQ-9 or Skyborg UAVs to deploy ALE UAVs, as well as USVs and UUVs that are smaller and less detectable than manned platforms and would be acceptable losses, depending on the mission.

The EA-18G is the Navy and Marine Corp’s only offensive airborne EW capability today. Expanding beyond it is essential to achieving EMS superiority in future confrontations. More importantly, the diversity of launch platforms, force compositions, and effects possible using disaggregated EW systems would provide naval commanders more options than are available today and would increase the complexity imposed on enemy planning and targeting efforts.

Scaling Anti-Submarine Warfare

Russian and Chinese submarines are a significant threat to naval forces, but for different reasons. The Russian Federation Navy’s (RFN) submarine force is relatively small, but its SSNs are on par with their US counterparts in terms of quieting, sonar, systems, and weapons. RFN SSNs could evade US and allied ASW efforts and threaten attacks against the US coast or naval...
forces, including the nuclear ballistic missile submarines (SSBN) comprising the US strategic deterrent. In contrast, the PLA Navy’s (PLAN) fleet is comprised predominantly of diesel-electric (SS) and air-independent propulsion (SSP) submarines—but it is rapidly modernizing. In a confrontation, the PLAN’s growing numbers of quiet conventional submarines could overwhelm US ASW capabilities.

As noted in Chapter 1, Navy P-8As are too vulnerable to conduct ASW operations in the most advantageous locations against the PLAN, which are chokepoints in the First Island Chain separating the East and South China Sea from the Pacific Ocean. Out at sea, MH-60R helicopters cannot conduct search far enough from naval forces to detect a submarine before it is within ASM range. And even if enemy submarines are detected, the Navy lacks sufficient P-8As, surface combatants, or SSNs to track them until rules of engagement allow ASW attacks.

The proposed ASW concept, depicted in Figure 20, would shift the bulk of ASW search and track from manned helicopters or P-8As to unmanned systems, including the MQ-9B, medium USV (MUSV), medium unmanned undersea vehicles (MUUV), and stationary sensors like the Transformational Reli-
able Acoustic Path System (TRAPS). In addition to allowing the use of risk-worthy systems in contested areas, the low cost and specialization of unmanned ASW systems would provide scale and flexibility to US ASW operations, which depend today on a relatively small number of multi-mission platforms that have other, sometimes conflicting, roles such as strike or air defense and which themselves need to be protected.

The scalable ASW concept would place MUUVs towing passive sonar arrays or TRAPS in likely submarine transit lanes such as chokepoints. MQ-9Bs would use cueing from these unmanned sonars and their own or offboard ELINT sensors to deploy and monitor sonobuoy fields to localize and track submarines, augmented if needed by the additional sonobuoy capacity of P-8As. Each MQ-9B could carry 40 sonobuoys, which would be sufficient to deploy and replenish multiple sonobuoy fields. When the submarine begins to exit the sonobuoy fields, operators in the P-8A would turn contact over to MUSVs equipped with passive or active towed sonar arrays, which would maintain loose trail on submarines until they are engaged or return to home waters.

Relieving P-8As of most sonobuoy deployment and monitoring duties would enable them to focus on C2 of ASW operations, which could be performed from more permissive areas and by a smaller number of aircraft. MQ-9Bs would provide processed sonobuoy and organic ELINT or radar sensor data to P-8As, or to surface combatants, via datalinks such as Integrated Link 16 with JREAP-C, TTNT and CDL using line of sight (LOS) transmissions that are difficult for an enemy to jam or exploit. MUSVs have demonstrated towed sonar array operations and should be able to conduct onboard sensor data processing in the same way as TRAPS or Surveillance Towed-Array Sensor System (SURTASS) ships, providing contact information and acoustic data to P-8As via LOS datalink.

The Navy plans to replace the MH-60R during the mid-2030s with an aircraft developed by the Future Vertical Lift-Maritime Strike (FVL-MS) program. Until then, the proposed ASW concept would use MH-60Rs for ASW self-defense around naval groups. The FVL-MS program is likely to leverage results of the Army FVL program, which is developing manned and unmanned rotary-wing aircraft with longer range and endurance compared to the current fleet. These improvements will likely enable manned shipboard helicopters to conduct ASW search near submarines’ ASW range but will encounter the same fundamental lack of scale as the MH-60R because one helicopter can only cover a small sector around a ship and—based on the Army program FVL aircraft—will still likely be limited to less than one hour of search at a range of 300 nm. If it can achieve longer endurance, lower costs, and smaller size compared to manned helicopters, the unmanned FVL aircraft could address these constraints.

ASW engagements in the scalable ASW concept would be conducted predominantly by P-8As and SSNs, enabling an operator to remain in the loop for weapons deployment and allowing MQ-9Bs to dedicate their payload capacity to sonobuoys and sensors. To expand weapons delivery capacity in wartime, the concept would use MQ-9Bs, MQ-8Cs, and MV-22s from amphibious ships to attack submarines.

ASW campaigns such as the Battle of the Atlantic showed that submarines were prevented or deterred from completing their missions more often than sunk. In large part, this was due to the inherent limitations of submarines, which are relatively slow compared to ASW aircraft, lack significant self-defenses like those carried by surface combatants against ASMs, and cannot establish the sensor precision or timeliness to quickly determine if a torpedo is likely to miss. As a result, submarines detecting an incoming torpedo are compelled to evade almost any attack. P-8As would exploit submarines’ limitations and increase their capacity under the scalable ASW concept by employing small, relatively inexpensive weapons like the Compact Rapid Attack Weapons (CRAW). Although it has a smaller warhead than the Mk-54 torpedo P-8As use today, the CRAW would compel submarines...
to evade, breaking off their operations and enabling easier tracking for subsequent engagements. Moreover, air-launched torpedoes like the Mk-54 likely do not have high lethality against modern submarines, many of which are double-hulled, suggesting air ASW should focus on submarine suppression rather than attrition.77

In contrast, SSNs would be used for engagements in which the enemy submarine needs to be destroyed or disabled, such as counter-SSBN or homeland defense operations. The heavyweight Mk-48 torpedo can be placed more precisely compared to air-launched torpedoes and has a warhead that is five times larger than the Mk-54, increasing the likelihood of a kill.78

The Importance of Metrics

The new operational concepts proposed by this study are designed to increase naval forces’ adaptability by improving their ability to scale, enabling attacks from a wider array of locations at sea and ashore, and increasing the complexity they present to opposing forces. These metrics can be summed up as increasing the number of options available to US commanders while reducing those afforded to the enemy. As the away team facing peer adversaries, the US Navy and Marine Corps cannot afford to base their force design primarily on winning wars of attrition. They will need to put opponents like the PLA into situations for which they did not plan and reduce their confidence in a successful outcome.79

The next chapter will describe the implications of these new concepts for force structure, followed by a concluding chapter on implementation of a rebalanced naval air portfolio by the early 2030s.
Most force structure studies, including naval aviation’s own vision document, focus on far-term timeframes for incorporating dramatically improved platforms and systems to overcome rising threats. But this mindset ignores the urgency of today’s security threats and hinders efforts to gain more persistent advantages by exploiting the adaptability and flexibility of naval forces. This study is centered on the 2030 timeframe to produce creative, affordable, and executable ways of addressing naval airpower’s central challenges. The operational concepts described in Chapter 2 therefore do not rely on dramatic shifts in Navy or Marine Corps force design.

Although new platforms would help address naval air forces’ capability gaps, the primary change needed for this study’s pro-
posed airpower concepts is rebalancing aircraft and missions from sea to land, from the Navy to the Marine Corps, and from manned to unmanned vehicles. Shifting missions off carriers and onto shore or other ships will enable CVWs to maximize their capacity for offensive missions at extended ranges. More importantly, rebalancing airpower would increase the range of options available to naval commanders and the complexity imposed on enemy planning.

An essential element of rebalancing naval airpower is increasing the fleet’s reliance on UAVs for operations beyond their traditional role of providing ISR&T. Naval forces can exploit the lower cost of unmanned aircraft to achieve greater scale in AEW&C, ASW, and EW operations that will be necessary to counter more robust threats at longer ranges. Moreover, the risk-worthiness of UAVs enables operations in contested areas that constrain manned platforms’ freedom of action and limit options for commanders. And although UAVs are generally capable of fewer missions compared to manned aircraft like strike fighters or MPA, their modular systems enable UAVs to be configured for the operational need and free up manned aircraft for missions like C2 in which a human operator is required.

Fiscal or technological constraints may limit the rebalanced 2030 air portfolio to existing platforms, but the Navy and Marine Corps’ planned aircraft will require modifications to fully implement the concepts described in Chapter 2. For example, to support their expanded mission set, UAVs like the MQ-4C, MQ-9, and MQ-25A will need to add sensors, processing power, and—for the MQ-25A—the ability to carry weapons. Manned aircraft will require countermeasures and passive sensors that reduce the aircraft’s signature while exploiting the IR and UV regions of the EMS where stealth technology is less mature. Many of these upgrades are planned but will need to be protected as essential elements of future air operations.

Payloads such as weapons and ALE offer another way to sustain the operational concepts of Chapter 2 despite more challenging operational environments. Longer-range weapons can extend the reach of naval strike fighters or allow them to attack enemy aircraft from outside the opponent’s sensor range. Detection systems on weapons or ALE that are modular and more easily upgraded could overcome the shortfalls of aircraft sensors by exploiting new regions of the EMS or by more closely approaching targets.

The next section describes the deployed naval aviation force structure needed to implement the operational concepts of Chapter 2, including associated modifications and payloads. The section that follows will address attributes the Navy and Marine Corps should be prioritizing in the next generation of naval aircraft they are developing today.

**Proposed CVW and Deployed Naval Air Force of 2030**

The range and survivability limitations of today’s sea-based naval aircraft could be offset by restructuring the CVW and other sea- and land-based maritime airpower around naval missions, rather than administrative organizations. The starting point for rebalancing naval airpower would be the CVW, because about 15 MQ-25As will be needed to refuel its 44 strike fighters to reach 1,000 nm for strikes or anti-ship attacks while supporting counter-air CAPs around naval forces.81 As shown in Figure 21, making room for 15 MQ-25As will require displacing some EA-18Gs and E-2Ds. Although, Gerald R. Ford-class carriers can carry about 10 percent more aircraft than Nimitz-class CVNs, the greater capacity would only mitigate the reduction needed in CVW E-2D and EA-18G detachments.

The CVW composition of Figure 21 could be adjusted if the AETP engine is incorporated into Navy strike fighters. By increasing their range by 25-30 percent, the AETP could reduce the number of MQ-25A tanker aircraft needed in the CVW, allowing EA-18Gs and E-2Ds to return to the CVW at sea. This tradeoff is one Navy leaders should explore as they consider whether to field the AETP engine.
As described in Chapter 2, reducing the number of EA-18Gs and E-2Ds in CVWs is beneficial to their respective missions of EW and AEW&C. The constrained endurance and range of the EA-18G will prevent it from supporting power projection operations against capable opponents, rendering it mostly a defensive platform supporting missile defense. Maintaining an EW CAP over a CSG will only require four to five EA-18Gs, rather than the five to seven planned for today’s CVWs. Similarly, E-2Ds lack the survivability to operate near areas where OCA sweeps would engage enemy bombers preparing ASM attacks and would instead focus on C2 of integrated air and missile defense operations, using their onboard radar to target and track ASMs around the carrier. By remaining over the CSG, E-2D orbits could be supported by a combination of carrier- and land-based aircraft.

With EA-18Gs and E-2Ds focused on defensive operations, naval air forces will need different platforms to conduct offensive EW and AEW&C in the growing airspace between naval forces and the enemy. As described in Chapter 2, unmanned systems can support these efforts, and do so in highly contested environments like those adjacent to China or Russia. Passive RF and EO/IR sensors on LEO satellites, MALE UAVs like the MQ-9B, HALE UAVs such as the MQ-4C, and stratospheric balloons could detect and track enemy aircraft under the management of E-2Ds. Attritable UAVs, including the RQ-58 or UTAP-22, could execute long-range electronic attack, deception, and decoy operations in support of Navy or Air Force strikes or anti-ship attacks. And smaller unmanned systems such as ALE could conduct EW over shorter ranges.

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**Figure 21: Proposed CVW of the early 2030s**

- **Three V(F)A squadron:**
  - Each with 10 F/A-18 E/F aircraft

- **One V(F)A squadron:**
  - 14 F-35C aircraft

- **One VAQ squadron:**
  - 4-5 E/A-18G aircraft

- **One VAW squadron:**
  - 3-4 E-2D AEW&C aircraft

- **One VRC squadron:**
  - 15 MQ-25A utility/tanker aircraft

- **One VRC detachment:**
  - 2 CMV-22 multimission aircraft

Assuming 0.7 Ao for S/F, about 30 available at any given time.

To fit on CVN, E/A-18G and E-2D squadrons reduced to detachment (results in total 67 A/C)

Likely all available MQ-25As will need to deploy on Indo-Pacific CVNs in early 2030s

MQ-25As could conduct ISR&T or strike as well as refueling

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REGAINING THE HIGH GROUND AGAINST CHINA: A PLAN TO ACHIEVE US NAVAL AVIATION SUPERIORITY THIS DECADE
The most challenging aspect of the PLA threat is its capacity of capable shore, ship, and air launched ASMs. As described in Chapter 2, naval forces will need a multi-domain and multi-platform approach to shrink, dilute, and defeat incoming missile salvos, including OCA sweeps to destroy some bombers before they can launch ASMs, attack operations to suppress ship-launched missile attacks, and CAPs and surface combatants to shoot down ASMs that reach naval forces. Successful AMD will also depend on a new approach to ASW that can scale with the threat, mitigate the P-8A’s vulnerability, and avoid requiring space on the carrier. Using land-based MQ-9B UAVs and unmanned surface and undersea sensors, naval forces could detect, track, and engage submarines under the control of P-8As to suppress ASM attacks.

The combined changes implied by the proposed operational concepts of Chapter 2 result in a naval air force posture like that depicted in Figure 22. This force, notionally in INDOPACOM, would be deployed by two CSGs, an ARG with an embarked MEU, and a Navy MPRA detachment and Marine Littoral Regiment ashore.

### Modifications and Payloads Needed for Planned Naval Aircraft

The discussion above and in Chapter 2 incorporates several new payloads and improvements to existing or planned aircraft. For clarity, these modifications are summarized below and form part of this report’s recommendations:

- **Strike fighters:** New detection techniques are reducing the utility of S or X-band radar as a sensing technology as well
as undermining the value of traditional stealth measures such as reducing an aircraft’s radar cross-section. Passive RF sensors can locate an aircraft by its radar or radio emissions. Lower frequency radars in the HF or UHF bands can achieve precision and accuracy on par with fire control radars by exploiting greater computer processing power.\textsuperscript{62} Infrared sensors can see hard-to-eliminate aircraft heat signatures, and emerging UV detectors could be used to find airborne objects by virtue of the shadow they create in pervasive background UV radiation.\textsuperscript{53}

Existing strike fighters like the F-35 and F/A-18 cannot dramatically change their detectability in the IR and UV EMS regions. However, they should incorporate improved passive sensors to regain their detection range advantage and leverage offboard decoys and jammers to create a more complicated targeting picture for opponents, as addressed under payloads below. The Navy’s ongoing F/A-18E/F service life modernization (SLM) will return Block III aircraft to the fleet with IRST Block II, and F-35Cs have passive EO/IR sensors, but these capabilities will need to be augmented by advanced EW and survivability improvements to F/A-18E/Fs and offboard systems such as ALE or attritable UAVs that can more closely approach targets.\textsuperscript{84} Future strike-fighters, such as that associated with the NGAD program, should address the need for stealth in new regions of the EMS.

The Navy should also assess the impact of modifying strike fighters to incorporate the AETP engine. Although the 25-30 percent increase in range provided by AETP would not necessarily change the operational concepts of Chapter 2, it would reduce the number of MQ-25As needed in the CVW to enable strike fighters to reach 1,000 to 1,500 nm for strike or counter-air operations. The Navy should assess the cost of introducing AETP compared to the cost associated with buying enough MQ-25As for each deployed CVW to carry 15 tankers. However, buying MQ-25As would provide naval aviation more flexibility than introducing AETP, given the potential for MQ-25As to refuel other types of aircraft and incorporate other mission capabilities over time.

- **P-8A and E-2D:** Both aircraft are at or nearing the end of their production, and this study does not recommend the United States procure more than planned, although allies and partners could procure these aircraft. Moreover, as each aircraft is envisioned moving primarily into a C2 role, modifications of existing aircraft beyond those planned are not recommended, although they should be sustained to maximize their service lives.

- **MQ-25A:** The MQ-25A could be fielded in relevant numbers by 2030, but not every CVW would be able to have 15 aircraft until later in the decade. New force management approaches could be used to enable deploying CVWs to carry the needed capacity of MQ-25As. For example, MQ-25As could move between deploying carriers while their operators and maintainers remain with their CVW.

By 2030, the Navy should take full advantage of the MQ-25A’s range and endurance by equipping it with enhanced communications capabilities and passive IR and RF sensors that could support ISR&T against surface targets and AEW&C of air targets. Although the MQ-25A could incorporate a surface-search radar, such a change would be expensive and reduce the MQ-25A’s range or endurance while making it more vulnerable to counter-detection. By the mid-2030s (and sooner if possible), the Navy should pursue an MQ-25B variant that would be able to carry weapons in its mission bay. The MQ-25B could provide a longer-range strike or ASUW capability that would be more operationally unpredictable for adversaries and would provide a hedge in case CSG operations needed to stand off even further from enemy threats than currently anticipated.

- **MQ-9:** The Marine Corps’ existing and planned complement of MQ-9A UAVs are intended primarily to support ISR&T for strike and ASUW operations by MLRs, and secondarily to provide surveillance and targeting for the naval force overall. To expand their range and endurance, the Marine Corps...
should purchase the MQ-9B version, which can also support ASW as described in Chapter 2. To improve the survivability of Marine MQ-9Bs, they should be equipped with self-protection pods like the AN/AAQ-45 Distributed Aperture Infrared Countermeasure (DAIRCM) system to counter missiles that use EO/IR seekers or the BriteCloud RF countermeasure system to defeat radar-seeking missiles.

**Attritable UAVs:** The UTAP-22 and RQ-58 UAVs are being adapted for air warfare missions primarily by the Air Force under the Skyborg program. They are configured for rocket-assisted surface launch, reducing their dependence on runways, and allowing them to be flown from a wider range of locations. As noted in Chapter 2, the Navy and Marine Corps can exploit the 1,500-3,000 nm range of these UAVs to support EW or ISR&T missions.

To speed fielding, the initial versions of naval attritable UAVs should carry payloads like ALE that are already built for EW and ISR&T missions. RQ-58s, for example, have already demonstrated the ability to deploy smaller UAV payloads. For ISR&T or to allow modifying EW operations, an attritable UAV could act as a communication relay to the ALEs that it deploys. By the early 2030s, the Navy should incorporate sensors and EW systems into attritable UAVs themselves. For example, EW systems like those carried by the Miniature Air-Launched Decoy and passive sensors like those on the MQ-9B are already modularized and designed with relatively low-power requirements.

**Air-launched effects:** Although initially pursued as part of an Army program, Marine Corps helicopters and MQ-9s operating from EABs could deploy ALE to extend their sensor coverage over nearby maritime areas, like the Army plans to do with its helicopters and MQ-1 Gray Eagle UAVs. Small and large ALE vehicles have wide applicability to support several naval airpower concepts described in Chapter 2.

The Navy and Marine Corps should adapt small ALE vehicles such as the Altius 600 or Raytheon Coyote to be deployed for ISR&T and EW missions by MQ-9s, helicopters, and MQ-25As as well as unmanned surface vessels. However, the primary deployment platform for small ALE would be attritable UAVs like the RQ-58, which could more closely approach targets to mitigate the impact from the relatively short range of small ALEs. Further, the short range of ALEs and wide array of other ISR&T capabilities available—including RQ-58s themselves—suggest the most important capabilities to incorporate into small ALE will be EW systems that emulate the emissions of larger manned aircraft or jam adversary active sensors using digital radiofrequency memory (DRFM) techniques.
The Navy and Marine Corps should adapt large ALE with greater range and payload such as the Sparrowhawk or Altius 700 for ISR&T and EW missions in which they would be deployed by MQ-9 or MQ-25A UAVs. In addition to enabling long-range operations deep into contested areas, MQ-9s could deploy and recover the Sparrowhawk ALE.89 Because of the versatility afforded by their greater range and payload capacity, large ALE should be equipped with a wider array of capabilities compared to small ALE, including passive RF and IR sensors to target enemy ships, aircraft, and air defenses; RF and IR decoys; and EA systems to confuse enemy radars.

- **Stratospheric balloons**: Developed for commercial telecommunications and scientific research, stratospheric balloons able to support military communications and ISR&T have been tested by DARPA, the Army’s Space and Missile Defense Command, and companies including Alphabet. Balloon UAVs such as the Alphabet Project Loon vehicle shown in Figure 24 navigate by adjusting their altitude to catch stratospheric wind currents in the direction the vehicle needs to move. Solar panels power the vehicle, which can remain aloft for more than 100 days.90 In contested areas, stratospheric balloons could be deployed by Marines ashore or LPDs at sea to act as pseudo-satellites, carrying lightweight payloads such as communications relays or passive RF or EO/IR sensors. Although the balloons can be spotted and attacked, their low cost makes them attritable and once their missions are completed, they can be recovered, and their payloads can be reused. The Navy and Marine Corps should collaborate with DARPA and the Army in testing balloons and incorporating new payloads that support naval missions.

- **Weapons**: The concepts described in Chapter 2 are designed to extend naval forces’ reach by adding refueling aircraft to CVWs and shifting ISR&T, AEW&C, ASW, and EW missions to longer-range land-based aircraft or attrita-ble UAVs. Although the proposed concepts assume today’s weapons do not dramatically improve, longer-range air-to-air and air-to-surface missiles would help keep concepts viable in the face of advancing adversary sensors and weapons.

The Air Force and Navy are collaborating on a new long-range AAM, the AIM-260, which may enable engagements at much longer ranges than the >20 nm of today’s AIM-120 AAM.91 Longer-range AAMs like the AIM-260 or others could allow naval aircraft to engage high-value targets such as enemy bombers and AEW&C aircraft at standoff distances, as well as regain a “shoot first” advantage over enemy fighters. In the distributed air defense concept of Chapter 2, medium- and short-range AAMs like the AIM-120 and AIM-9, respectively, would be employed to engage enemy ASMs. The Navy and Marine Corps should also field smaller, medium-to-short range missiles such as the proposed Cuda or Peregrine AAMs, which could be carried in larger numbers than AIM-9s or AIM-120s.92

The more impactful long-range weapons opportunity is in air-to-surface missiles. The Navy today is fielding the LRASM to engage surface combatants, which has a range of about 300 nm and is derived from the land-attack JASSM.93 The
Navy should leverage Air Force efforts to develop an extreme-range version of the JASSM that could reach 1,000 nm to field an improved LRASM. An extreme-range LRASM could enable naval strike fighters to engage targets 1,500 to 2,000 nm from carriers with minimal MQ-25A refueling. Additionally, the Navy should collaborate with the Air Force in developing new mid-range, low-cost precision guided munitions that could be designed with low observability and other features to penetrate air defenses. This class of weapons would allow naval aircraft to target lower-end naval combatants, merchants, and targets ashore that are defended, but do not require the employment of sophisticated munitions like LRASM.

**Implications for Next-generation Aircraft**

Modifying existing platforms and payloads will be sufficient to support this study’s proposed operational concepts in 2030, but the Navy and Marine Corps will need next generation fixed and rotary-wing aircraft to sustain these or new approaches in the face of intensifying threats by the end of the 2030s. These efforts are underway now with the NGAD program, which is developing a successor to the F/A-18E/F, and the FVL-MS program, which will replace today’s MH-60R and MH-60S helicopters. Replacement programs are not yet underway for the Marine Corps’ UH-1Y and AH-1Z helicopters, but could leverage Army and Navy FVL efforts, and the Marines are currently fielding the CH-53K heavy lift helicopter, which has the range and payload to be relevant in establishing and supporting EABs from sea.

As noted in Chapter 2, the Navy’s MH-60R helicopters are of decreasing utility for the ASW mission due to their limited reach and the growing range of adversary submarine-launched ASMs. MH-60Rs remain relevant for SUW against small boats and for over-the-horizon ISR&T, and MH-60S helicopters will continue to be a workhorse for logistics across the fleet. Given the size constraints imposed by surface ship hangars and facilities, a substantially longer-range or endurance vertical lift aircraft like the Army FVL program may not be practical or cost effective in the mid-to-late 2030s. The Navy should therefore prioritize an unmanned FVL variant, which could support ASW engagements based on shipboard or third-party targeting and leverage the Army FVL program to field an FVL-MS aircraft with low technical risk but improved range and payload for logistics and SUW against small craft.

The Navy and Air Force both have NGAD programs underway centered on a new manned multirole strike-fighter—in Navy’s
case called F/A-XX—which would be supported by unmanned systems that conduct ISR&T, EW, or provide additional weapons capacity. F/A-XX will be needed to replace aging F/A-18E/Fs when they retire during the mid-2030s, but will require off-board systems to address the survivability, range, and payload constraints facing even a highly sophisticated 6th generation fighter.

Today’s 5th-generation F-35C was designed during the late Cold War and its aftermath when the main detection method for air combat was S and X band radar. However, adversaries are using new areas of the EMS to gain a detection advantage against US forces. As noted in Chapter 2, IR and UV sensors will likely constitute the next predominant type of sensor in air warfare, as RF stealth continues to improve, and militaries refine their emission control capabilities and practices to thwart passive RF detection. In addition to being passive technologies that do not reveal the presence or location of the sensor, IR signatures are more challenging to control compared to RF emissions and UV detection exploits the lack of UV emissions by aircraft to detect their presence.

In addition to incorporating a reduced signature in the IR and UV spectra, the FA-XX should use decoys, jammers, and other countermeasures to obscure its signatures and create alternative targets to attract or confuse enemy defenses. In concert, attritable or expendable unmanned vehicles could more closely approach targets, enabling F/A-XX to find enemies earlier and gain an effective detection range advantage over adversaries. Moreover, offboard platforms like RQ-58 could provide additional weapons capacity and communications relay nodes to support sustained F/A-XX operations inside contested areas.

The role of F/A-XX as “quarterback” for operations inside contested areas suggests its design should de-emphasize traditional metrics such as speed or maneuverability and instead prioritize stealth and C3-related attributes. F/A-XX will need to act as a distributed network and computation hub for its offboard systems because long-range communications will likely be degraded or denied where it will be operating. It will therefore need a baseline level of stealth and range, but will more importantly need processing power, diverse and resilient communication links, and robust decision aids for operators to manage the fight forward. This shift from a platform-centric model for fighters to an architectural one implies the F/A-XX acquisition approach should look more like that of a system of systems than of a monolithic aircraft.

Fielding an Affordable Future Force

The Navy and Marine Corps will need to balance their desire to develop next-generation capabilities against the need to field a force during the next decade that can protect US and allied interests. The recommendations above are designed to affordably improve naval aviation’s ability to execute operational concepts that could raise the uncertainty of success for PLA leaders and assist in dissuading PRC aggression.

The investment needed to rebalance naval airpower and modify existing platforms and payloads should be balanced against spending on next-generation aircraft, which will only be relevant if efforts to deter US opponents are successful between now and 2030. However, platforms including F/A-XX and FVL-MS will be needed to recapitalize the force and address the next wave of threats that could emerge. The next chapter and conclusion of this report will provide a spending plan for DoN aviation that balances near-term and long-term investment.
CHAPTER 4. BUDGETING AND CONCLUSION

US naval aviation risks sliding into irrelevance unless Navy and Marine Corps leaders embrace organizational and investment changes that would enable more effective operational concepts against peer adversaries. To support approaches like those in Chapter 2, naval air forces will need greater reach, adaptability, and capacity, which this study proposes to address by changing the composition of CVWs and repurposing aircraft based ashore or on surface combatants and amphibious ships.

Rebalancing naval aviation as described in Chapter 3 primarily involves force management, supported by additional procurement or modification of existing aircraft and payloads. This contrasts with prevailing Navy and Marine Corps plans, which sustain the existing force with minimal improvements while prioritizing development of next-generation capabilities. Not only does this approach fail to address the urgent nature of Russian and Chinese threats, but it also perpetuates the DoN’s expectation that revolutionary new capabilities will fix problems that demand tactical, organizational, or adaptive technical solutions. That strategy failed to deliver in the cases of the Littoral Combat Ship, Zumwalt-class destroyer, and Ford-class carrier. F/A-XX—even if successful—is unlikely to transform naval aviation but could consume resources needed to address peer adversaries during the next decade.

Procurement

Naval air forces are completing a cycle of aviation recapitalization, with US procurement of the P-8A and E-2D ending and the F/A-18E/F in its final decade of production. The Navy’s exist-

ing plans for F-35C and MQ-4C procurement should continue, as they are key elements of the proposed future naval air force, complemented by some F/A-18 E/F production to sustain strike fighter inventories. To rebalance naval air forces as shown in Figures 21 and 22, the DoN will need to buy additional MQ-9s, focused on the MQ-9B variant, MQ-25As, and attritable UAVs such as the UTAP-22 and RQ-58.

The new procurement needed to rebalance naval air forces as proposed by this study is not accounted for in current Navy plans, resulting in additional costs. To ensure deployed naval air forces in the Indo-Pacific can execute the operational concepts of Chapter 2, the plan shown in Figures 26, 27, and 28 will buy enough MQ-9Bs and MQ-25As by 2030 for four rotations of CVWs and land-based aircraft. Continued procurement after 2030 will increase the force’s sustainability and provide replacement aircraft for attrition or maintenance. The cost associated with new procurement is offset by reducing F-35B and F-35C purchases by 8.8 percent and 7.4 percent, respectively. As shown in Figure 28, even with increased aircraft purchases
naval aviation procurement costs remain at approximately the same amount predicted by the Congressional Budget Office for the Navy’s existing plans.

**Modifications**

This study’s most significant investment changes are for new payloads and modifications to existing aircraft. Upgrading F/A-18E/Fs to Block III, F-35Cs to Block IV, and incorporating new EO/IR and ELINT sensors onto MQ-9B and MQ-4C UAVs will require procurement (OPN) and operations and maintenance (OMN) funding. Some of these modifications are already built into Navy and Marine Corps budgets. For example, the F/A-18E/F SLM and MQ-4C IFC-4 are already planned, but F-35C Block IV upgrades were cut by congressional action. EW and survivability enhancements could help F/A-18 E/Fs remain relevant in contested areas and mitigate the impact of slower F-35C fielding.90

Similarly, to field at scale the operational concepts described in Chapter 2, the Department of the Navy will need to mature and acquire small and large ALE. The longer-range weapons that will help sustain those concepts after 2030, such as the
extreme-range LRASM and AIM-260, will also require additional development and procurement. Table 1 depicts a representative set of important non-aircraft initiatives that should be pursued in the 2020s. Navy and Marine Corps budgets are unlikely to experience significant real growth between now and 2030, which will make the improvements described above difficult to implement. This study therefore recommends paying for addition—

Figure 28: Proposed Department of the Navy New Aviation Procurement Costs by Category

al aircraft, modernization, and payloads through reductions in R&D of next generation capabilities like the F/A-XX and FVL-MS. Although new aircraft will be essential for long-term superiority against peer adversaries, if the Navy and Marine Corps are unable to deter aggression between now and 2030, investments in future aircraft will be irrelevant. Moreover, this study’s operational concepts and their reliance on unmanned systems could mitigate the urgency for new manned platforms. And when F/A-XX and FVL-MS do arrive, they would benefit from naval aviation having already broadly implement-ed manned-unmanned teaming.

Conclusion
The shortfalls facing naval airpower against the PRC are significant, but not insurmountable. Analysts have pronounced the death of the aircraft carrier several times since the end of World War II, but by exploiting its adaptability and mobility US naval forces could remain relevant against peer opponents despite the emergence of long-range sensor and precision weapon networks. However, achieving the reach and capacity necessary to counter Chinese aggression in the Indo-Pacific will depend on carriers focusing on the missions that, among naval forces, only they can do sustainably and at scale—long-range counter-air and strike warfare.

By recomposing CVWs to consist almost entirely of strike fighters and ISR&T/tanker aircraft, naval forces can deliver effects at 1,000 nm to more than 2,000 nm away and dramatically expand the maneuver space they can exploit at sea. The counterintuitive benefit of this change is that by shifting all or some EW, AEW&C, ASW, and ISR&T to other ships, space, or shore, the naval air force would become more adaptable and present a more diverse array of challenges to opponents like the PLA. And although this rebalancing may increase the carrier’s dependence on other platforms and land bases, commanders would retain the ability to recompose the CVW for independent operations such as in transit.

The costs for these changes will be substantial in the longterm, as additional unmanned systems will eventually need to be procured at scale for new approaches to succeed. But unmanned systems can be more flexible organizationally than manned aviation squadrons, allowing a small vanguard force of MQ-9s, MQ-25As, attritable UAVs, and ALE to remain deployed in the Indo-Pacific as the Navy and Marine Corps build their inventory. And the delays necessary in future capabilities to pay for additional procurement and payloads would enable naval aviation to embrace new airpower concepts sooner instead of betting new manned aircraft will solve its problems.

### Table 1: Representative non-new aircraft 2020s investments into naval aviation

<table>
<thead>
<tr>
<th>INITIATIVE</th>
<th>NUMBER</th>
<th>UNIT COST (MILLIONS)</th>
<th>TOTAL NEW COST (MILLIONS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW and survivability improvements for F/A-18E/Fs</td>
<td>450</td>
<td>$4</td>
<td>$2,800</td>
</tr>
<tr>
<td>Double annual munitions procurement</td>
<td>1</td>
<td>$506</td>
<td>$506</td>
</tr>
<tr>
<td>Incorporate soft-kill countermeasure (such as ALE-55) on P-8As</td>
<td>128</td>
<td>$5</td>
<td>$640</td>
</tr>
<tr>
<td>Mature and integrate with two aircraft classes a new type of large ALE</td>
<td>1</td>
<td>$150</td>
<td>$150</td>
</tr>
</tbody>
</table>

Source: Authors.
The Navy and Marine Corps have an opportunity to dramatically improve the ability of maritime airpower to influence events in the Indo-Pacific. However, rebalancing naval aviation will require overcoming cultural, organizational, and programmatic hurdles. As described in this report, the necessary changes are possible and affordable, but only if naval leaders embrace the urgency of their challenges and do not continue to hope they can push their problems—and solutions—out into the future.


4 The Navy’s share of anti-ship operations in the Taiwan Strait will also be raised by the Air Force’s slow adoption of weapons and tactics for surface warfare, which initially be a role for the B-1 bomber the Air Force plans to retire in the early 2030s; see Duke Z. Richardson, David S. Nahom, Joseph T. Guastella, USAF, “Presentation to the Senate Armed Services Committee,” June 22, 2021, https://www.armedservices.senate.gov/imo/media/doc/SASC%20Airland%20Modernization%20Written%20Testimony_Final_OMB_Approved1.pdf.


7 The figure draws data from the 2021 US Department of Defense Report on Military and Security Developments Involving the People’s Republic of China, China Aerospace Studies Institute report on China’s Ballistic Missile Industry, IHS Jane’s database, and CSIS Missile Threat database. The figure assumes the employment of all the depicted PLARF missile types up to their estimated maximum ranges and that all the payload capacity of the missiles is devoted to deliverable payload. The estimate conservatively assumes an equal number of launchers to those reported by DoD in 2021, except for new CJ-100 launchers. New missile units (DF-17, a notional projected DF-1X, and a notional projected DF-2X) substitute for older DF-11 and DF-21A units on a one-to-one basis. Missile procurement is assumed to progress at a rate approximately equal to that observed over the past five years. DF-1X and DF-2X ranges assume an approximately 11% improvement over the DF-16 and DF-26, respectively, which could be achieved by adopting a lighter design, more energetic propulsion, and/or a gliding body. In terms of aircraft, the figure assumes the employment of half of the aircraft of each type, 70% operational availability rates, 4-hour turn times, and when required multiple crews. JH-7A/A2s, J-10B/Cs, and JH-XXs deliver direct attack or stand-in weapons, while H-6K/Ns and H-20s deliver 6 and 8 cruise missiles (such as CJ-20s), respectively, that fly 80% of the cruise missiles’ notional maximum ranges of 1,000 nm. Dashed lines for J-10B/C and JH-7A/A2s signify strike capacity and range with drop tanks that substitute for weapons. Aircraft inventory estimates for 2030 assume no additional JH-7/A2, J-10B/C, or H-6K/N beyond those reported for 2021 and that JH-XX replace aging JH-7As and J-10Bs on a one-to-one basis. New H-20s are additive to the force.

8 By 2030 some surface combatants will be equipped with high energy lasers, but these systems are unlikely to be widely distributed throughout the fleet until the late 2030s.


15 Per the 2019 Marine Corps Aviation Plan, the F-35C has a combat radius of 600 nm (https://www.aviation.marinest.gov/Por-
tals/11/2019%20AvPlan.pdf). CBO estimated the LRASM range as 600 km (323 nm) (https://www.cbo.gov/system/files/2020-
02/56068-CBO-long-range-options.pdf). The same CBO report cites the JASSM-ER range as 925 km (499.5 nm).


17 The 1:2 ratio applies to F-35Cs with two internal AIM-120 and two internal GBU-31 (or four internal AIM-120s). When armed with two external LRASM and four internal AIM-120s, each F-35C would require 9,500 lbs. of fuel, which would require one MQ-25A to support each F-35C. One MQ-25A can refuel two F/A-18E/Fs to 900 nm, rather than 1,000 nm as with the F-35C. See Sam LaGrone, “Navy Releases Final MQ-25A Stingray RFP; General Atomics Bid Revealed,” USNI News, October 10, 2017, https://news.usni.org/2017/10/10/navy-releases-final-MQ-25A-stingray-rfp-general-atomics-bid-revealed.

18 Of the 44 strike fighters in a squadron, 30 are likely available on any given day and about half will be devoted to air defense missions. Rick Burgess, “Navy’s Future Carrier Air Wing Configuration Coming into Focus,” Seapower, September 14, 2020, https://seapowermagazine.org/navy’s-future-carrier-air-wing-configuration-coming-into-focus/; this assumes a CVW of 44 strike fighters with an operational availability of 0.7, making 30 aircraft available. (US Navy Doubles Down On Range Requirements For Its MQ-25A Tanker Drone (thedrive.com)).


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27 Bryan Clark, Dan Patt, and Harrison Schramm, Mosaic Warfare: Exploiting Artificial Intelligence and Autonomous Systems to Implement Decision-Centric Operations (Washington, DC: Center for Strategic and Budgetary Assessments, 2020), https://csba- online.org/research/publications/mosaic-warfare-exploiting-ar-
tificial-intelligence-and-autonomous-systems-to-implement-decision-centric-operations; Bryan Clark, Dan Patt, and Timothy A. Walton, Implementing Decision-Centric Warfare: Elevating Command and Control to Gain an Optionality Advantage (Washington, DC: Hudson Institute, 2021), https://www.hudson.org/re-
search/16729-implementing-decision-centric-warfare-eleva-
ting-command-and-control-to-gain-an-optionality-advantage.


ing-losses-in-classified-wargames.


56 The Army is deploying SM-6 as a ground-launched surface-to-air weapon. The Marine Corps uses the same launchers and could deploy SM-6 in concert with its G/ATOR radar to provide a limited air defense capability. See Sydney Freedberg, “‘Army Picks Tomahawk & SM-6 For Mid-Range Missiles,’” *Breaking Defense*, November 6, 2020, https://breakingdefense.com/2020/11/army-picks-tomahawk-sm-6-for-mid-range-missiles/ and Gina Karkins, “Marines Need Funding for Missiles that Can Target Chinese Ships, Top Pacific Admiral Says,.”


Assuming strike or anti-surface attacks will have sizable sorties, e.g., eight F-35Cs armed with two LRASM and four AIM-120 each and six F-35C escorts armed with six internal AAMs each, and assuming that two, 2-ship DCA CAPs are maintained, then there is no additional capacity for DCA CAPs in support of more distant naval forces. If the STW/ASUW operations were not taking place, then those aircraft could support the forward DCA CAPs or sweeps. In essence, it is either/or. Even when operating with a second carrier, operations may take place on 12-hour cycles between the two, so the same challenge would be faced.


101 Assumptions: SSNs carry 12 missiles except for Block V Virginia-class submarines with the Virginia Payload Module, which carries 28 weapons total. SAGs consist of 2 DDGs with 25% of their loadout in strike weapons and 4 DDC/LUSV with 32 strike weapons each; DDC/LUSV rearm 1,250 nm away with a 15% evasion distance factor, true transit speed of 20 knots, a reload rate of 10 VLS cells or equivalents per hour, plus an extra hour of friction. CVWs consist of 44 strike fighters and 15 MQ-25As with an availability of 0.7 and 0.8, respectively, and 2 sorties per day; 10 aircraft are devoted to defensive requirements.