Chapter Working Title: Smart Missile Tactics and Behaviors

TOC

Introduction

Conclusion

we need to understand smart anti-ship missile salvos as dynamic strike packages in their own right. That's because, fundamentally, missile power is just another expression of air power

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Search Section

Intelligent missiles can cooperatively sweep over the area surrounding a last known warship contact. Using a variety of sensors, behaviors, and networking, missiles can rapidly search across a large area to find targets. Cooperative search will better allow missiles to close their own killchains and meet more of the information demands of their attacks. This will subsequently enable fleets to fire on less information and speed up the tempo of its operations. Of the many potential tactics offered by smart anti-ship missiles, their scouting behaviors could be among the most decisive.

Scouting tactics try to solve the fundamental search problem of naval salvo warfare. After a warship is sensed, a contact report is created that includes its estimated location. Contact may not be continuously maintained with the warship, subsequently leading to a last known location. The possible location of the warship expands as time goes on. This is depicted as a circular Area of Uncertainty (AOU) that surrounds the last known location of the warship. The rate of expansion is a function of how fast the warship could be moving. If a warship has moved from its last known location at a speed of 30 knots for three hours, the resulting area of uncertainty is roughly 42,000 square miles, or about the size of the state of Virginia. **(Double check the math). (Simple AOU graphic)**

The area of uncertainty generated by a warship's movement should be measured against the movement of the attacking weapons. The top speed of warships has not changed in 80 years. But the speed of attacking missiles and aircraft have gotten much faster in that same period. The faster the attacking weapon is relative to the target, the less perishable the weapon's original targeting information becomes. Warships can be considered maneuverable at the operational or strategic levels of war, but they are quite slow at the tactical level, because much of the overall combat dynamic of modern warfare will be heavily dictated by the speed of missiles and aircraft that are traveling up to 50 times faster than warships. If a warship is moving at 30 knots and an attacking salvo traveling at 600 mph has 30 minutes of travel time to reach its range of 300 miles, then in those 30 minutes that warship will have traveled about only 15 miles. This is likely the span of only a single missile seeker's search area. The tactical maneuver of a warship can do relatively little to complicate the search challenge of a missile after it has launched, unless moving into obscurants and squalls, or the flight time of the missile is especially long, like Tomahawk. From the perspective of especially fast weapons such as ballistic missiles or hypersonics, warships can be moving so slow by comparison that they are practically standing still.

A warship's mobility is unlikely to expand the area of uncertainty by a tactically relevant size in the short time between missile launch and impact. Rather, the mobility of a warship is mainly competing against the broader timeframe of the killchain that initiates fires. The AOU gains most of its size from the maneuver that can be accomplished in the time it takes to decide upon contact reports and organize firepower. There can be a substantial time delay between receiving a contact report and deciding to strike, and then another time delay between deciding to strike and having enough firepower ready to launch. Maneuvering during this timeframe is what primarily grows the area of uncertainty to a tactically relevant size.

The area of uncertainty that can surround warships can be used to highlight the survivability and maneuverability of naval forces. But the area of uncertainty of a warship should also be measured against the area an attacking salvo can cooperatively sweep with its sensors. If the area of uncertainty can be well-covered by the collective search area of salvo, then the attack has a higher chance of success, and the missiles may be capable of clarifying much of the uncertainty themselves.

Area of uncertainty around a moving target can be effectively covered by terminal seekers operating together in a horizontal pattern ….very different way of putting it than saying X-thousands of square miles……

Tactical maneuver for a warship can do next to nothing to get ships out from underneath the collective seeker coverage of a horizontal salvo that is fired at them…..calculate the square coverage and also describe it as equivalent to area of a state or country (Virginia, Greece, for 45-50k square mile).....and how many hours a warship AOU increases to what size and still be covered….you can lose contact for a warship after X hours and still effectively cover the AOU with this many missiles……

(Footnote my math: Calculating the search area of a missile salvo flying in a horizontal formation, sweeping in a line abreast. For a single seeker: Surface area of a triangle: height is 15 miles, base is 10 miles (Field of view), that's 75 square miles searched by one missile at one point in time, traveling at sea-skimming altitude (30-100 feet). If the missile has 300 miles of range, it will cover that 15-mile height once every 90 seconds. With a 30 minute flight time, that turns out to be 20 seeker spans, or 1,500 square miles for a single missile….30 missiles is 45,000 square miles, the size of Virginia, equivalent to the AOU of three hours at 30 knots…..**(Have a graphical overlay….a circular AOU with a rectangular track overlayed on it by a horizontal sweeping missile formation)**

One concern of AOU is if there is a chance the warship could have left the missile's range during the time delay…..(**Graphic?** situate an AOU within a range ring…(and/or reverse range ring?)…..the AOU grows but the range ring does not, and the AOU can grow beyond the scope of the range ring, not just a range ring, **a search ring**, which remains relatively fixed, although it can be grown by adding more missiles to it…**a convergence ring, that shows how much of an area all the missiles can reach**….….however there are also probabilities within the AOU….what are the chances the lost contact actually traveled toward you instead of away from you? Probabilities of maneuver…..

A challenge with cooperative search behaviors is the need for missiles to regroup after a target is found. If a missile detects the target and relays the target's location to the rest of the salvo, those missiles will need to transition from a spread-out search formation to a more concentrated attack formation. A variety of missiles will have to travel a variety of ranges before they can be in position to pose a concentrated volume of fire to the target. If a target is detected near the limits of a salvo's range, some of the missiles may not have enough range left to regroup into an attack formation, decreasing the volume of fire that can make the final attack.

Transitioning between search and attack formations will come at a cost in time and range that can diminish strike cohesion. These factors result in an area of convergence, which is the remaining area a searching missile salvo can regroup into a tighter attack formation without losing any missiles to range shortfalls. This adds pressure for forces to fire sooner so the area of uncertainty does not exceed the area of convergence. It also encourages forces to provide outside retargeting support so salvos do not burn so much of their range while searching that they end up stretching themselves thin and diluting the volume of fire that can converge on a target. Fresh targeting information is key not only for launching attacks, but maintaining strike cohesion during attacks.

There is a tradeoff between maximizing search and maximizing strike cohesion. Some search formations can opt to not stretch a salvo to its widest extent. Rather, they can feature a calculated balance between search and convergence, and accept less search area for the sake of having greater confidence that a fuller volume of fire can converge on a target after finding it.

(Could have a graphic for the search-to-attack transition, and how some missiles may be lost to range considerations….then another graphic to show different balances between max search, and balanced between convergence and search)

When fighting against a distributed fleet especially, an area of uncertainty can contain multiple distributed forces that are undiscovered and are not the original contact that formed the basis of the AOU. Missiles sweeping over an AOU can discover new contacts that make for targets of opportunity, present distractions, or pose disruptive threats. Smart missiles will have to dynamically decide target prioritization when encountering new contacts in the AOU. This can include bypassing low-priority targets and disruptive threats in such a way that allows the missiles to continue their search while minimizing the contact's ability to chip away at the volume of fire.

Missiles searching across an AOU may be challenged to maintain their cohesion in the face of unexpected contacts. If targeting info is lost and salvos must initiate searches, those searches can encourage salvos to divide themselves. The start of a search can mark an opportunity for smart missiles to act more independently, where missiles can split up in a bid to broaden the search area. But as separated missiles discover new contacts and fresh targets present themselves, the missiles may opt to attack secondary targets on short notice and with only a fraction of the volume of fire.

Dynamic search within an area of uncertainty can lead to less strike cohesion as a volume of fire is diluted across multiple unexpected points of contact. Without careful coordination, a volume of fire may divide into piecemeal attacks against secondary targets. This encourages attackers to stay coordinated when searching so they can maintain strike cohesion even if a choice in targets develops. If the separated missiles of a searching salvo encounter multiple frigates before the priority carrier is found, the missiles can be smart enough to decline attacking those warships so they can still have enough volume of fire to threaten the carrier if it discovered later.

- Area of uncertainty – The area around a last known target's location. This area expands with time as a function of the target's estimated speed.
- Area of search –The area a missile salvo can cooperatively search. This area is a function of how many missiles make up the salvo, the range of their sensors, and the range of the missiles.
- Area of convergence: The area a full missile salvo can regroup into a concentrated volume of fire against a target after detecting it. This area shrinks the larger the salvo and the farther the salvo has to travel to detect a target.

- Waypointing fires, are they searching along their waypoints?

- The wider the search, the more you threaten strike cohesion….searching and striking assets can be separate assets to ensure the latter can have good cohesion….
- Forces can also prioritize their salvos toward higher-probability zones within the area of uncertainty, rather than treat the uncertainty uniformly across the area.

Distributed mass fires can feature multiple salvos penetrating into an area of uncertainty from multiple angles. These salvos can

The convergence area between multiple separate salvos…..without effective cross-salvo communication or outside retargeting support…one salvo may not be able to tell the other where the target is, and may be forced to converge on the target alone…..

Retargeting Section

The tension between firing sooner and waiting for more information…..retargeting is the key capability that prevents these two actions from being mutually exclusive….that new information can be quickly acted on even if it was gained after missiles were fired….

Potentially three sources of configuring the behavior of fires: Weapons programming from the launch platform before the weapon has launched, the organic retargeting capability of the weapon itself, and non-organic retargeting coming from other platforms to the weapon after it has been fired.

Retargeting Content from FDMO Carrier CONOPS Brief:

Retargeting is important because it's the key capability that will make mass fires more resilient and flexible. The tactic of mass fires is something that can already be very dependent on precise timing and positioning of assets, and that can make it a fragile tactic that depends on a lot of things going right. But retargeting capability gives mass fires a lot more flexibility. So rather than having mass fires depend on you maneuvering your platforms into a precise position and then you launch at a precise time, you can focus on launching the missiles and then maneuvering them into place after the fact. This is a more weapon-centric way of combining firepower rather than platform-centric. So instead of waiting on launch platforms to finalize all kinds of weapon programming and mission planning beforehand, you can launch sooner and provide some of those inputs afterward through retargeting….So this is the fundamental capability that lets you control your mass fires in real-time and adapt them to the changing conditions in the battlespace. It's the capability that prevents your options from being locked into place once you launch and it opens the door to all kinds of tactics.

The less intelligent a missile's autonomous behavior is, the more complex mission planning and retargeting support that missile is going to need, if it's going to employ more advanced tactics. Some missiles are probably going to be smarter than others. So I can imagine that LRASM is going to need less help than Tomahawk for example.

Another consideration is the challenge of range. Even if the missile is smart enough to perform its own complex retargeting functions, that may be limited to just within the one salvo it's a part of. But when we are talking about mass fires, we are talking about many salvos coming together on a theater-wide scale, and the retargeting capability of a smart missile is not going to be able to handle those ranges. We are also talking about multiple types of weapons potentially having to fit together into a common volume of fire, which means you have a variety of autonomous behaviors, different levels of capability across missiles, that you may need to harmonize with outside retargeting.

Because aircraft can field better capability than missiles when it comes to sensing and communications, they can be the ones that ensure these widely separated salvos are able to navigate a contested battlespace and come together. They can be the ones that help integrate the uneven autonomous capability across missile types, so that the Tomahawks get enough retargeting that they can keep up with the LRASMs. So in that sense, airborne retargeting is augmenting the organic retargeting capability of the weapons themselves.

You can also consider a combined arms relationship within a salvo. Maybe an LRASM can command a salvo of Tomahawks and guide them on the way to the target. Maybe you have some missiles flying higher to scout on behalf of the salvo while having some hang back to conduct battle damage assessment and act as data relays.

Intelligence and Adaptation Section

As a missile salvo sweeps over tens of thousands of square miles within an area of uncertainty, it can populate the operating picture with fresh contacts while mapping out corridors for bypassing select contacts.

Critical to jam attacking missiles so they can't transmit critical BDA or depletion info out to their friendly forces….they are gaining valuable information by being the assets that gain the closest proximity to the adversary, subject it to a variety of sensor types, and whose attacking behaviors stimulate a wide range of sensor activity from the targets themselves….the information attacking missiles collect is invaluable….Intelligent munitions are collecting valuable operational info with their sensors…..they are at the forward edge of tactics and the offensive/defensive balance, they are bearing the brunt of enemy countermeasures…..this data is critical toward wartime adaptation and sharpening the behaviors of subsequent salvos…..they are not just killers, they are critical gatherers of intelligence, both for the immediate operational situation, and the broader challenge of refining our knowledge of complex interactions between weapons and countermeasures…..there needs to be a system in place to rapidly process these lessons and shoot updates out to the force at the speed of a software update, where a salvo launched a week later in a war should be smarter than one fired a week earlier…..

It is likely that the anti-ship missiles of opposing forces can cross paths on the way to their targets, and it would be useful if that info could be relayed somehow, that missiles that encounter other missiles could tell platforms they are about to be under attack…..

Asymmetry of BDA is that the attacked often know the results of being attacked sooner than long-range missile attackers, assuming some of them survive….this is already stated somewhere in the series, but where? Highlight the need to close this gap with missiles performing BDA…. Flying formations, have some missiles in the back that can perform BDA….Flying formations for gathering intelligence and relaying it back may be different than flying formations for gathering intel solely for the purpose of closing one's own killchain…

We also need to view our salvos as critical sources of information. These missiles are not just weapons for striking targets, they are going to be major sources of intelligence on adversary capabilities and the dynamics of salvo warfare. These weapons are going to be subjected to all kinds of sensors, electronic warfare, hardkill and softkill defenses, and they are going to see a lot of interesting things because of the kind of proximity they can get to targets. And if the missiles can't send that information back to us because of jamming or some other limitation, we need aircraft who can be close enough to potentially receive and relay that information. So not only do we need battle damage assessment, we need to be able leverage the information gained by our salvos to sharpen our understanding of the adversary's capabilities and the exact nature of naval salvo warfare.

One example is that a salvo could travel in a horizontal pattern to sweep over a wide area and find a target.

They are also going to be some of your most flexible avenues of wartime adaptation, because it can take a lot less time to make a missile smarter than it takes to build a new weapon. That battlespace information these weapons can collect will be valuable not only for improving your operations in real-time, but also sharpening those weapons' capabilities. Because some of the intelligent behaviors of missiles can be improved at the speed of a software update, that battlespace information could mean that a salvo fired a week later in a war is smarter than one fired the week before.

Threads

Unsorted

Perhaps leverage some quotes from the “Tomahawk Tactics” article on seeker engagement…..

Retargeting section from Legacy Pt. 7 goes here instead?

Intelligent salvos…map the disposition of a co-located formation and then discern where the gaps and corridors are in its air defense….the path of least resistance…. Intelligent swarming behavior: Being able to look at a naval formation at the point of contact and perceive gaps in coverage or spaces where a lower density of defensive effects can be applied by the target…..perhaps having all the firepower approach a warship and use it to shield the missiles from some defenses from the other warships, and then having portions of the volume of fire break off and press their attack against the remaining warships…..intelligent behaviors should know how to take advantage against naval formations….slipping through versus breaking through…..

Implications of salvos overflying large numbers of Maritime militia and state owned shipping….use deceptive patterns, turn that source of information into a source of confusion….conflicting reports, information overload……

The pattern and behavior of a missile and air attack can show if they know where you are or not, or if they have to grope around in the darkness a bit….that could also be used to deceive, to make it look like you don't know where they are when you do….what's the benefit of that? Strike cohesion is diminished by search, as missiles broaden their spacing to search a wider area….

Missiles dispersing when intercepted by aircraft….to maximize the amount of time it takes to shift targets and down them one by one….making the aircraft chase each individual missile, rather than just having them sit there in formation, flying and not reacting…. Changing salvo pattern and behaviors in relation to sensing illumination and jamming, maintaining line of sight comms if they get jammed, closing together if needed…..

Force development challenge of building trust in smart weapons abilities, so we can fire them on less information…..that will take time, training, and plenty of live-fire exercises that subject the weapons to rigorous contested environments…..would also be good to have digital twins…..the operators should know the training data that was used to sharpen the autonomous thinking of these weapons….. Missiles powered by AI that have been trained on millions of simulations of engagements that represent a wide range tactical possibilities and challenges that could be faced by a missile trying to hit its target….

Also be mindful that if you are doing the all-in horizontal attack, that could be highly wasteful and prompt massive overkill….maybe save some missiles to have some remainder firepower…..

Survivability is lethality….the more the missile stays alive, the more it can strike a target…..

Jamming the comms of a cooperative salvo may force it to tighten the formation to keep line of sight direct comms……jamming the radars of such a salvo, how would it affect their behavior? Simply shift to other seeker types……

Good source for intelligent swarming behaviors of missiles

Unused/Unsure

Kamikaze are often described as heralding precision munitions and ASCM, but it also hinted at the intelligent behaviors of suicide craft… Helps to conceive of anti-ship missiles as unmanned, intelligent kamikazes with significant autonomous decision-making…..as dynamic strike packages in their own right

Kamikaze piece from Trent Hone discussing their tactics and distribution…..intelligent swarming behaviors, maybe cite some of it, and see what exactly were their behaviors….study kamikaze tactics…..and link it to robotic kamikazes….make it the intro, “When fighting Kamikazes off Okinawa….”

.....The highly automated battle between defending combat systems like Aegis and the attacking automated systems of the missiles……

(Mostly used…) Losing targeting info on original target can lead to attacks becoming disjointed, because independent retargeting can take over and dynamic target redistribution occurs, the various salvos may opt for different secondary targets and make the attack disjointed and looser, how to maintain strike cohesion despite the need for dynamic redistribution of multiple separate volumes of fire……do we split up and search a greater area, or do they stick together and search a more limited area, to maintain strike cohesion…..

<u>Legacy FDMO Pt. 5</u>

Introduction

There is more to the lethality of a volume of fire than sheer numbers. Missile salvos can take on different patterns, both in how the missiles are arranged within a single salvo, and how multiple salvos can be arranged together into a combined volume of fire. These patterns reflect how the aspects of concentration and distribution apply to the weapons themselves, and how these configurations apply within salvos and between salvos. Different patterns will affect how a volume of fire takes shape and can multiply the threat it poses. Commanders and autonomous missiles can leverage these patterns to increase tactical advantage by changing how salvos are maneuvered throughout key elements of the fight. These patterns have considerable tactical implications for defending against missiles and maximizing offensive volume of fire.

Stream versus Saturation

It is infeasible for a warship to instantly fire a large volume of missiles all at once. While warships can certainly fire missiles rapidly, their rate of fire is typically limited to only a few missiles at a time from the whole of their launch cells.[1] Because the entirety of a salvo cannot be fired at once, salvos often default to a stream pattern, where a long, vertical column of missiles travels toward a target (Figure 1). Each missile in the column is slightly further away from the target than the missile ahead of it, because each missile was fired slightly later than the missile before it.

Figure 1. Click to expand. A warship launches a salvo in a stream pattern. (Author graphic via Nebulous Fleet Command)

This typical salvo pattern has several disadvantages, such as how an attacking stream salvo can allow the defender to more easily defeat the missiles in detail. If the streaming missiles are flying closely enough along the same flight path, destroying missiles at the head of the stream can disrupt missiles further behind as they may have to fly through exploding shrapnel and debris. A stream salvo can also minimize the maneuvering and targeting readjustments needed to apply warship defenses that are more directionally limited, including mounted defenses such as laser dazzlers, rolling airframe missile launchers, and close-in weapon systems (Figure 2).

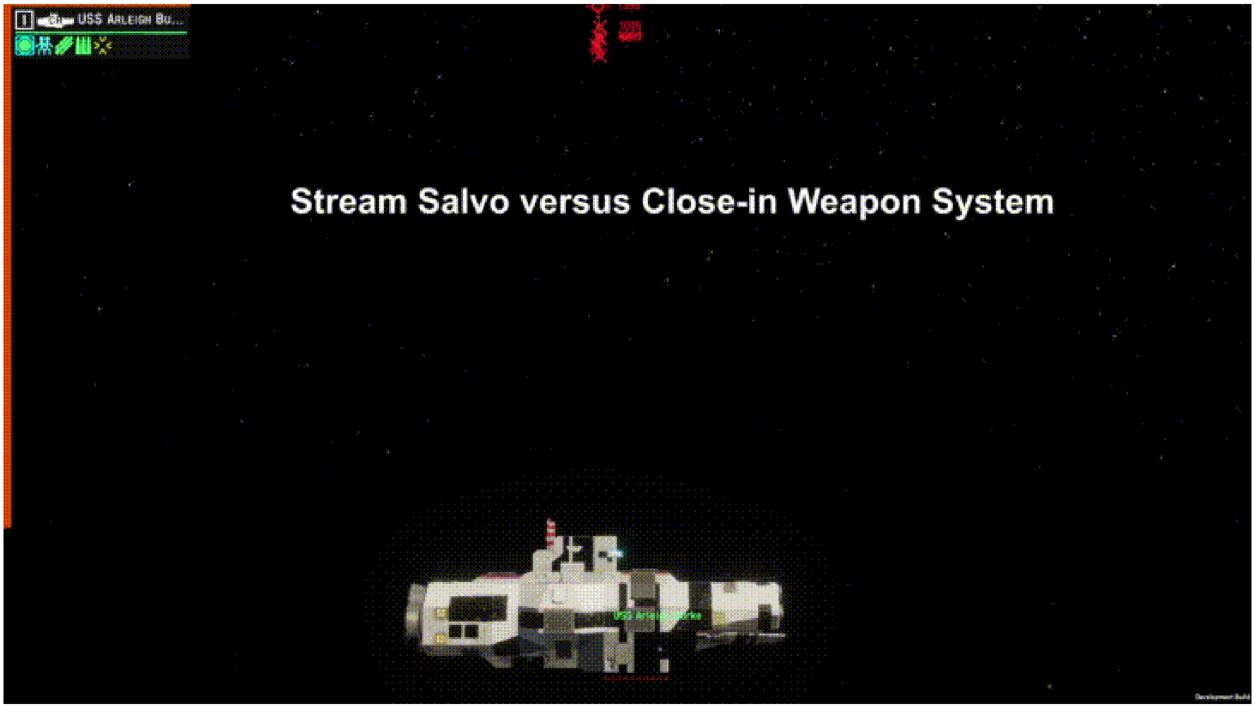

Figure 2. Click to expand. A close-in weapon system engages multiple missiles of a stream salvo approaching on a single axis. (Author graphic via Nebulous Fleet Command)

Alternatively, a saturation pattern has greater tactical advantages. Instead of flying in a staggered sequence or vertical column, the missiles are traveling abreast of one another in a wide horizontal row. This salvo pattern poses a broad front of concentrated firepower compared to the long and narrow front of a stream salvo, where a saturation salvo takes the form of a multi-axial attack instead of the stream's single axis. Once a saturation salvo crosses over the horizon, all of the missiles aim to be at a similar distance from the target warship, intensifying the challenges of defense. Directional defenses will need to traverse more angles to acquire new targets, and the attacking missiles run a lesser risk of having to fly through the exploding debris fields of their destroyed colleagues (Figure 3).

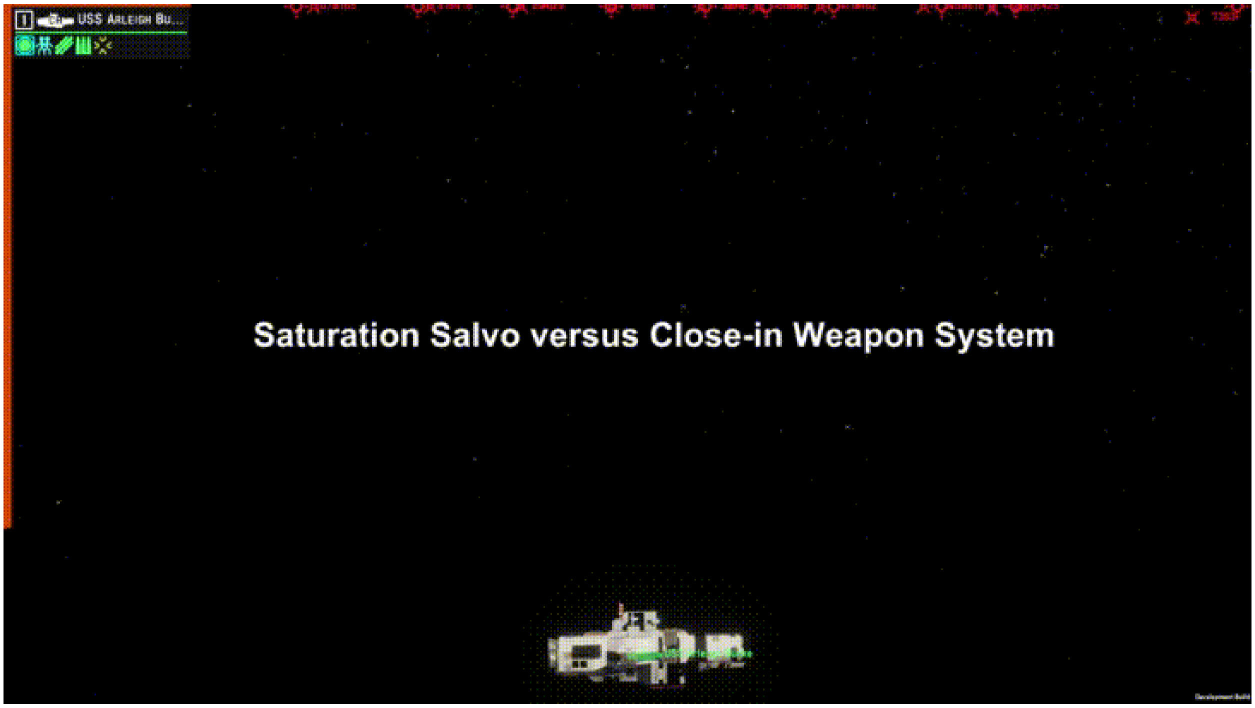

Figure 3. Click to expand. A close-in weapon system engages a saturation salvo's missiles across multiple axes. (Author graphic via Nebulous Fleet Command)

Platforms that feature small magazines and larger numbers, such as aircraft, truck launchers, and small missile ships can more readily assemble into firing formations that generate saturation patterns from the onset. But the feasibility factors that bottleneck a warship’s rate of fire make a saturation pattern more unnatural for a warship to launch than a stream pattern, where warships can only launch large salvos in streams. The missiles will have to be maneuvered into a saturation pattern after the salvo is fired. Ideally this will be facilitated by networking and autonomy on the part of the missiles, rather than a complex firing scheme on the part of the launch platform. Modern anti-ship missiles will be able to be programmed to self-organize into a saturation pattern after they are launched from a warship, or outside retargeting and in-flight updates could provide similar instructions.[2] By maneuvering weapons after they are launched, these capabilities serve the critical function of helping a salvo's missiles maximize the overlap of impact timing regardless of the launch platform’s rate of fire.

In salvo combat, if a missile is not able to hit the target because it was shot down by defenses, the next best thing is that its destruction can buy a sliver of time for another missile in the salvo to have a slightly better chance of striking. This dynamic can continue throughout an engagement, where through their destruction, missiles are buying small consecutive improvements in striking opportunity for other missiles. The way impact timing is distributed across a salvo’s missiles will affect how much opportunity the destroyed weapons purchase for the survivors. A majority of a salvo's missiles will likely be destroyed in the process of ensuring that only a handful have a real chance of striking the killing blows.

Stream patterns stretch the volume of fire thin with respect to the timing of impact. Each missile in the salvo would impact the target at a slightly later time than the missile ahead of it, where the distribution of impact times across a stream salvo is mainly limited to being a function of the launching warship's rate of fire. If defenses are robust enough, a defender can even keep a stream salvo at a fixed distance away from the target until the salvo is fully destroyed. The ability for stream salvo missiles to buy time for one another is diminished by how destroying the missile at the head of the pack slightly rolls back the clock.

What a saturation pattern offers is a salvo that is always closing the distance regardless of the extent of attrition. Even if missiles are being destroyed, the minimum time to impact is steadily winding down. The volume of simultaneous defensive effects required to keep the whole of a saturation salvo at a fixed distance away from a target warship is far higher than that of a stream salvo, because it would require destroying the entirety of the saturation salvo simultaneously.

A saturation salvo epitomizes the principle of concentrating effects, where all missiles in the salvo are angling to strike the target at the same time, and bring the full weight of the entire volume of fire to bear at once. Saturation salvos improve efficiency by maximizing concentration, and can reduce the number of offensive weapons required to overwhelm warship defenses.

Because defensive missiles typically have much less range and flight times than long-range anti-ship missiles, they have far less opportunity to be maneuvered into saturation patterns, especially when they must strike incoming missiles that are only miles or seconds away from impact. Saturation patterns can chiefly be a feature of attacking salvos, while a warship's defending salvos are more likely to be relegated to stream patterns. This forms a critical asymmetry in the offensive-defensive balance and confers significant advantage to the attacker in naval salvo warfare.

Salvo Patterns and Tactical Information

One of the most critical considerations for preserving missile inventory and preventing wasteful fires is guarding against deception and maintaining quality targeting information while salvos are traveling toward distant targets. Salvo patterns heavily influence the tactics of missile search and deception, especially given how capable modern seekers have become.

Anti-ship missiles are difficult to evade and deceive when their onboard seekers feature a robust combination of sensor modes including infrared, electro-optical, active, passive, and others. These combined sensors are meant to work together to maximize their strengths while covering each other's blindspots. They aim to simplify the challenge of terminal search while negating softkill capability. A passive radar receiver can often detect a target or radiating decoy at longer range than an electro-optical sensor, but the latter is much harder to deceive when the contact enters within visual range.[3] At that range missiles will be especially challenging to deceive, where they are close enough to visually verify a target's authenticity. And once they make their final approach, the missiles' targeting logic can employ aimpoint selection capability, where they select the most lucrative impact points on a ship to maximize destructive potential, such as hitting a ship directly in its missile magazines.[4] Aimpoint selection capability makes effective damage control a dubious proposition and helps ensure that only a single well-placed hit is enough to destroy a target, reducing the volume of fire necessary to inflict sufficient striking power.

These electro-optical and infrared sensors are major force multipliers by making it much easier for missiles to ignore the short-ranged warship-launched decoys that form a major portion of a warship's softkill defenses. Even if these decoys pull a missile away from a ship at the last moment, an intelligent missile would know to circle back for another pass, where the decoy only buys the warship more time to shoot down the threat. Effective softkill deception against intelligent missiles therefore needs to occur at a distance that goes well beyond the horizon. Otherwise deception measures that occur within the horizon view of a warship will struggle to have an effect against missiles that can literally see the warship.

[caption id="attachment_56795" align="aligncenter" width="600"]

The seeker head of an IRIS-T air-to-air missile. (Photo via Airforce-technology.com)[/caption][caption id="attachment_56796" align="aligncenter" width="998"]

PACIFIC OCEAN (July 11, 2018) – The guided-missile destroyer USS Dewey (DDG 105) launches an electronic decoy cartridge from an MK-234 Nulka Decoy Launching System while underway. (U.S. Navy photo by Mass Communication Specialist 2nd Class Devin M. Langer/Released)[/caption]

Successfully deceiving these anti-ship missiles may be less likely to take the form of getting them to strike false targets. It may instead become more a matter of keeping them at arm’s length and pulling them in directions away from friendly forces until they waste enough time and fuel that they fall from the sky. But most of a typical warship’s decoy capability is very short-ranged, and warships are extremely limited in their ability to deploy decoys tens of miles away from the ship. They may have to rely on other platforms such as aviation to deploy decoys at a tactically meaningful distance away from the warship.

Once a salvo is fired against a warship, an area of uncertainty grows around the target, where the warship may have moved from its original position at the time of launch, and where decoys may be deployed within this area of uncertainty. This area of uncertainty remains relatively small for the speediest weapons and missiles with short times-to-target. But for long-range and subsonic weapons, this area can grow to include thousands of square miles.[5] If the area of a missile seeker's coverage can overlap most of the area of uncertainty, then the problem of terminal homing is somewhat simplified. But if the area of uncertainty exceeds seeker coverage, then missiles may need to rely more on their own search capabilities to find and discriminate contacts for attack in the final phases.

Saturation patterns maximize the ability of a salvo to search and find a target. A saturation pattern spreads missile seekers across a wide front, allowing each seeker to search a given axis (Figure 5). If a seeker acquires a target, in-flight networking and autonomy between missiles can allow them to converge on a specific contact. A stream salvo by comparison makes for a highly redundant search pattern by concentrating seekers along a single axis, which is hardly ideal for searching across an area of uncertainty (Figure 4).

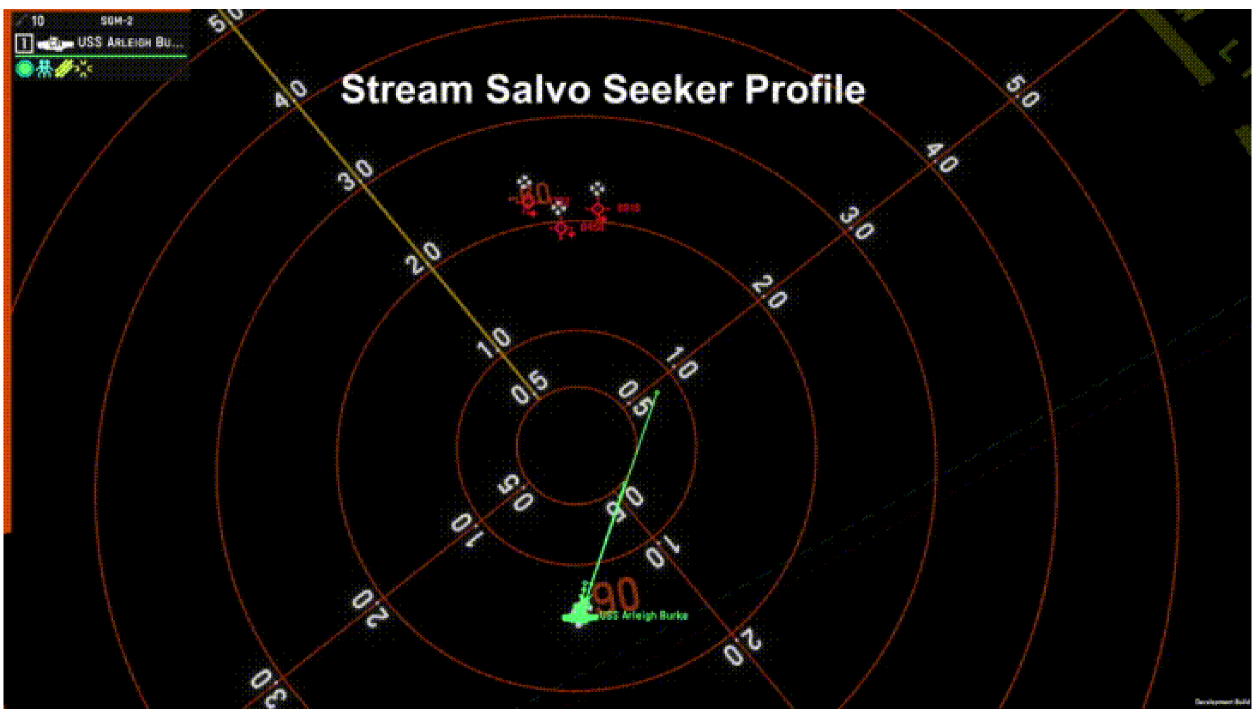

Figure 4. Click to expand. The seekers of a stream salvo pattern search along a narrow axis. (Author graphic via Nebulous Fleet Command)

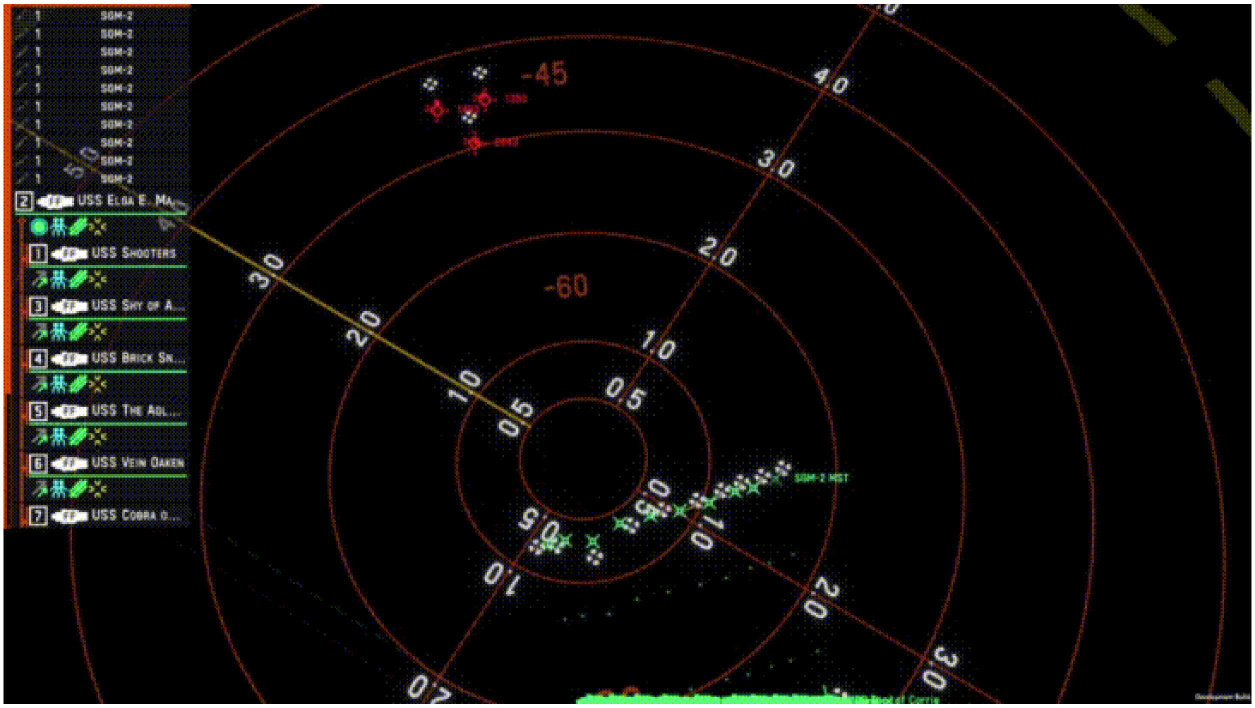

Figure 5. Click to expand. The seekers of a saturation salvo search across multiple axes. (Author graphic via Nebulous Fleet Command)

Missiles can be drawn to contacts that turn out to be decoys, which may need to be discriminated by much shorter-ranged seeker modes than radar, such as electro-optical or infrared sensors. The need for missiles to close the distance to more rigorously investigate and verify contacts can threaten the cohesion and range of the salvo. Relying on only a few missiles at the head of a stream to do most of the searching on behalf of the salvo runs a greater risk of having the whole salvo being led astray by false contacts, which will come at a significant cost to fuel, range, and time. Advanced networking and autonomy may do little to alleviate the inherent tunnel vision of a stream salvo, where the whole of the salvo can be made to suffer penalties if only the leading missiles are deceived. If the missiles lack the programming and networking to work together, a stream salvo encountering a decoy could fragment and lose its cohesion as some missiles take the bait and others do not.

In a primitive stream salvo, the pattern of searching for a target and attacking a target remains virtually the same, compared to the more dynamic expansion and contraction of a saturation salvo that widens while searching for a target and then converging on it. A saturation salvo is much better able to withstand the disruption decoys can inflict against the coherence of the volume of fire. When the salvo is searching across a wide front, a single weapon could investigate a contact and make sure to only cue the rest of the salvo to converge on the contact after it has been verified. This helps a saturation salvo reduce the cost of deception to a single weapon or a handful of weapons being led astray at a time, rather than larger segments of the salvo like a stream pattern. However, if the deception is effective enough to get networked missiles to cue convergence, then a saturation salvo that is made to repeatedly expand and contract as it converges on false contacts and then renews its search is a salvo that will be quickly running down its mileage.

Stream salvos may offer some informational advantages when it comes to battle damage assessment and assessing the effectiveness of an attack. Missiles later in the stream could use their sensors to perceive that the target ahead has been destroyed and communicate fresh battle damage assessment information to the network. Or they could communicate that the vast majority of the missiles ahead them have been destroyed by defenses and strongly suggest that a salvo is on the verge of being defeated. In either case, missiles could deliver especially critical and time-sensitive intelligence on the effectiveness of attacks and defenses, assuming they are able to deliver such information through a network in those contexts. A saturation salvo that simply maintains several weapons to the rear of the main wave of attacking missiles could deliver similar information.

If the targeting and search capabilities of salvos are capable enough, they can lower the threshold of information required to precipitate a strike and speed the decision cycle. If the missiles are capable enough to sort out contacts and even decide their own distribution of fire across a target naval formation, then commanders can launch on less information knowing the missiles themselves can reliably sort out critical details. If an adversary is presenting a mass of cluttered signatures that makes target discrimination difficult from afar, saturation salvos could be fired into the mass in a bid to earn positive identification themselves and function as one-way scouts. Modern seekers that can visually identify a target based on robust onboard databases of warship designs should be capable enough to differentiate most warships from civilian vessels and minimize the ability of navies to use commercial traffic as human shields.

With respect to the vulnerability of the launch platform, a stream salvo can more easily betray the position of its launching warship by providing a clearly defined line of bearing back toward the vicinity of the platform. A warship under attack from a stream salvo could fire its offensive weaponry down this line of bearing in a last-ditch salvo and have a greater chance of striking back. Nonlinear flight paths and saturation patterns can help mitigate this risk through multi-axis attacks that can manipulate perceptions of where an attack originated.

But nonlinear attacks and saturation patterns incur penalties in range and fuel economy. Stream salvos will suffer less penalties than saturation salvos in this regard because it is more fuel efficient to maneuver a salvo across waypoints when maintaining a stream pattern. By comparison, saturation salvos will suffer a greater cost in fuel given how some missiles will have to cover more distance than others to preserve the abreast formation while traveling across waypoints. It may be more preferable to confine a saturation pattern to the terminal phase of attack rather than the cruise phase of missile flight, where a stream salvo only expands into a saturation profile just before breaking over the target's horizon.

Salvo patterns can therefore be flexed during flight to emphasize search, fuel economy, or lethality depending on what is more applicable at various points in the engagement. The need for maximizing range and fuel may compete with the need to search and withstand deception, where these latter factors encourage a saturation pattern. If enough outside retargeting support can confidently convey information to a salvo during flight, then it can minimize the amount of fuel the salvo would have to expend in a broader search pattern. This can also improve the survivability of the salvo and improve its element of surprise, where a saturation pattern engaged in search could provide more early warning to an adversary by posing a radiating wall of missile seekers. Even emphasizing passive detection can reduce the element of surprise, since missiles may have to leave sea-skimming altitudes to broaden the reach of their sensors. Outside retargeting support is helpful toward improving the range and survivability for missile salvos on their way to the target by allowing them to maintain low-altitude stream patterns, and reduces the need for saturation patterns to only the final moments of attack.

[embed]https://www.youtube.com/watch?v=HFQ0R2ZKSmY[/embed]

A salvo of Soviet P-500 *Bazalt* anti-ship missiles (NATO reporting name: SS-N-12 *Sandbox*) is fired by a *Slava*-class cruiser against a U.S. Cold War-era surface action group. Demonstrated intelligent missile swarming behaviors include self-organization from stream pattern into saturation pattern, single high-altitude missile searching on behalf of larger sea-skimming salvo, target prioritization for distribution of fire, and weaving flight profiles in terminal attack phase. Blue trails mark offensive missiles, pink trails mark defensive missiles. (Work-in-progress developer video of forthcoming naval wargame, Sea Power: Naval Combat in the Missile Age.)

Patterns of Combining Fires

Saturation and stream patterns go beyond describing individual salvos, where they can also describe the broader aggregated salvo as a whole. Depending on how contributing fires are being amassed from distributed forces, the aggregated salvo itself may take on an overall stream or saturation profile, or some mixture of the two. The overall profile of an aggregated salvo may feature an amalgamation of waypointing and salvo patterns that generate especially complex threat presentation as a shapeshifting volume of fire closes in on a target (Figure 6).

[caption id="attachment_56815" align="aligncenter" width="726"]

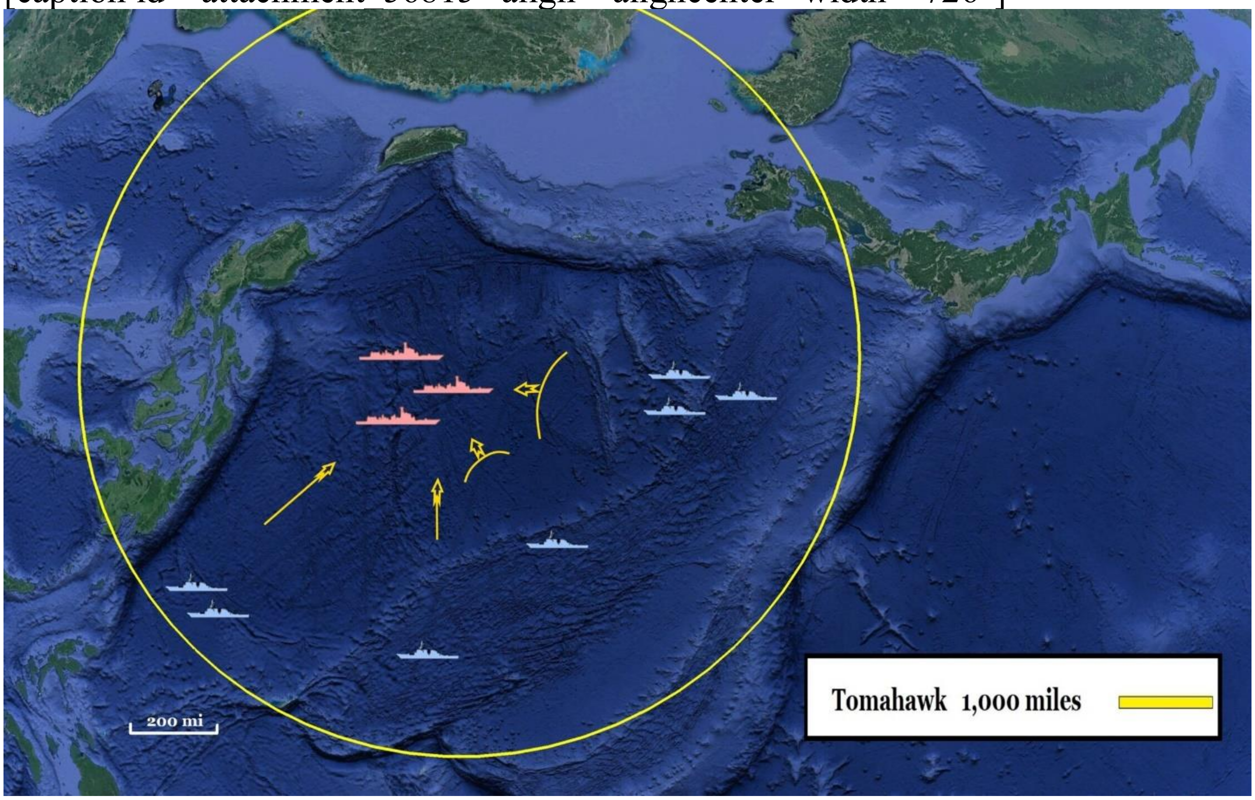

Figure 6. Click to expand. A reverse range ring is centered on a REDFOR surface action group under attack by massed fires featuring a combination of stream and saturation patterns. (Author graphic)[/caption]

It is easier to combine with stream salvos than saturation salvos. Because not all missiles in a stream salvo will hit the target at the same time, there is slightly more opportunity to overlap with the salvo, which can measure in the tens of seconds. A saturation salvo will pose greater challenges for effective aggregation because the salvo is already attempting to position all its missiles to strike the target at the same time. Outside salvos attempting to combine with saturation salvos will have to be very closely aligned in timing because of the minimum of opportunity for overlap.

In-flight retargeting and programming can play a critical role in ensuring aggregation can maximize opportunity for saturation. Multiple contributing salvos can approach a target as streams and then travel waypoints in a holding pattern beyond the target's horizon until more contributing fires arrive. Once the final attack is initiated, the contributing fires switch to saturation patterns and converge on the target. The efficiency of the stream pattern buys more time to grow the volume of fire, and the lethality of the saturation pattern is reserved for the final approach.

As various contributing fires approach a target, the defenders may prioritize the destruction of specific salvos based on their patterns. Defenders may prioritize saturation patterns especially, believing them to be the greater threat. The more complex the flight profile and missile behavior, the more an adversary may assume that a set of contributing fires consists of more capable missiles, and prioritize those salvos for interception by its defensive airpower and other means.

Salvo patterns can be flexed to manipulate adversary threat perceptions and potentially open gaps in defenses. By flexing a combination of salvo patterns and waypoints, a set of contributing fires could expand into a saturation profile to draw adversary airpower away from a target and open opportunities for other salvos to make the strike. And as a salvo comes under attack from airpower, it can shift its flight profile as it senses radar illumination and notices that friendly missiles are disappearing from the local network. By shifting flight profiles while under aerial attack, a missile salvo can make defense more challenging and buy time for the overall strike. Primitive anti-ship missiles by comparison may hardly change their flight behavior when under attack or radar illumination, simplifying the defender's challenge.

Salvo Patterns: A Forthcoming U.S. Advantage?

The ability to leverage the tactical advantages of salvo patterns may be one of the key advantages the U.S. will have over China by fielding the anti-ship capable variants of the Tomahawk missile, assuming China does not develop similar weapons. The Tomahawk missile's especially long range gives it great flexibility for maneuvering through various patterns and along many waypoints. Greater range also improves the missile's ability to recover from deception by false contacts and extend its search for real targets. These capabilities are magnified by another dimension of salvo patterns, that of sea-skimming versus high-diving attacks.

Anti-ship ballistic missiles can take on saturation patterns by virtue of being launched by multiple platforms with shallow magazines, such as truck launchers. But despite having similar range as Tomahawk, anti-ship ballistic missiles are heavily disadvantaged when it comes to reconfiguring their salvo patterns in real time. The fixed nature of a ballistic trajectory strongly constrains the ability of these weapons to alter the disposition of their salvos while in flight, and the steep high-diving nature of their final approach constrains the scope of ocean their onboard seekers can search across.[6] A ballistic missile on its terminal descent cannot decline a false contact and then default back to a wider search pattern as easily as a cruise missile. A ballistic missile locked into its terminal descent is only moments away from hitting the ocean regardless of whether its targeting information is viable or not, whereas a cruise missile has more margin for error. By their nature, ballistic missile attacks attempt to minimize the area of uncertainty around a target not so much by coordinating search across a salvo's seekers, but more by having tremendously high speed that helps preserve the viability of the original targeting information given at launch.

The differences in terminal search and attack patterns between ballistic missiles and cruise missiles is somewhat similar to that of the attack profiles of WWII dive bombers and torpedo bombers, respectively. The dive bomber, like a ballistic missile, makes its final approach from a steep angle at higher altitude, exposing itself to a broader array of sensors and defensive firepower, while having relatively little leeway to shift to new targets midway through its high-speed dive. The torpedo bomber by comparison is usually traveling more slowly, but its flight profile is at a flatter angle that affords it much more maneuverability, even in the terminal attack phase. This flatter flight profile offers a broader scope of opportunity to investigate contacts, recover from deception, and shift targets, while giving the platform more options in when it begins its terminal approach.

A sea-skimming cruise missile is therefore better able to employ a wider search pattern across the area of uncertainty around a target than a weapon locked into a high-diving flight profile. While the visibility of sea-skimmers is more deeply affected by horizon limits than high-divers, a high-diving platform or missile may struggle to radically reorient itself toward a new contact during its dive, and the smaller size of the seekers used by missiles can limit how much those weapons can leverage the broader visibility for search. However, sea-skimming attackers may have to break through successive layers of defending warships and aircraft before they can threaten a priority target in the interior of a formation. In exchange for some disadvantages, high-diving attackers can threaten those priority targets directly.

Conclusion

Sharpening the intelligent swarming behaviors of anti-ship missiles will be a key area of naval competition, one with significant potential for building offensive advantage. These capabilities should be expected to proliferate and magnify missile threats. Navies should take care to assess the programming and autonomous targeting logic of their salvos to consider how this may make their striking power concentrated or stretched thin during an attack. When warship salvos have little in the way of effective networking or autonomy, they default to more primitive stream salvo patterns and suffer major disadvantages. They become more susceptible to deception, struggle with long-range search, and raise the cost of attack.

As a distributed force masses its fires, it will attempt to maximize the saturation effect. In those final phases of attack, the greatest offensive advantage will be gained when saturation patterns characterize how salvos are arranged as they converge on a target. What these salvo patterns make clear is that in the missile age, the weapons themselves have become a chief maneuver element.

DMO Book Master Tracker Doc

Meta Notes

Change the title to *Naval Salvo Warfare and Fleet Combat Operations*?

Play more Command, Seapower, and Nebulous during drafting of the book

Figure out how to do headings for these docs

Consider what can be folded into the main thoughts collection in the NavForcDev doc

Make it an iterative process…..we are working on the first edition, there will be a third edition in 5 years after that……never stop, use the book edition process as a way to stay focused and spend deeper time on the issues,

Edit for passive voice

Add a section listing books and reports marked as being of interest, and general order of priority for reading, consider writing some kind of reading strategy for the project

Last-ditch firing dynamics chapter….

"Strategy can only ever achieve what tactics can deliver." B.A. Friedma

Possible new chapter for force packages and changing tables of organization…..

Read CNA Objective writing guide to help with refinement

Talk to folks for actual comment, not just review…..Fitzsimonds, feasibility of mass fires…..

Drones and fleet warfare chapter?

Put bad mental models chapter up front? Include section on technical interpretation of tactics, quantitative, challenges with salvo equations….need to be able to understand shaping behavior, virtual attrition, etc…..Capt Johnson long quote on what tactics are and their difference between technical…..

Ask people how to read China's military journals and reliable translation? Toshi, Erickson, Martinson, Wuthnow…..

Consider putting salvo pattern chapter ahead of weapons depletion chapter?

Before doing full round of finalizing passes, read CNA Objective writing guide sent by Michelle McSweeney on 8/15/24

Historical battle research as key…..especially carrier battles…Coral Sea, Philippine Sea….

Put last ditch sensitivity section of certain platforms in Pt. 6 into Pt. 4?

New chapters and sections can be republished on CIMSEC, with link back to the book….

What is my mental model of how to win a naval war, naval battle? Narrow-minded single decisive battle perspective like the IJN?

A glossary of key terms and explanations?

Some sort of chapter or a few paragraphs on cyber destruction of fleets? Reference Tyson Meadors article to some extent….

Edit for passive voice

Add a section/chapter on combat lessons from the Red Sea and War in Ukraine

Keep the chapter subsections relative brief if possible to make the writing more digestible and managed at a better pace…..don't need to artificially create briefness, but rather just insert subsection titles where it makes sense to create frequent enough dividers to facilitate a better reading cadence

Distro effort….offer to guest lecture at SSP, NWC, NPS, etc? Or do some kind of standalone event not related to a specific class?

<u>Next Priority Steps</u>

- Initial editing pass on each piece
  - Part Two
    - Complete first full pass
    - Introduction needs refinement

        - Flesh out SM-6 section
- Devise reading order and schedule for reports

Sequential Steps

- **Opening Review**
    - One finalizing/review pass of each part, make minor edits and updates as suitable
- **Preliminary Cover Design**
    - Figure out the dimensions in Amazon KDP and then send that along to the Fiver person, along with the examples and links saved
- **Curation phase**
    - Review DMO article thoughts doc for spare thoughts and threads of interest, no need to develop them, just curate and collect them for deeper assessment later
    - NavForcDev doc master review and reorganize, similar curation and collection as Article Thoughts doc
    - "Distributed Lethality and Concepts of Future War" piece and curation
    - "Information Dominance carrier" piece and curation
- **Development of additional content**
    - Perform deeper assessments of spare thoughts and threads of interest, flesh them out and fold them into the appropriate chapters as deemed suitable
    - Request republication of Atlantic Council piece (August timeframe)
        - Deception and distributed command sections combine into targeted decision-making chapter that goes after force structure chapter, before implementation chapter
- **Graphics**
    - Develop graphics in PowerPoint to replace the Nebulous video graphics (17)
    - Test proofing, request hardcopy samples for reviewing graphical quality
- **First Round Finalizing**
    - Do two refining passes on each chapter
    - Ensure references sections are complete
- **Amazon KDP Upload**
    - Epub
    - Formatting
    - Cover
    - Draft dedication, preface, misc pages, etc.
- **Reviews (send hardcover w/color to reviewers)**
    - First, submit requests to top folks desired for back cover quotes
        - Request foreword
    - Second, submit requests to folks desired for sell page quotes

- **Indexing**
    - Done by Fiver contact
- **Second Round Finalizing**
    - Two refining passes on each chapter, before final publishing?
-

General Steps

- Master list of tables, figures, charts, at the beginning
- Come up with alternative chapter structure for consideration, to create more chapters and make things more digestible
- Request permissions from Atlantic Council for DMO piece
- Cover image design via Fiver
- Dedication section?

Finalizing Pass Counter

Introduction:
Chapter 1:
Chapter 2:
Chapter 3:
Chapter 4:
Chapter 5:
Chapter 6:
Chapter 7:
Chapter 8:
Chapter 9:
Chapter 10:

Editorial Items and Notes

Chapter 1

Consider splitting into a new chapter on explaining value of warfighting concepts and importance of tactics to naval administration. (Based on intros to DMO presentation remarks and Atlantic Council DMO project). Then next chapter focuses on defining DMO, mass fires, and core tenets.

Can find choice quotes from Krepinevich, Ben Jensen…

Consider using those sections from Atlantic Council piece that explain the what and why of DMO here

Perhaps write a new introduction that explains the whole of the project better than what is in the original part 1

Chapter 2

Update table graphic to account for latest inventory figures

Chapter 3

Chapter 4

Chapter 5

Chapter 6:

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Sections to Rewrite, Merge, Fold Into

- Fold FDMO presentation content into main chapters
  - Intro
    - Value of warfighting concepts and how to talk about them
    - Core importance of tactics to naval policymaking and administration

            - Naval salvo warfare tenets will be more enduring
        - Other parts as suitable
- “Distributed Maritime Operations – Solving What Problems and Seizing Which Opportunities?”
    - Request permissions
    - Article
        - Section on defining distribution and offensive-defensive balance into part on value of warfighting concepts
    - Presentation
- “Distributed Lethality and Concepts of Future War”

Graphics

Devise new graphics in PowerPoint for the Nebulous videos

Ideas to Consider

Reading Campaign

Books

Battle of Midway Parshall^^^
WWII pacific carrier warfare^^^
100 Days Falklands Woodward^^^

General Naval Tactics Vego^^^
David Poyer books (Hunter Killer)^^^

Soviet naval tactics Vego^^ (get from Vego or buy off CNA library?)

Understanding Naval Warfare 3rd edition^^
The Sixth Battle^^

Origins of Carrier Air Power and Joseph Reeves^
Magnificent Mitscher^
Fighting in the Dark: Naval Combat at Night^
The Generals' War^
Battle of Midway Symonds^
Battle of Midway Stille^
WWII carrier warfare^

Reports

Batch 1

Affordable Mass PGM mix (Mitchell Institute)^
Beyond Precision Strike Advantage Munitions CSBA 2023^
The Russian air war RUSI^
Putin's Missile War Ukraine Strike Campaign 2023 CSIS^
CSBA reintroducing theater-based missiles^
Ring of fire post-INF Missiles CSBA^
Employing land based anti-ship missiles in the western pacific^
The PLA Coastal Defense Cruise Force (CASI 2024)^

Batch 2

Naval Maneuver Warfare^
A close look at the operational level of war at sea wayne hughes^
Naval classical thinkers and operational art^
Major Naval Operations (Vego)^
Richmond Kelly Turner: Planning the Pacific War^
Tactical Success and Operational Failure in the Anti-Access Area Denial Environment^
Anti-carrier warfare and naval operational art^
Replacing battleships with aircraft carriers^
Building a doctrine U.S. Naval tactics and battle plans in the interwar period^
Surface battle doctrine^
Archipelagic Defense 2.0 (Hudson 2023, Andy Krepinevich)^
Tightening the Chain Maritime Pressure Pacific CSBA^
Ukraine and the problem of restoring maneuver on the battlefield (ISW 2024)^

Batch 3

Agent-Based Simulation of Aegis Cruiser CIC Performing Battle Group Air Defense^
Evaluating Carrier battlegroup AAW Capability^
Battle group stationing AAW model^
Carrier task force anti-air warfare in the 1970s^
Screen disposition of naval task force against ASCM^
Distribution of firing directions in SSM engagement^
Harpoon employment in naval anti-surface warfare^
Fleet Air Defense Falklands Lessons 1984^
Anti-Air Warfare Defense of Ships at Sea (CNA 1981)^
A Stochastic Salvo Model Analysis of the Battle of the Coral Sea^
Surviving the Kamikaze off Okinawa^
A Plan to Achieve US Naval Aviation Superiority This Decade (Hudson 2022)^
The Counterair Companion^

Batch 4 (Soviet Collection, needs to be updated with latest picks)

The Soviet Naval Cruise Missile Force: Development And Operational Employment^
Soviet Capabilities To Counter Us Aircraft Carriers^
Military Thought (Ussr): The Employment Of Tactical Rockets Against Naval Targets^
Reconnaissance Indications Of Preparation For A Surprise Attack By Us Naval Carrier Strike^
Naval Aviation in Soviet Anti-Ship Planning^
Soviet Tactics for Warfare at Sea^
Soviet naval operational art soviet approach to naval war fighting NPS^
Soviet naval operational art^
The Soviet Army Operations and Tactics^

Batch 5

PLA Operational Concepts (RAND)^
Gaining Victory in Systems Warfare China (RAND 2023)^
System Confrontation and System Destruction Warfare Chinese Understandings RAND^

Batch 6

B-52 ASUW^
Trends in air-to-air combat (CSBA)^
Why Air Sea Battle? (Krepinevich)^
Command and control (three papers from Mitchell Institute)^
UAVs for penetrating strike (Mitchell institute)^
Winning the killchain competition (Mitchell Institute)^
Procuring 5th generation fighters (Mitchell Institute)^
Piercing the Fog of War: New Operational Concepts (CSBA)^

Fighting the Air Base (Mitchell Institute)^
Air to Air Combat with and without Link 16 RAND^
Dispersed ops under EMCON^
Maritime Deception and Concealment^

Articles

Maneuver in naval warfare^
The prevention of preemptive attack^
MARSTRAT: Tomahawk's role^
Missile Chess^
The Offensive Passive Ship^
Battle of the Philippine Sea (Buel)
Battle of the Philippine Sea
Spruance and single naval battle
Countering the Kamikaze^
Trends in maritime challenges

Historical Reading Content of interest

Major fleet battles, including Jutland, Philippine Sea, Coral Sea, Leyte Gulf…..

Opener Quotes of Interest

Jackie Fisher – On know how to fight in order to know what to build….How many of our admirals have got minds? (Chapter 9 Force Structure)

"The whole body of tactics and weaponry and the modus operandi of the fleet was really in its formative stages. It caught both the aviation and the surface communities very, very much short." – Vice Admiral Hank Mustin (Introduction, chapter on the importance of warfighting concepts?)

Individuals to Pull Quotes From

- Yamamoto
- Wayne Hughes
- Arleigh Burke
- Raymond Spruance

- T.F. Sprague
- Mahan
- Jellicoe
- Woodward (Falklands)
- Jack Fletcher
- Akiyama Suneyuki
- Tōgō Heihachirō

Table of Contents

Foreword

Fighting DMO Series/Book Project Thoughts

Self Publish Book Thoughts and Additions for Consideration

Table of Contents (T1)

Meta/Structural Ideas and Considerations

Make things personal and human….by couching a lot of things in terms of the fleet commander and what they can do….

Create a graphics directory for managing the various illustrations

For republishing the new chapters on CIMSEC, make that a named series in its own right? What could be the name… "…." With an opening introduction explaining how this is an expansion upon the Fighting DMO series, how that content has been further refined, and how both are in the same book….and include the same caveat that this is all speculative, pay respect to the intangibles and unpredictable nature of war….

Closely synchronize book's release with the CIMSEC adaptation release launch….so any insight gleamed when writing the CIMSEC adaptation is also featured in the book….

New chapters could fold into existing chapters where appropriate…..

Concluding chapter….has lists and frameworks for putting it all together in one place?

A chapter on the strategic dimensions and implications of major fleet combat….and flaws with orienting on decisive battle….(recall Montgomery and Ouellet WOTR article)...the specter of quickly losing a huge portion of the fleet casts a long shadow over aspirations…….

Put smart missile behavior chapter after the assembling mass fires chapter, so it potentially becomes the new part 4

Conclusion chapter…..put it all together, some sort of unified framework….

Maritime militia….role of irregular forces in fleet combat operations….to include sealift….a separate chapter?

Read content on drone swarm stuff (like from CNAS) as a corollary to salvo warfare?

A mid-book photos section?

How many of these tactical things are myopic? How do I determine what is more important than what? For every single tactical dynamic I could bring all the others together with it, like timing, patterns, retargeting, etc…..it's a lot of interdependent and interactive content to be relating back and forth…..may have to use discretion when it comes to that….make sure to step back and consider if something is really important enough to include, or is it a bit too deep down a rabbit hole….

New Intro

Tactical principles sound good but we have to put them into the specific context of the combat dynamics that currently characterize modern warfare…..take the initiative, have superior tempo, delegate command, what does that actually look like in modern fleet combat? How do we operationalize and put it into practice? If we can't get specific, then tactical principles devolve into exhortations and platitudes we can

Very first thing to start off with as an attention grabber….the anatomy of a sea-skimming missile engagement description??

Nuance….linear tactical thinking….much more to naval warfare than just concentrating fire on the biggest target…..

A disclaimer….I am not a DMO advocate, that just because I have devoted considerable effort to trying to articulate it should not be interpreted as me being a believer in it. Is DMO the right answer? The right answer to what question: What should the warfighting doctrine of the U.S. Navy be for how to win modern fleet battles and naval campaigns? I don't know…..use the language from the Atlantic Council presentation, what are we talking about? We are talking about how to win fleet battles and naval campaigns….and DMO is one theory of how to do that, it is a part of that conversation…

Emphasis not only on combat dynamics, but key leadership decision points in managing the fight….(have to have a sense of what choices leadership has to make)

Say something about the methodology was used, consult the presentation given to CNA on how FDMO/HFFF was written….exploratory writing trying to go several steps deep to anticipate how tactics may evolve and outpae one another….and also an emphasis on defensible frameworks and criteria to assess the value of tactics, capabilities, and force structure in the specific context of naval salvo warfare.

Mention graphics and their use and purpose…simplicity is best for conveying the concepts clearly and also accommodating the limited graphic design skill of the author.

Perhaps also define a co-located formation/force package (traditional formation of warships generally keep each other within horizon view), the traditional formation, versus a distributed formation….

Include Line on "tactics are not minor details or options…..rapidly escalate into strategic liabilities…."

On scope: Many of the factors of fleet combat and missile tactics are overlapping and deeply intertwined, offering many possible combinations to explore. The process of examining this has revealed there are seemingly always more layers to peel back and more considerations to factor in when envisioning the art of the possible in missile combat between naval forces. This work represents an effort to focus on the more impactful dynamics, rather than attempt a full accounting of tactical possibilities and relationships.

Key Mental Models to be Questioned, Mine and Others (New chapter here?)

Single decisive battle instead of Savo island battles…..don't fixate on chasing a climatic naval battle and thinking it is the be-all, end-all…..what is the alternative?

Tactical-level success turns into operational-level success

Mustering volume of fire versus penetrative ability of the volume of fire…

Range ring firing outermost limit fallacy, put it in here?

Battle of the Philippine Sea as primary geography

Enough inventory for a repeatable tactic?

No theater ASW and undersea warfare campaign considered?

Siloed warfare areas……don't view AAW/ASUW/ASW in isolation…

Attrition centric, focused on destruction of forces rather than destruction of key enablers……how do we apply a systems destruction warfare approach in salvo combat? (Reference MCDP 1 contrast) Is it all about efficient application of fires?

Classified capabilities will save the day

Pt. 1

"Naval combat in the Inner Sphere is all about massing strength at single points. While a dispersed defensive function…." Core tactical problem in FDMO is how to generate and maneuver enough volume of fire to break through dense naval defenses, but dense is relative, like the term “heavy”….When I think of dense, I’m still imagining co-located groups of ships…..what if every single ship of opposing fleets is distributed as a lone combatant, not co-located with any other? Aircraft can still augment defensive density….even if everything is distributed, there will still be some basis to prioritize targets, and more prioritization means more fires to guarantee kills….even if kills can be bought cheaply, there are still incentives to widely distribute the sourcing of fires, like depletion, complex threat presentation, etc..…. Tactics of massing fires may still strongly apply to land-attack fires, where things may still be concentrated, such as key targets and the air defenses that protect them….

Point from Atlantic Council paper on lowered cost of distributed combatants….individual kills can be bought more cheaply, but they resolve less uncertainty…

Update parts on historical examples of salvo warfare……Russia-Ukraine, Red Sea, Iran April and October 2024 missile raids against Israel……

Describe strike cohesion as a term….and salvo density….are they the same thing?

Concentration offers both offensive and defensive kinetic advantages…..communication and C2 advantages……but counter-targeting disadvantages…..does distribution over offensive kinetic advantages……and binning the advantages by kinetic and non-kinetic….distribution seems to focus on asymmetric non-kinetic advantage…..

Knowing standard force packaging goes with exploiting concentration….If I see a group of a six American warships, I can infer with some confidence that it’s a CSG….if I see a carrier, I know there are probably several destroyers nearby…..If I see X….then I know XYZ and Z is nearby, and that helps flesh out my estimates of their local forces and tactical options, because I know their force packages. Distribution is elastic enough that it can reduce how much extra information can be inferred from a single contact, simply based on a knowledge of an adversary’s standard force packaging….this is of course a double-edged sword…having knowledge of one’s own force packaging streamlines the employment of combined arms tactics, among many other things…..jumbling up force packaging to confuse an adversary could also be messing it for yourself….

Use distribution to mask true strength….difficult to gauge enemy composition, disposition, and numbers of forces……a distinct main body simplifies that….distribution can be used as a lure, entice by posing an opportunity to inflict defeat in detail, when in reality more forces are available and the correlation of power is very different…..trying to complicate calculations of the correlation of forces (Jutland, IJN at Midway)

Think about how effects of distribution change and/or are maintained if everyone knows where everyone else's units are at….

Distribution….could expose forces to defeat in detail, but can also foreclose possibility of wholesale defeat, of losing a lot in one fell swoop…..a theory of staying power and survivability, that concentrated defenses will be enough to defeat or deter attacks, or that taking hits is inevitable and that distributed platforms will be better able to collectively endure…..

Tension to gain more info versus pressure to shoot sooner….also pressure to shoot sooner with less firepower, or wait longer to organize more firepower….

A meaningful distinction (?) between missiles that slipped through defenses, versus broke through defenses…..the first is the case for most ASCM strikes in 20th century, the capability was clearly there to stop it but it was poorly wielded due to poor readiness…..the second is that the capability was effectively wielded but was simply overwhelmed…..have salvos that can slip through defenses as a better alternative than concentrated mass fires? Is that a different paradigm?.....slipping past defenses can also include waypointing around defensive barriers and concentrations and sensors on the way to a priority target……warfighters need a much more nuanced idea of how to fight than simply putting steel on target….**slipping through versus breaking through as a key paradigm to apply throughout the entire body of work, a way of organizing two principal forms of the tactics, attrition versus maneuver sort of, with of course some degree of overlap and complementarity between the two**

Have a section in Pt. 1 on the maritime backdrop?

Logistical constraints of distributed disposition……having two ships rendezvous stands out, and offers the tantalizing prospect of killing one of the most high-value units – the fleet oiler……if a destroyer needs to refuel once a week, and take on its fuel well beyond the range of adversary surveillance and weapons, and then merge with sea lanes, and then leave again to refuel……how long can a ship be in those forward sea lanes before it has to pull out to be on track for its next refueling?……a lengthy cycle of rendezvous, going back and forth, back and forth……

Forces can be stretched thin purely by a desire to dispersed enough to avoid ISR and scouting….non-kinetic driver of dispersion can stretch thin options for kinetic mutual support…IJN at Midway

merchant ships don't move in structured, multi-ship formations….include content from Atlantic Council on deception and maritime backdrop….How does the formation change when you don't have a maritime backdrop?

Do concentrated formations have advantages in massing fires compared to distributed ones? Better connectivity of course which can speed decisions, and less far-flung tactical dependencies for combining fires……concentrated formations could be a lot faster at massing fires….could still waypoint their fires to increase their complexity of threat presentation to some extent….far-flung tactical dependencies is not just the immediate tactical situation around a launch platform, but the tactical situation around the airspace the missiles must fly through…..if a launch platform believes it could be sending its missiles through airspace that is within reach of enemy aircraft, that could be a major complicating factor…..the amount of airspace that a concentrated volume of fire has to have situational awareness over is likely much less than a distributed one……

No clear "main body" of the enemy fleet, as in generations past….

Maritime traffic environment…..one ship on a single steady course, only a handful of course changes or just two warships steaming in formation will stand out against the backdrop and invite closer scrutiny….how do we design a formation for that?

Maneuvering that could help improve a ship's survivability against a submarine threat, such as zig-zagging, course changes, and changes in speed, will make it stand out against the maritime backdrop……despite the numerous contacts across a vast expanse, the maritime backdrop presents a fairly constrained/rigid environment, rigid adherence to the typical behavior of merchant vessels, whose behavior is optimized for efficiency, namely traveling solo, steady course and speed,.... departing from these behaviors can make one stand out against the backdrop……

Skilled formations and maneuvering, blending with traffic…may allow ships to close the distance and engage enemy warships that greatly outstick them….

pervasive PRC state-owned shipping could provide early warning to a degree……a huge part of the backdrop is Chinese-owned….Mixing naval formations….you may be immersed in maritime traffic where much of it is Chinese owned and with prying eyes everywhere…..those allegedly "commercial" vessels could cue fires themselves…..have to be careful when mixing in with commercial assets, and making an effort to deliberately avoid them can make you stand out against the backdrop….

Backdrop End

Unsure/Unused

Pt. 2

Stealth, how does it help weapons? It can help extend range by allowing weapons to fly at higher altitudes while entering into the edges of radar coverage……….but at close range they could be likely resolved…..can also minimize last-ditch firing opportunities for targets…..stealth as a penetration aid……

Harpoon…so few and so short ranged as to be functionally nonexistent for a fleet combat actions for U.S. destroyers….the naval equivalent of bringing a couple daggers to a Phalanx fight….MST will be especially transformational for surface fleet, going from 8 short ranged harpoons to potentially dozens of missiles with more than ten times the range…..

Missiles can certainly carry their own countermeasures, like flares, chaff, and EW that make it challenging to shoot them down….

Framework of nonphysical attributes….as well as the margin and modularity of the weapon and its ability to be upgraded with new capability, especially via software update…..and how many seeker mode types? Radar, optical, infrared, passive ESM, home-on-jam, anti-radiation…..More seeker types working together creates a combined arms ISR dynamic of its own, mutually supporting search functions…..

Can exquisite capability be more cost effective? If a couple hypersonics are enough to accomplish what a larger more expensive salvo of cheaper munitions…then is there some bonus there? Exquisite capability focuses on penetrative capability, better able to slip through defenses….slipping through can usually be more efficient than breaking through….and if an adversary discharges a large number of interceptors to down a single exquisite attacking weapon, that may put the attacker on the better side of the exchange in terms of cost and sustainability….

Include some material on hypersonics?

Mention Japan's Type 12 ASCM as a strong candidate?
https://www.navalnews.com/naval-news/2024/12/japan-unveils-first-images-of-new-type-12-anti-ship-missile-tests/

SM-6 boost phase…..not only betrays the location of the missile, but can betray the location of the launching warship as well……

Don't even have enough LRASMs to full outfit a single carrier air wing….if all the strike fighters of an air wing did 3-4 sorties equipped with two LRASMs, the entire LRASM of the Navy would be depleted….and potentially in a single day.

Low observable missile may not be seen until it crosses the horizon and is very close to the target….low-observable missile may not be noticed as easily by aircraft or early-warning platforms…

Survivability and penetrative capability of weapons are virtually one and the same….the longer a missile can survive a contested air defense environment, the more deeply it can penetrate…..

Munitions recommendations section?

"And so the amount of risk that features in a mass firing sequence can be a function of the missile types that form the contributing fires and how much volume they are contributing." (graphics that depict this, various missile types, adds up to a salvo fo 60 or so, and characterize the risks….a Harpoon-heavy salvo versus another type of salvo….)

Cluster bomb cruise missile…..submunitions that heavily damage sensitive topside areas…..allows missile to deploy the submunitions from a distance to an extent rather than requiring the missile to physically impact the ship, break open and release the submunitions which can travel some distance….a swarm of submunitions for which warships cannot defend against with their air defense capability…..combined arms missiles, have some conventional missiles take the lead so they can buy space for the cluster missiles further back to gain sufficient proximity….ships with knocked out topside sensors can be killed at a small fraction of the cost….another way of attacking left and systems destruction warfare, blinding not just operational level systems but even individual warships….

CAMS anti-ship missile idea….affordable mass- type PGM?....Stand-in PGMs as a way to increase volume of fire……Quad-packable ASCMs? Especially for use by submarines to help them increase volume of fire at close range………longer range is not always better, has to be balanced with affordability and capacity….

Consider framing slight inventory in same way Gunzinger did on page 23 in combat coded aircraft…..how many aircraft can carry the weapon, how many weapons per max loadout, and how many sorties per platform to totally deplete the inventory…….

Long range and high speed are not always better, because these traits come at significant cost….have to consider how affordability affects the overall inventory number and the volume of fire we can put into magazines…

Metric of hit percentage/on target percentage at a given range?

VLS loadout has no impact on radar cross section, but heavy external loadouts do affect the cross section of aircraft….

CHAMP-like missiles, defensive missiles with microwave payloads to have an area of effect, and kill multiple missiles non-kinetically, rather than only having one missile kill one other missile at a time….

What is the ideal missile? You could say hypersonic, stealthy features, with advanced targeting, broad platform compatibility….but cost has to be kept in mind…..we have to be mindful of cost, and of the importance of good tactics and not just good technology in making the most of our weapons….

Pt. 3

Long lead times for setting up attack geometry, through scouting and maneuver, but once things click into place, the escalation of violence is rapid and intense….an enduring feature of modern naval warfare….compared to land warfare, naval warfare appears to be moving in slow motion, until the violence explodes with incredible force…...

Expand on the theme of tactical/operational pace based on flight times of missiles……implications of tempo……

How much flex time do you have within a mass firing sequence and leading up to it? How do you account for that?

Indirect approaches….willing to pay a price in fuel and range in order to secure element of surprise and/or increase complexity of threat presentation….

Trying to perceive how cohesive or disjointed a mass firing sequence is….the staggered nature of the timing and the use of deliberate nonlinear flight paths and waypointing can mask the true level of strike cohesion….hard to know for sure….

you don't fire at maximum range because you want to have some margin to afford missiles room to waypoint, search, etc…..maybe make a list of factors on why you want range margin for missiles…..range margin equals room for maneuver on the way to the target….

A stretched pattern and looseness of fires can suggest they haven't localized your location yet and are counting on the fires to scout things out and close their own killchains, or they have fired a large amount of missiles in the hopes of covering an area of uncertainty with sufficient volume of fire….but that could also be a form of deception, that they appear to fire in loose formations, but they actually do know where you are, and are programmed to converge at a set point in time….

Introduce term of "strike cohesion"....to differentiate from loose, fragmented attacks……waypointing and autonomous tactics mask the cohesion of the strike to complicate interpretation….a strike that appears to have poor cohesion may in fact turn into something highly cohesive later in the firing sequence…..

Waypointing salvos can also mask sophistication of attack, an attack that looks haphazard and poorly organized at first can subsequently become more organized later in the firing sequence…..

What to do with the remaining firepower if the salvo is successful? A branch plan for how to employ surplus firepower after destroying a target so that firepower doesn't go to waste? Something that would most likely have to be done by the missiles themselves through smart organic retargeting….

Having some standardization of salvo sizes, in relation to specific force packages target, who have suffered an estimated level of depletion…based on estimates of the offensive-defensive balance and the expected trades…..sort of like basing standard force-packaging of combined arms strike packages on estimates of off/def balance….so if we need to destroy three destroyers that we estimate have depleted 25% of their defensive firepower, then what salvo size and composition do we think is appropriate for that? And what tactics of employment do we want to use, as far as waypointing, flying formations, etc?

How the disposition of the opposing fleet affects waypointing opportunity…..return to graphics at start of Pt. 2…difference in spread of distribution and waypointing opportunity…..waypoint between individual ships in a formation? Not necessarily…..but maybe? More like waypointing between formations…..try to get more specific

Threat complexity of anti-ship missile attacks: Salvo patterns, weapons composition, timing, speeds, type of launch platform and its location…..EW used in support of it?

Waypoint around distributed air defense bubbles…..screening combatants have to be very close to the high-value unit if they want to minimize the ability to waypoint fires around them, assuming the attacker knows the disposition of screening forces and their HVU (could make a simple graphic of a waypoint bypassing a defender….)

Dynamic target redistribution of fires…..need effective real-time BDA so missiles can know they can opt for different targets and change course in time to pursue those options, rather than being irrevocably committed to attacks against targets that are already destroyed….but also harder to do this with saturation-style attacks rather than wave attacks/stream attacks….structure of multiple separate salvos can risk of defeat in detail but can also turn into more efficient target distribution if earlier waves can be successful with their own volume of fire…….narrowing possibilities of target redistribution the more the missile burns through its range, can be represented by a shrinking range ring around the missile at it travels and depletes its range, what targets still remain within the ring at given points in time? (retargeting section? Smart missile salvo section?)....

Critical favor of time….you can launch piecemeal attacks sooner but which will suffer defeat in detail…or you can wait until you can build up greater combat power, hopefully enough to achieve the critical mass required to break through defenses…..salvo warfare involves the artful management of the tension between haste and patience….

Timing may be heavily influenced by the arming and programing times of weapons….capability trends suggest these times have gone down….and it would be wise for short-notice “snapshot”-like options to exist for weapons to be fired on short notice, and which would be more feasible given the smarter the weapon….the smarter the weapon’s autonomous logic, the less the operator needs to precisely program behaviors…..

Can’t fire at limits of range for a very long-range strike, since you need to afford the missiles some margin to be able to search in the terminal phase if that is needed….

Sometimes it may be best to just err on firing a larger volume of fire rather using more complex and sophisticated tactics that allow you to score kills at lower cost……those tactics may require more skill, more information, more specific circumstances……the tension between time and sophistication of attack, you can save time by just shooting more…….

Not just the speed of the weapons, but speed of the fires process, the targeting cycle……

Give serious thought to how electronic warfare can come into play here…..for both offensive and defensive purposes…..electronic warfare as an artificial source of temporary cover…electronic warfare as a method for manipulating the sensory and networking environment, the information environment, adding new and more complicated information challenges for the adversary…problem is the low density of aerial EW assets….stand-off versus stand-in jammers……use jamming to cover salvos flying over unknown surface contacts to an extent? Use jamming to minimize early warning time? Use jamming defensively to hamper the inter-salvo network…..missiles at opposite ends of the salvo may struggle to communicate with line-of-sight….jam the salvo, and then kill off portions of them to break their line-of-sight chain of communication…..

A key metric is the Density of the volume of fire at the time it cross the horizon/enters air defense engagement zone….a large distinct volume of fire, versus a scattering of fires that are too spread out to be called a distinct volume of fire…..a scattering of fires could be a tactic of distribution as well…..not forming into a coherent volume of fire until late in the firing sequence to minimize the enemy's attrition of it with airpower…..stretch them thin across an area, see where their aircraft respond and concentrate on, and then dynamically cohere the volume of fire away from where the aircraft went to minimize their ability to chip away at the main volume….?

Fleet-wide rate of fire….100 missiles an hour out to 500 miles……multiple rounds of mass fires per day, what's the overall rate of fire for that? Fleet-wide weight of broadside, over what range and within what timespan…..

Standardized time costs….how much to arm and prep a given amount of firepower from a certain type of platform? Know these costs so a commander can consciously choose how much more they want to delay a firing sequence to add to its firepower….like Kido Butai costs (45 min to launch full strike force, 30 min to recover, two hours to rearm, etc, know these costs and work them with intention….if you must have firepower on target within the hour, you know what you can work with…..a commander should set a deadline that represents a risk calculus between shooting sooner, knowing more, and using more firepower, the deadline of initiation of a mass firing sequende is critical and not to be prolonged until ideal conditions manifest)

Faster missiles and forward assets (like submarines and aircraft) can be used to augment a volume of fire in real time to an extent….once a firing sequence is set in motion, the volume of fire is not set in stone….it can still be changed on the fly in some ways….

Doctrine should not be solely hinged on firing only when you can guarantee maximum mass, but be flexible enough to make due with a limited volume of fire….doctrine's prescriptions for managing the time pressures between firing sooner and massing more fire and having more information should be flexible and not rigid…..knowing how to make due with less volume of fire and how to wield it effectively, and knowing when to consciously accept more risk and chance to discharging a smaller-than-ideal volume of fire…..

Unsure/Unused

Pt. 4

maneuvering fires and last ditch salvos……inflicting depletion against multiple naval formations could be more beneficial than just killing one of them

Last ditch salvos….a form of responding in kind…..you want an opportunity to respond in kind, you don't want to be sunk before you have that opportunity

Depletion stretches a force thin….if one piece of the fleet is depleted, the relationship of mutual support can get stretched thin….

Last ditch may also slightly improve survivability by removing a major threat to the ship's survival, being struck in magazines that are full…..

Mention something about the implications of at-sea reloading….higher optempo…what else?

Deception is linked with depletion….if you may not be able to outright muster the necessary volume of fire, inflicting depletion with creative deceptive tactics may be needed first in order to lower how much volume of fire may be needed to break through….but how much depletion in order to lower the density of the defensive volume of fire? That density may be kept up through a given portion of a warship's magazine, say the first 50%? Before firing doctrines are changed to have more efficiency at the cost of lowering defensive density…..are we trying to deplete them so much with deceptive attacks that they run out in the process of defending against the real attack?

What are the thresholds and parameters of last-ditch salvos? A given volume of fire that is a certain time away from striking the platform. That time may be decided by how long it takes that warship to fully discharge its offensive firepower, and maximize how much time it can bring the incoming salvo under defensive fire. The intent to minimize the overlap between two phases – 1) the last-ditch fires, which are completely focused on discharging offensive weapons, and 2) the protection of the warship, which is focused completely on defensive weapons….minimizing overlap so they aren't competing for limited launch windows within the warship's fixed rate of fire…. The rate of fire of the ship's missile launch systems could be a limit, in order to discharge all offensive firepower before defensive systems would come into play…..notional rate of fire of VLS could be one missile per two seconds (cite the logic somehow, rough estimate).....if a warship is carrying 40 weapons it wants to discharge in last-ditch fires, including land-attack and anti-ship missiles, that is nearly 90 seconds of firing…..if a subsonic salvo is 90 seconds from breaking the horizon limit, how far away is it? What about supersonic? Faster salvo provides less warning and imposes greater sensitivity to last-ditch firing dynamics? This also assumes the missiles are spun up and ready to fire…..it is unclear from open-sources how long it takes missiles to be prepped to fire, with one source saying the original Tomahawk taking 11 hours and more recent variants taking much less, the capability trend is clear, and for the sake of last-ditch firing protocols, it may be useful to have expedited prep procedures….last-ditch fires may be more dependent on in-flight retargeting updates because they were fired on less information…..warships can discharge weapons sooner if they can be more confident that other platforms and units can take the time to input more detailed targeting information into the weapons…..what if the missile salvo is approaching at high altitude? Defensive firepower could be brought to bear earlier, but could also compete with offensive last-ditch fires earlier as a result…..

Last-ditch salvo….use it or lose it dilemma…playing chicken with a salvo that could just be trying to deceive you into last-ditch firings….maneuvering that salvo to get under the thresholds that trigger last-ditch firings, the amount of time it takes to fully discharge offensive weapons etc…..

A longer-term battle of attrition, not of platforms, but of firepower…..what if one side deliberately launches attacks, or invites attacks, because it thinks it will eventually deplete the adversary's firepower? That my defensive missile inventory will outlast your offensive missile inventory, or vice versa?

How much defensive firepower depletion is enough to warrant pulling a ship out of the fight? If a single salvo attack is depletes 50%, are you pulling out? How deep are you in the WEZ and is there a chance you may be the target of a follow-on attack? If so, better start pulling out sooner than later because you may be totally depleted before you can pull out of the WEZ….being forced out of the fight before you can use offensive weapons….depletion is another source of last-ditch fires perhaps…..let me fire off my offensive weapons before I am too depleted to credibly defend myself anymore….the lower your defensive inventory, the more sensitive you are to last-ditch firing dynamics, like how a large surface warship can be reduced to having the defensive potential of a smaller surface warship due to depletion, and suffer the commensurate last-ditch firing sensitivities….

Last ditch salvo is a form of counterattack….

Depletion at the operational level of war….calculate it….

Can be hard to gauge incoming volume of fire given how the multiple contributing fires may be widely distributed……a small incoming volume of fire may seem manageable until a salvo of ASBMs emerges on short notice to overlap the target with it….

The order for the last-ditch salvo, comes from the unit itself, or a higher echelon? Potential for friction there?

Apply Gunzinger's logic of depletion….of platforms in the inventory, their hypothetical loadout, hypothetical optempo….how fast do we deplete stocks? In a week….In a day?.....Is all we are talking about here in this book overall, is how to win the first week or two of warfighting in a protracted conflict? The initial salvo competition? Operational pauses may be heavily dictated by the need to mass enough forces, and mass enough weapons in the magazines of the forces, to then create options for further operations….

Firing multiple missiles per target…..if one of the missiles fired earlier downs the target, the fire control system should be able to redirect that missile toward another target rather than lose it….

Fast-breaking predicament of one unit can force the hand of another to support it

Unsure/Unused

Pt. 5

Swarm…resilience, survivability, riskworthiness….means it can gain enough proximity to use more sensors, more short range clarifying sensors like optical infrared….

Dividing a volume of fire up at the point of contact against multiple ships in a co-located formation is different than dividing a volume of fire across multiple ships that are distributed…….the former features mutually supporting defenses, and so the missiles are mutually supporting each other offensively, even as they divide among targets….(May need a graphic to show the difference between the two….penetrating a single air defense bubble versus multiple)

Scouting fire salvo precedes kill salvo…not just a couple missiles devoted to scouting while retaining some proximity for cohesion's sake, but a whole salvo fully committed to scouting and with no need to maintain proximity for strike cohesion, maximizing scouting …..how close to sequence the scouting fires with the striking fires?.....scouting fires reduce the need for large volumes of fire to conduct both search and attack, and spare them the risks of trying to do both….namely, the risk to strike cohesion.

BDA clarity facilitates real time target redistribution, reduces wasteful fires….

Unsure/Unused

Pt. 6

Submarines may have to sacrifice some of their independence to fit into mass firing sequences…dispositions….be on call to reinforce fires…..

submarines can challenge CAPs because they can be in positions to launch those oblique angle fires and bypass caps…..it's hard to orient a cap in the forward direction of a submarine if you don't know where it is…..it may force you to keep the CAP very close to the threatened naval formation for the sake of being able to react at all and contribute some salvo attrition, rather than attempting to lengthen the defensive envelope in such a way to maximize attrition along a particular threat axis…..

Most ideas of mass fires envision fires coming from the outside in….from the enemy's dispositions to ours…but submarines can attack on the enemy's interior lines, and launch fires across their interior lines…..

Aircraft can better penetrate into the gaps of a fleet formation…..AAW range is shorter versus ASUW range, plus ability to fly low to spoil the killchain…..

Aircraft….the key enablers of a rapid maneuver defense capability….

Lack of VLS on PLA subs makes U.S. sub-launched fires a major asymmetric advantage…..fires coming in from interior lines, oblique angles, etc…..need to have surface search sensor coverage over your task force to discover subs launching missiles and periscopes…..

Bounding effects….one platform's attribute or weakness bounds the behavior of another….long pole in the tent….fighting as a team….but can also create liabilities in certain circumstances, need to use discretion as to when it is necessary to respect bounding effects or ignore them for the sake of some other imperative….create a subsection for bounding effects and have a specific structure, like 1) the limitation that is imposed, 2) the unique capability that is circumscribed, and the 3) overall force multiplying benefit that is achieved and 4) example of a deliberate exception….list examples specific bounding effects of interest using this framework: Magazine depth of more common combatants limiting larger combatant, refueling of small/escort combatants limiting larger combatants, time it takes to wind up aerial strike packages, speed and range of more common missiles limiting those of faster missiles, time it takes to launch aircraft to escort salvos could limit how soon you can fire those salvos….range of aircraft and their anti-air weapons limits how far they can provide strike escort to those salvos (500 mile range of F-18 compared to 1,000 mile range of Tomahawk).....The range and endurance of the air wing should have some sort of bounding effect over the operating radius of the surface fleet…

Submarine small-salvo limitation and limited ability to grow their volume of fire if they penetrate deep can be mitigated in the commerce raiding mission….assuming long-range fires can be effectively cued, or if they close within close range, submarines can fire at lightly defended supply ships and still have sufficient volume of fire….

The more missiles can take on the burden of completing the killchain….the less aircraft are needed to risk themselves in providing that information, but still needed to defend the salvos from other aircraft……

Without air cover for counterscouting, warships can simply be shadowed by aircraft that stay outside the range of the warship's anti-air weapons, and maintaining that contact, and help facilitate killchains….

Large-scale strikes can mean a much more episodic presence of the air wing, compared to maintaining a more steady-state presence for local air defense missions and information support with fewer aircraft….

Add maritime patrol and helicopter communities to the combined arms chapter….what are their roles in salvo warfare

Would help a lot to have aerial scouting forces organic to surface forces, like Soviet hormone helicopter, or WW2-era scout planes based on cruisers and battleships

Unsure/Unused

Pt. 7

Articulation of the role of airpower in salvo warfare and modern fleet combat.

Aircraft may be forced to choose between continuing to escort friendly missiles or breaking off to chip away at enemy salvos…..

Division of labor between CAP and strike escort…..tensions and tradeoffs

Air superiority helps with information superiority….and information superiority for the sake of what? Early warning, retargeting, and battlespace intelligence collection and capability refinement

Range limitations…..how much fighter escort and for how long and how far can it be provided to missile salvos…..there will be gaps in escort for sure…..and may the dispositions and vectors of the escorting aircraft also have to take non-linear flight paths to confuse the adversary? Or will they be more limited in their dispositions because of fuel constraints, and therefore shed some light on how the waypointing missiles may come together and how they will attack? We cannot provide anti-air escort to missile salvos everywhere and all the time and in great strength, so where do we choose to prioritize this? Certain portions of the firing sequence, certain timeframes, certain volumes of fire?...could use some graphics for this, such as overlaying the radius of a carrier's fighters with the radius of a destroyer's MST radius, and having destroyer be hundreds of miles away in distributed fashion, showing only a portion of overlap between the two…..

Key Aircraft dilemma….torn between escorting salvos versus protecting warships…..where are you spending your anti air missiles?

Articulate a role for the carrier in the combined arms team that is the fleet and the broader joint force……quarterbacking the maritime fires killchains of the joint

Cultural challenges of switching to defensive and search roles for an offensively minded force…..IJN hated devoting attack aircraft to search (Shattered Sword pg 108)....E2 isn't good for aggressive or stand in scouting, mainly for screening or careful scouting, E2 is the least riskworthy asset in the air wing, and we need riskworthy assets to be forward scouts…..

Unsure/Unused

Pt. 8

Vls advantages…..PLAN does not have quad-packed ESSM equivalent

Can't just look at an A2/AD range rings and assume tactics based off that, like that they will shoot at things at the limits of their range…..when looking at a WEZ, have to consider many kinds of factors density of capability, density and quality of supporting ISR, the various tactical possibilities that emerge, the various layers of capability in different areas, different scopes of timing and opportunity, have a more qualitative and textured understanding of the tactics and operations within a WEZ rather than just assuming an impenetrable wall of firepower at the outermost edge….

Unsure/Unused

Pt. 9

Dense air defenses will also increase the decision-making burden of commanders, both in terms of justifying the steep weapons expenditure required to overwhelm those defenses, and in the command-and-control challenges of harnessing a large amount of firepower from across distributed forces (already said this?)

some sort of force structure requirement…..process or presence requirement….based on salvo warfare….like we want to have more VLS than the next two naval powers combined, etc……what is the overall requirement that stems from this…..what requirements ensure a comfortable margin of overmatch….

Pt. 10

Defining force packaging is important for organizing force generation

Initiative can break concentration of effort…..

Mass fires decision support tool….no doubt already a lot of strike planning decision aids out there…but what could this look like?....visual representation of delivery density, waypointing, how to spread depletion across platform types, timing of overall firing sequence, platform types, proportion of weapon types and the risk involved….plus a variety of pre-sets….maybe ask Shane Halton to take a look at this section and provide feedback based on his experience designing a fires tool on a CSG (mentioned in his data article from Proceedings)

Force development standard….we need to be able to design and initiate a mass firing sequence within five minutes….lots of decision aids and streamlining…

risk of scripting things to be sure engagements take place within the range of weapons, assuming you can get into range to use them (e.g. interwar period battleships….)

Unsure/Unused

New Chapters

Fictional Narrative

Specific Vignettes

-

Other elements

<u>Combined Arms Missiles</u>

<u>Distributed Naval Formations</u>

Maybe ask John Klein about killchains and scouting between aircraft and satellites, limits of space-based sensors for maritime strike, cite Backfire bomber preference of having targeting information come from their own aerial scouts rather than satellites…

Picket section…..traditionally concentrated formation had its early warning performed by E-2Ds, but now warships may be in position to provide early warning via distribution….risky though…..but perhaps necessary to augment battlespace awareness….and when you are low on airborne AEW, you may be forced to use surface warships for early warning, which strongly affects their dispositions and risk profiles, like in the Falklands…….

Maybe put qualitative/quantitative tension of fleet formations in Part 1…..Formation dictated by BMD optimization, that has warships patrolling in tight, pre defined boxes….that makes them predictable targets with a telltale pattern of movement and disposition…..

picket section….read selections from article “FFG7 for outer air battle”

How deeply can you penetrate and then persist in a WEZ if you need to refuel once a week, and cannot risk the tell tale signature of UNREP and risking a valuable logistics ship? Do the math of this….of what the distance actually is if you are rotating in and out on a once per week basis at a moderate speed like that of commercial traffic…..

Graphics of distributed naval formations….embedded in traffic, with range rings of some sort…..(something like this)

How does fleet formation flex in relation to losses and depletion? More depleted, the further away you should be away from the contested battlespace, a matter of degree of course…..dispositions shift depending on how many assets are available, their endurance, their depletion…..if warships are destroyed, their positions cannot be easily replaced because of the warship speeds and theater-level scales we are talking about here….aircraft will have to be used to plug holes, but only for a time because of their transient presence….how resilient are formations? Having them in depth counts….Having a formation where killing a few warships opens a corridor that can be decisively exploited is not ideal……(but what does such a formation actually look like?).....a lot of ISR effort could be prioritized on discovering the disposition of enemy forces, with an eye toward developing a sense of what are the weakpoints of that disposition and the ideal places to target effort to undermine the whole….the path of least resistance toward key objectives, the most economical application of effort….trying to find the corridors, or discern where there could be corridors blown into a formation…..

Attackers facing defense in depth….settle for attriting secondary targets at the forward edge if attempting to push deeper will just result in outright salvo destruction…. if there is no real way to bypass secondary targets enough that it will preserve the volume of fire, then they may have to settle for striking those secondary targets, which in turn serve as missile sumps that absorb volumes of fire on behalf of less riskworthy platforms…..having a forward edge of defense, can force missiles to overfly them to preserve their range, but exposing themselves to more defensive fire, forcing the missiles downward will still have useful effect of affecting their range…..

Distributed forces can link up and form new force packages within hours….complicating the organizing of fires…..decide to attack a lone warship, but then that warship links up with another in the time it takes to wind up the strike, and now your offensive/defensive estimates are off, and to the point you call off the strike or have to engage in organizing more firepower…..(put this in pt. 1 on force packages para?)....the rapid recombination factor of distributed forces is a major consideration that complicates the allocation of fires…..(even if their ability to meaningfully fight together as a deeply integrated unit is doubtful….still have to respect the capability to pool firepower)....does depletion lead to recombination and aggregation, as forces that are less depleted are drawn toward forces that are more heavily depleted of defensive firepower in a bid to protect them as they try to reposition to a less risky place…….

Perils of Carrier Strike/Massing Fires with aircraft

Missiles are far less limited than aircraft when it comes to enabling infrastructure and platforms….Missiles don't need airfields, don't need flight decks….the ability to deliver aerial firepower that can travel hundreds of miles without the need for an airfield is a major benefit of the missile age, and a critical distinction between air power and missile power….

Operational cycles of aircraft can result in defeat in detail….launching piecemeal attacks as soon as aircraft are ready….you will have to wait for some aircraft readiness cycles to catch up to others, in order to launch sufficiently massed attacks….

Missiles are not beholden to the same operational cycles as aircraft….cycles that govern the availability of those platforms….

Timescale of naval warfare…..ships are slow, but they can cover enough distance in a matter of hours to complicate planning for aerial strikes, because aerial strike packages can take hours to prepare and get into position…..the timescale of warship maneuver can effectively compete against the timescale of readying aerial force packages, especially ones that are attempting to muster volume of fire alone as a standalone unit…..

Higher rate of fire is good for strike cohesion, because the missiles launched earlier do not have to burn as much time and range to group up with missiles launched later….a salvo launched in a minute will be much less diffuse than one launched over the course of half an hour……consider the implications for carrier launched mass strikes…..higher rate of fire reduces the tension between attacking sooner with a smaller volume of fire, versus waiting longer to organize a greater volume of fire…..Forces may be strongly tempted to attack sooner even if it means using only a fraction of their available firepower….Once some measure of firepower is airborne, forces may be tempted to send it onward while other fires are still waiting to be launched, sacrificing some strike cohesion in a bid to strike first…. (Battle of Midway example….footnote other examples of divided strike packages from WWII carrier battles?).....rate of fire of individual platforms, of individual strike packages and force packages, or entire distributed fleets….remember, rate of fire is not just how fast the missiles leave the launch tube, it's how fast it takes to set up and decide and get the firepower on station, etc…the tempo

Attack Waves/Multiple Rounds of Fires

Defenses become more shallow after a certain rate of depletion….trying to find less shallow air defense envelopes

subsequent waves have less element of surprise

Tendency is for one massive pulse, shoot to kill nature of salvo warfare, try to guarantee to be overwhelming at the point of contact….but there may be mitigating circumstances, options, dynamics that encourage multiple waves, such as what though?....including….warship heavily depleted by first round, links up with less depleted warship that helps provide escort, second round tries to kill both……

Operational-level of war chapter

Strategic implications sector of fleet warfare? (Utter destructiveness, extremely expensive, generational recovery, and it would obviously be best if it never happened again.)

The balance of fires estimate…..offensive and defensive inventory…..a methodology, a framework….number, timing, geography, geometry…..

Most of what's described in the book is about warfighting concepts at the level of the battle, not the campaign….

How much can you really plan this stuff, and stick to the plan during unfolding events and combat? (In games for me personally, not always much of a battle plan, just a general thrust of intent, and then falling back on many tactical/doctrinal heuristics depending on the evolving situation, moment to moment….)....the planned mass firing sequence may be a minority compared to the adaptive/improvised mass firing sequence….

Read again Iskander Rehman's WOTR Vegetius piece and my highlights of it

Are submarines inherently more attritional, able to whittle away enemy strength?

Consider force preservation….pervasive consideration….hardly riskworthy assets…..what loss rate is tolerable at the operational level? gauging comparative rates of attrition and regeneration across multiple rounds of engagements, who gains and holds the advantage? Risk calculus changes….what was once somewhat risk worthy could become irreplaceable…..

ASW and Salvo warfare

Aircraft lifting off from carrier is a telltale signature….so are helos lifting off from warships, ASW helos…..whose movements could betray a contact…..advance screening with sonobuoys and helos can betray the future movements and locations of a formation…..

Scouting fires

Scouting fires as ambush hunters….triggering ambushes….how does the ambusher know if its a scouting fire versus something more important?

Flying at a higher altitude not only enhances search, it invites longer-range and higher-angle anti-air attacks. The distinct boost phase of those attacks can be useful for localizing the launching warship….even if the warship is firing on sensor information provided by outside sources……boost phase attacks of anti-ship missiles can also be a betraying signature….like how I maneuver aircraft from carriers in Sea Power, staying at low altitude immediately after being launched from the launch platform is important for managing signatures and not betraying locations……

An F-35 retargeting inputs, telling missiles to go far forward of the volume of fire to close and investigate unknown contacts with visual/infrared sensors to make sure they aren't ambushers…..

<u>Gen/Misc Thoughts to add for book project</u>

General consideration of what is more economical in distribution? Concentrating for defense but running the risk of losing more if an attack is successful, or spreading to lose less if an attack is successful but not being able to concentrate as well for offense?

How do you leave room for emerging problems, and not have something that is so tightly scripted as to be very fragile? How do you build margin into mass fires?

Inferring enemy composition from volume of fire and strike cohesion? Distinct salvos coming from distinct directions? 100 missiles could have come from a single destroyer or 50 destroyers…100 fighters or a dozen bombers….hard to judge this based off volume alone…..

Some sort of visual framework for how mass fires come together….lines on a map with a certain density to reflect volume of fire….lines that show the routes the missiles took, plus information, including the launch point and launch platforms of each set of contributing fires, how long it took them to

reach the target, the ideal time of overlap, how much attrition was suffered, how much depletion was spread….some sort of two-part breakdown…including a map with the above info, and a table with the percentage magazine depletion of the platforms, the flight times, the amount of attrition the fires suffered, the proportion of overall volume of fire they contributed, and a qualitative comment section to describe feints, deceptions, and other tactical effects of note…..

Decisive entanglement can be a key thing to employ deception towards, like giving false impressions of where is my main thrust of effort….amphibious landings can be ripe for deception….

A list of leadership decision points….like fleet disposition, timing of fires, depletion, etc….

Any value to having radars on so you can witness boost phases of missiles, both offensive and defensive, both enemy and friendly?

Once scouting competition is sufficiently resolved….transition into kinetic competition…..

Estimating enemy force composition based on incoming volume of fire…..can be difficult, helps to know the missile types and be able to classify them….Tomahawks come from ships and subs and land-based, LRASM comes from air…..does anything come from air and warships that is decent? SM-6 maybe?...

Smarter the weapons…..the fewer of them may be needed to kill targets, and the more depletion they can inflict against an adversary……how to combine depletion, deception, and attack tactics to earn kills at lower cost?.....The threat of depletion forces us to think creatively and qualitatively….and also, the smaller the force relative to its adversary, the more tactically brilliant it has to be to compensate, similar logic applies to running low on missiles, or being very concerned with weapons depletion…..

Communications can also govern the disposition and detectability of fleets, and yet communications are critical for facilitating combined arms relations…..another form of risk calculus……

Considering force preservation and making projections……are you getting favorable trades and exchanges, do the tactical-level trades amount to operational/strategic-level advantage?...especially critical to have a sense of this because of how much attrition can be suffered in such a short time in naval warfare, and how almost all types of losses are irretrievable in a war lasting less than a year, including ships, aircraft, munitions, personnel, facilities…. Troops in Korea probably thought they were getting good trades because of the lopsided kill ratios in their engagements, but Chinese/DPRK forces could withstand those ratios better than UN forces (probably….)

How can we boil this all down to basic heuristic simplicities? Keep things simple….some doctrinal rules of thumb to keep our decisions fast and flexible in the midst of a complex and hotly contested battlespace

Decisively entangled…can mean lots of missile salvos sent out….don't suffer from target fixation, be ready to change targets and redirect salvos if needed…

Irregular forces: Distributed warships in sea lanes gain proximity to maritime militia and commercial vessels, what if they launch swarms of suicide drones that could challenge conventional air defense systems? Score hits on key components and systems, like radar arrays? (Can SEWIP down drones?) (See massive volume of fire of loitering munitions from a single containerized weapon system)

Below threshold chapter or section??: Potential benefits of fires that do not have sufficient volume to be overwhelming, but can still stimulate emissions, shape behaviors, trigger depletion, etc…

Push to contact….see how much ground they let you take before they put up a fight….(how does this apply to naval warfare)

Suppressed by fire, how does that work? And suppressed by scouting as well…

To shoot archers before arrows, you need information advantage…airborne early warning is critical for that……

What does it mean to gain or lose the initiative? Firing effectively first…..seeing salvos coming in before you have fired in a sense means you are now reacting to them and letting their actions compress yours, such as tightening your firing sequence…..but simply the appearance of incoming fires is not enough, is it a harbinger of more fires to come, is it a weak volume of fire, is it a poorly organized attack, how can you tell, how can you interpret that in real time and know if you are truly in a contest now over the initiative, that you should let their fires force your hand?

How to lower the networking and information demands of this kind of warfare? Lower the threshold?

Imperative to shoot and scoot…the scoot imposes additional command and control burden, because you now have to frequently manage maneuver….where should they maneuver next, how far from the last position, etc….adds cognitive demand….want to delegate this down to unit-level initiative so they know to do it without the commander having to move them around….more effective mission command, less cognitive burden on the higher-echelon commander

Force packaging can have some scope of standard intervals in mind for distribution….that your spacing does not exceed this distance, whether going too far or too close….and some understanding of how loosely or strictly this spacing is to be maintained….for the sake of being organized as some sort of mutually supporting unit….

Simply putting things within weapons range can be enough to shape behavior…..

How can you ascertain loadouts before they have even fired? By disposition in formation, heading? (Platform type is already discussed to an extent)....

Elastic delivery density for defensive volume of fire…..think of the delivery density graphic but for defense, how aircraft can augment it and increase/decrease density based on their movements…. also think of weapons depletion, and its effect on how much density can be maintained for a given amount of time (like 30 seconds) before it starts to decline….? Interesting thread to pull on, how does the delivery density graphic apply to defense, how could that overlap with the adversary's offense…..may need to consider commissioning/purchasing graphics from Louis Vezian

Scouting shortfall can be compensated with volume of fire…launching salvos across areas of uncertainty and hoping something hits, rather than narrowing it down and then launching a more precise amount…more meager assets, more intel needed to make the most of it….

Set piece battle bias….consider engagements with more common forces….smaller force packages, surface and air and sub units…..if the operational pauses are dictated by the availability of a handful of capital ships, that could be a major liability…..surface forces need some self sufficiency….and how would they fight without carriers? Land based air?.....operational tempo dictated by what exactly? Availability of certain assets, munitions, logistics, advance bases?

Nuclear powered submarines….less dependent on logistics and networks than the rest of the distributed force…..they can persist and maneuver more freely…..

It's not always clear when you've been found or discerned in naval warfare until they start shooting at you…..any preliminaries to being shot at that are obvious tells? Maneuvering units into place, extra scouting…..simply being hit with emissions isn't enough….and even if they do know you are there, some effects of distribution are in place, it's not as clear cut as to be seen is to be destroyed….

How does information superiority translate into more penetrative hits?

What are my core tactical principles? My tactical constants, like in the traditional of Hughes? What is my "fire effectively first"

Average warship will likely lack enough ASCM missile firepower to break through and kill another single average warship…….no common parallels in other forms of warfare….

Sensitivity to small advantages in force…..snowballing effect….means that it is very difficult to recover the initiative once lost, the more it is lost, the more asymmetric you may have to go to equalize, or arrest the other's momentum……does not automatically mean going on offense, but can also include encouraging the adversary to attack into the teeth of defenses and suffer attrition and depletion, like Battle of Philippine Sea, if we are sure we hold the advantage in that respect……..how does this work for salvo warfare? Absorbing attacks on purpose and then counterattack…..?

Improving margin of overmatch with more munitions is beneficial, and having a more complete ISR picture to fire upon is also beneficial, but….if it takes more time to organize and bring more firepower to bear, that time could result in taking a blow before one could muster it….the tension between mustering more strength and then discharging it in a timely fashion before the adversary does the same…..use line from AC DMO report "the inherent tension between gathering info and striking sooner."

Penetrative ability for stand-in stealth strikes against warships? Viable and cost effective, or highly risky?

Flanking attacks in salvo warfare….seems odd since a modern warship has 360 degree coverage….but when you have a multi-layered system of defenses, flanks bypass some layers of defense to handle fewer of them…..consider a flanking attack that bypasses aircraft defenders that are postured toward a specific direction….like bypassing the sector a chainsaw is focused on covering (Dance of Vampires for example was a flanking attack….)

Stand off Jamming to screen a salvo, so it can fly at higher altitudes before being detected, at which point it can drop to lower altitude? As a method of saving fuel economy and extending range perhaps….

What about multiple mass firing sequences happening in tandem, and between opposing forces? Most of this took the form of one sequence against one target….expand it to the interactive nature, and multiple concurrent engagements….what are the possibilities there?....and then think about multiple rounds of fires, how does the dynamic evolve for the 2nd and 3rd rounds of strikes? When does depletion start kicking in, attrition, etc…..

Have a single overarching narrative of the fleet-level concept of operations, like in Kaigun's narrative of IJN surface battle doctrine….and be mindful of assumed prerequisites, enemy interference, and the interactive opposed element

Aircraft may need to use guns to maximize the volume of fire they can shoot down in a single sortie….but using guns is likely more time consuming than missiles….more time consuming means more early warning is required…..especially if the missiles are smart enough to begin evasive maneuvering once they sense members of their salvo are being downed…..

Think beyond the close-in sea skimming terminal defense scenario, there may be other scenarios where they are flying higher, also consider these scenarios that feature a more expansive air defense envelope

Possibly having to fire more missiles to cover a larger area of uncertainty? Covering more sectors with a sufficient volume of fire, hoping one of them will find the target and be enough to kill it? Blanket coverage of firepower across an area of uncertainty…..

How well did we discuss the practicalities of coordination across platform types? Could maybe say more….different communities and services may have different procedures and tactics for employing missile firepower…this has to be harmonized

MALD stand-in jammer capabilities…..could it complicate short range fire control radars? Very short range of those terminal engagements would make it harder to overwhelm with jamming…..

It is not enough to say that something has the desirable attributes and capabilities (distributed, small foot print, riskworthy, long range, high sortie generation rate….). It's the difference between describing what these things are versus how to use them well. These things are only points of departure for tactics, they are not the tactics themselves. It's the core tactical problems, and the tactical combinations that try to solve them, that are really what determine something's relevance. The real crux of the issue is at a level of detail in warfighting that we are not reaching with the current conversation. That needs to change.

How we discern erratic fire from organized fire when looking at a mass firing sequence? How do we discern a breakdown in formation on the scale of a distributed fleet?

The tethering effect of CSGs….surface tethered to HVUs and capital ships…..how does distribution affect how units are geographically tethered? Mass firing considerations….force package considerations….network considerations….combined arms considerations…..distribution is not a blank check for random geographic dispersion, it is bounded by numerous tactical considerations and relationships.

The longer the range advantage of the weapon, the more warships can fire from standoff distances, firing from beyond the range of weapons that can retaliate against them, and beyond the range of sensors that can perceive them.

The force package, the combined arms relations implied by the force package, and the formations of the force package…..new force packages will warrant major changes to the force generation process that deploys those packages, the navy has spent the better part of the past 20 years painstakingly squeezing out every bit of efficiency it can out of its current force generation process, which has specialized in deploying packages like carrier strike groups, amphibious readiness groups, etc….if the Navy is unwilling to change its force generation process to allow for different force packaging options, then that's going to be a major constraint on evolving the fleet for DMO and fleet-level concepts in general.

Unsure/Unused Book

Follow-Through Ideas

Pitch presentations to NWSI, CSBA, CNO SAG, NWDC, N7 Stratsynch, NWC, SMWDC (?)

Carrier version brief:

- Walker Mills for USMC MQ-9/F-35 community
- Mark Jbiely for Pacific Weapons School **(awaiting)**
- Trevor Phillips-Levine for 7th fleet fires **(awaiting)**
- NAWDC, via Trevor somehow?
- Justin Cobb **(awaiting)**
- Michael Dahm for Mitchell Institute

- PACFLT
  - Work through Molenda, Hein, and Fields. Potentially get this stuff in front of ADM Paparo. Ask them if they are interested in any conversation or discussion or presentation…..
- N9?
- N7
  - Hottendorf
  - Taddiken
  - "Leto" Boston
  - **Trevor Phillips Levine**
- J7
  - Julian Ouellet (former)
  - Dave Banschbach
- MCWL
  - Sean Welch
- NWC
  - Course elective idea like what Tony Cowden described. Who to reach out to and pitch the idea?

        - Wargaming: Mike O'Hara
        - JMO
            - According to Doug Kettler, 10/19 Adopted for professional military education coursework by the U.S. Naval War College's Joint Military Operations Senior Course (as of Fall 2023)
                - Consider pitching a presentation for NWC audience? Do they have a speaker series?
        - College of Maritime Operational Warfare
            - Edward Cashman
        - MAWS
            - Course adoption on July 17, 2023
        - Halsey Alfa
            - Jim Fitzsimonds
- Bryan Clark and Tim Walton
- Land-based ASCM launchers
    - 11th Marine Regiment, Alpha Battery
        - Sent Linkedin request to battery commander Justin Hildebrand on 10/18
    - Army
        - 3rd Multi Domain Task Force Commander is Col Dave Zinn
        - CDID is Army Arty doctrine center of excellence. COL Matthew D. Rauscher director.
        - Long Range precision fires cross functional team. COL Rory Crooks director. Rob Richt deputy.
        - Stephanie Ahern, Futures Command concepts center
        - People to ask
            - Nate Finney (10/18)?
            -
        - Army War College SAMS ASMP program
            - Barry Stentiford
            -
- USAF
    - Dave Lyle said he would forward to some colleagues working on Agile Combat Employment and Distributed Ops.
- PACAF
- LeMay Center
    - Dave Lyle
    - Matthew Neuenswander
    - Troy Stauter
- Air War College
    - Capt. Casey Baker (USN)
    - Capt. Steve Dradzynski (USN)

- DeVere Crooks:
    - “We recently used your DMO series as a primer for a Surface Navy Association session with RADM Cahill on that topic up here in Newport over the summer.”
- USNA
    - BJ Armstrong (says it will be added to content to consider for new Maritime Warfare class…should follow up)
- SAW
    - Col Poland
    - LtCol Troy Van Zummeren
        - Being relieved by below later this summer
            - LtCol Craig Giorgis
- SWOS
    - Capt. Mutty **(said could not meet intent)**
        - Trying again with Anthony LaVopa
    - Capt. Roy
- UWDC
    - Paul Vebber
    - Red beard guy
- NAWDC
    - Capt. Pops (never heard back from)
    - Trevor Phillips-Levine?
- SMWDC
    - **Chris Barnes (tried, said he passed to front office)**
    - Gil Clark (Received no response)
- NPS/NWSI
    - Jeff Kline
        - **Discuss course adoption potential**
    - Jeff Appleget
- NWDC
    - Matt Danehey
    - Tom Negus
- Ben Cipperly for CNO SAG
- Evan Montgomery for CSBA
- Marine Corps MCTOG
- CNA

Course Adoption Idea

- Ask Brett Friedman, he is teaching a course he designed for USMC Continuing Education Program
- Consider focus on pitching to "scholars" or elective curriculum, like SAWS, MAWS, ARPs, larger curriculum courses like standardized JMO may be harder to break into
    - Contacts on Force Dev Distro list
    - USNA
        - BJ Armstrong (ask in general for institutions…)
    - NPS
        - Ask folks for course adoption ideas for NPS Makalapa, short-run courses….
            - Kline
            - Hammerer
            - Phil Sawyer

Folks Consulted

- **Mie Augier on course adoption ideas**
    - Suggested it be turned into a course, and that there are intermediate steps and approvals that have to happen for a course to be created.
    - Suggested approaching professors of courses and pitching the material directly to them.
- **Jeff Kline on course adoption ideas**
    - Advised that it be included in a compendium of all the pieces.
    - Offered to send it to some folks and the Dudley Knox library.
    - Said NPS was not a PME institution and that it is mainly STEM degrees.
- **Brian Kerg on course adoption ideas**
    - Could propose a short 5-week course for continuing education programs. Brian offered to put me in touch with these folks.
    - Could build out a single guest lecture
    - Offer to do extracurriculars outside of normal instructional hours
    - Leverage my network to find specific instructors and approach them about sharing material with students and voluntary, after-hours opportunities
- **Ian Brown on course adoption ideas**
    - Suggested potential for an elective program, and that advanced research study programs are more feasible than standardized curriculum.
    - Suggested putting the idea in front of Krulak Center director.

- **Sam Tangredi on course adoption ideas (3/6)**
    - Says the series has Black Book potential (more so than HFFF) and could be leveraged in courses.
- **Frank Hoffman**
    - Said it wasn't of much use to the NDU curriculum and what they look at
- **James Fitzsimonds**
    - Recommended pitching it to JMO department since they are vast majority of student body
    - "We'll see this summer how we might incorporate it into my Halsey Alfa course."
    - From colleague of his at JMO: "We are folding portions of it into the reading for the next JMO SLC Course. ...unlike the other services, the Navy doesn't have any unclassified literature to tell the DMO story, which is why we are moving forward with the CIMSEC piece."
- **Kyle Cregge**
    - Said a SMWDC WTI recommended the content (currently published through Pt. 5 at the time of this writing), to the OPS Billet Specialty Training for 7th Fleet Ops, at the Surface Navy's Department Head school.
- **Milan Vego on course adoption ideas**
    - Says has shared the articles with faculty and students and a distro list of 100 contacts. Said some faculty will use the articles in teaching the junior section on naval tactics.
    - (Rubel said that the JMO course most go through at NWC is heavily focused on Milan's theoretical operational art work)
    - **Call with Milan 3/9/2023**
        - Students now are worse than in 1990, they don't read
        - NPS took tactics too far in the direction of science and equations
        - Suggests focus more on combined arms aspects of naval operations….things are too disjointed and siloed among the communities
        -

<u>People to Consider Asking</u>

- Randy Pugh
- Jon Hammerer
- UWDC
    - Joel Holwitt?
    - Joe Picinini
- SMWDC
    - Chris Barnes
    - Chip Swicker
    - Matt Hipple

Meta

Meta: In finalizing passes for all parts, apply framework of overconcentration, stretched thin, and distribution more deliberately and explicitly…….

Meta: Be mindful of Jon Solomon's helpful distinction between operating and operational concepts…..we are talking about DMO as an operating concept…..operational is more specific in context….

Meta: Careful where the desire for simplicity has yielded a staccato, halting style of expression and sentence/paragraph structure.

Meta: Reduce the use of the word "therefore" where applicable…

Meta/reflection: Conscious of how does this reach the deckplate, work with NPS, NWC, PACFLT, NWDCand SMWDC contacts…..retain consultants to help devise a plan for this? Swift, Yoshihara, McGrath, Bynum,

<u>Possibly done with…</u>

Meta: Do max wordcount test on Wordpress, see if it can handle 7,000 words max

Meta: Devise a scheme between weekly finalization and remaining content generation for when after series goes live

Meta: Update all Navy.mil addresses with the .mil and us.mail.mil pieces

Meta: Consider a composite third part in operational art, to keep the word count from getting too long….so assembling/aviation assembling….inventory/last ditch….patterns/sequencing in time……see how long the parts would be like this….

Consider putting the carrier part before the platforms part, so the latter immediately precedes the force structure part?

Meta: Delay posting to beyond first week of February to catch president's FY24 budget request for Part 2?

Meta: End of year, frontload refining on first 4-5 pieces, have days that focus on fleshing out sources and citations….more opportunity for refining passes because they do not have to be 3-hour minimum blocks

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Fresh Review Bookmark

New Subsection?

Overlap: chess analogy? **Chess analogy to go in the central tactic section…. It is less about the ranges of individual weapons through range rings, than it is about the extent of delivery density across a battlespace….how many weapons, and how many weapons of different types, can be combined, at what ranges…more range generally offers greater density of delivery because of greater potential of overlap?Take a serious look at Louis' graphics and consider how this could be augmented….**

What happens for smaller battles, the potential for broader aggregation? Don't go all in on major fleet actions, what about the future Guadalcanals? More risk of standalone fires from local forces in tighter seas? Political considerations of missiles flying over foreign airspace will limit aggregation, and waypointing to ensure missiles stay over international waters may not prove useful?

The temporary nature of aerial presence is what makes it an especially threatening and distributed form of on-call firepower. But it also makes aviation a more fleeting asset with an element of predictability, namely that planes often leave soon after they launch massed strikes. Compared to the more episodic nature of aviation's availability, the latent firepower posed by a warship has a far more enduring presence. A commander may find temporary relief in seeing a hostile bomber force remove itself from the battlespace after launching a salvo, but a warship can launch fires and then still remain a threat for further immediate action. Aviation's transience is both a blessing and a curse for preserving distribution…..transient presence versus stable presence and how that affects distribution…

A certain laydown of forces, a certain distribution or concentration of forces, offers a variety of options for massing fires and firing sequences…..

Possibly done with…

make some Nebulous graphics perhaps…use home-on-jam to depict convergence?...decoy stream salvo….decoy saturation salvo plus convergence via home-on-jam?

If the lead missile of a stream salvo is deceived by a false contact, then each consecutive missile has also been deceived in turn. (reconsider this for short-range decoys)

Because the highly redundant search pattern of a stream salvo mainly searches along one axis, it may only need to be deceived along one axis.

However, this may diminish the psychological effects of combining waypointing and saturation patterns to give targets the illusion of imminent destruction and prompt them to initiate wasteful last-ditch fires.

Between those two options, having a missile salvo expand into a saturation pattern in the terminal phase can be a more fuel and time efficient method for obscuring the origin of an attack rather than using waypointing a salvo across a non-linear flight path.

They are still a threat once deceived….how do you manage that, how do you keep them flying away….short-range decoys launched from ships may pull a missile slightly away from a warship in a local area, or visually obscure it, but that is no guarantee that an autonomous missile will not come back around and make another pass…..

How much of this is possible? LRASM maybe, but others? Advanced seekers and targeting logic should be expected to proliferate, complicating the threat….

(……...**how do you make a saturation salvo converge against a decoy then?**.... Broader front of saturation salvo, means broader front of potential deception….stream salvo only offers a narrow seeker cone, but also only a narrow cone of deception, limiting the directions it can be pulled in, but if the leading missiles get pulled into a false contact, then likely so will the whole of the salvo, so fewer directions they can be pulled in, but greater cost of failing deception…...)

..jamming is not just about downing the missiles, but preventing them from communicating critical tactical intelligence back to their broader combat networks.

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Definition Part

“Unless a proper definition of the strategic problem is arrived at, content-free concepts will continue to emerge.”

Jon Solomon’s preserving preponderance of forces point…..work it in there with a minor mention somehow…..

Distributed forces can still be integrated units that directly support one another, rather than coordinated units that take their own lane and are mutually reinforcing, but not directly supporting….

are something to be flexed according to operational necessity

Distribution….limit the amount of damage that can be done in one attack

Possibly done with…

They have enough missiles to kill a ship if they really want it dead….the question, what is stopping them from firing….Lack of targeting information, lack of inventory, the operational dilemmas posed by the wider disposition and composition of the force…..

Definition: …what is the basic kernel narrative here about what is happening and why? DMO is partly a reaction, and partly an evolution, trying to solve what?

Maybe put in carrier air defense…?Mutual missile defense at sea can also yield a naval equivalent of a “danger close” situation. These defensive engagements could feature a minimum engagement range or time, the latest point a defensive weapon can be fired at a missile attacking a friendly warship without endangering that warship in the process. Otherwise, an anti-air missile fired too late could end up looking to intercept its target by penetrating into the hull of the friendly warship. **(last part is unclear)**

Definition: A distributed fleet…..picture of a fleet formation……..in the fleet definitions section…. From CNO: " we moved away from fighting just as singular ARGs, as singular strike groups, to fighting as a fleet under a fleet commander as the lead…"

Definition?: concept is how you like to fight in the future, or how you will fight today? .Many orgs think they originated the concept, when really there has been a common convergence toward a roughly similar approach to warfighting, the distributed approach…….

State that the piece assumes that ducting is constant….radar horizon is constant…

Definitions: stealth and distribution, what does it mean for them to know what is there….deception and distribution, false contacts

Overwhelming definition section?: But salvos that attempt to overwhelm via a narrow margin of overmatch are more likely to fail. You compensate for uncertainty by launching an even greater volume of fire than what would be the most efficient volume to kill a target…..

Definition intro: Not just a Navy series, all the services are now getting into the business of sinking warships, and need to develop the tactical know….

Definition: Hider-finder competition…making individual units harder to find, and once found, harder to ascertain if they are worth striking……

What problem is distribution trying to solve? What problem is mass fires trying to solve? How do we frame the fundamental problem? (Achieve overwhelming volume, while spreading depletion more broadly….among other effects….you are facing an enemy that can mass superior volume of fire….you distribute to complicate things for him….

What is the theory of victory undergirding DMO and massed fires?

Radar Horizon Dynamic

The limits of a surface-borne air defense umbrella are much smaller in actuality because of the radar horizon limitation, the flight profile of sea-skimming missiles, and the fire-first advantage of anti-ship missiles.

The tactical effects of sea-skimming salvos and the radar horizon can combine to make the effective zone of air defense only a mere 15 or so miles from warships. Most of the range of the fleet's mainstay air defense weapons and radars would hardly be useful in defensive engagements taking place so close to ships. The extensive range of these sensors and anti-air weapons can give a false sense of security if the major constraints imposed by the radar horizon are not respected. Against long-range missiles with sea-skimming flight profiles, much if not most surface fleet air defense will be local air defense by nature.

The more attackers can keep their offensive salvos flying at a sea-skimming flight profile, the greater they will be able to defeat ships in detail. Even ships in a surface action group or strike group may not concentrate close enough together to be able to provide mutual anti-air support within the tight confines a radar horizon-constrained, local area defense engagement.

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Assembling Fires Part

If both sides are distributed at the macro level, then at the tactical level does that then look like more traditional formation vs. formation or ship vs. ship, only at missile range?

Max flight time represents the earliest a weapon can join a firing sequence…

Framework of aggregation….is this infused throughout (yes currently), or do I need a central guide/section/graphic to lay this out….I don't have the wordcount for a central section?

Change time-to-strike to flight time where it makes sense. Time to strike is a different metric than missile flight time. Also change "time-to-strike" to "time-to-target"

When combining missiles of various speeds, the speed of the faster missile can remove range as a limiting factor for aggregation. Only time-to-target needs to overlap.

Land-based ASBM missile flight times: Around ten minutes, **(source, source, source, source)**

Tomahawks will not be good for interruptive fires, they will be good for firing first…..what can be done for interruptive fires? SM-6? Hypersonics? You need a low time to strike weapon…..

Possibly done with…

What are the drawbacks of *not* being able to mass anti-ship fires?...fracture…munitions expenditure concerns ....inefficiencies and not preserving high-end inventory as well…A force that cannot mass fires from distributed forces will have to rely more heavily on massing fires from individual force concentrations and units…..effect of individual-level depletion threatening broader distribution…..lightly-armed forces and smaller force packages can be more safely ignored by the adversary, knowing that their smaller-scale standalone fires can be easily defeated by strong air defenses…

What is the relationship between time-to-strike of weapons, and aviation's need for preparatory maneuver….

[Graphic: Ship-launched tomahawk, B-52 position, B-1 position, F-18 position, for the time factors to overlap. Assume B-1 and F-18 use max speed]

A framework is required for understanding the aggregation potential of missiles. The range and speed of missiles combine to form varying degrees of aggregation potential. Attempting to combine different missiles into aggregated salvos will pose challenges but also tactical benefits.

What happens if forces cannot combine but fire piecemeal sequentially….worst that will happen is what? Inefficiency? But what if softkill measures can take a good chunk out if a salvo at zero cost to inventory of the defender? Need more overwhelming mass…..

The time-to-strike is how long it takes a missile to reach a target from its launch point. The maximum time-to-strike is how long it takes a missile to travel the full limit of its range.

The time-to-strike of a weapon must be understood in the context of its range. A weapon that takes ten minutes to strike a target….

Low Time-to-Strike

- Pros
  - Preserves distribution during massed fires
  - Speeds decision cycle
- Cons
  - Often launches later in firing sequence
  - More opportunity to be preemptively targeted
  - Missiles tend to be more expensive and fewer in quantity

High time to strike preserves distribution if it is long range. Low tim

Sequencing: What does time to strike mean in the context of aggregation? (disadvantages of more time-to-strike/flight time, more early warning for adversary, more time means more opportunity for an adversary to maneuver aviation to thin the salvo… more potential scope of preemption for everyone else who is friendly…more opportunity for last ditch salvos to be fired and enhanced with better targeting information…but a lot of this means an adversary needs quality long range

awareness across a broad ocean space…...[advantages? First to fire, so you are less to be preempted once a salvo is set in motion, you are often doing the initiating, more time means more ability to be aggregated with….) ….

more time and longer range enhance aggregation potential….

….long range and low-time-to strike is extremely fast, like hypersonic/ASBM…..what are the benefits of those? [USAF hypersonic 1,000 miles 10-12 mins]
They can be ready to contribute to any other salvo, and are so powerful and fast that they are less dependent on other missile types for building an overwhelming volume of fire….

Hypersonic glide vehicle bleeds off energy and speed on way to the target….changing its time-to-strike dynamically…..

Table: High time-to-target, high-speed: Extremely long range. Low time-to-target, low-speed…..very short range. Low time to target, high speed: Moderate range. Low time to target, very high speed: Long range.

Speed	**Range**	**Maximum Flight Time**	**Example Weapon**
Moderate (subsonic)	Very High (1,000 miles+)	Very High (120 mins)	Tomahawk
Very high (Mach 5+)	Very high	Very low (10-12 mins)	Hypersonic/Ballistic Missile
High (Mach 3+)	Moderate (150-250 miles)	Very low (4 mins)	SM-6

- Low time-to-target and moderate-to-low range makes for very little aggregation and waypointing potential. (SM-6)
  - Low time-to-target is a feature of both fast weapons and short-range weapons.
  - High time to target is a feature of weapons with long range and moderate speed (subsonic)
  - Low-time to target plus long-range allows for more options in preempting aggregation….but also they themselves can be preempted….
- High time-to-target is compensated for by range. Increases waypointing and aggregation potential, but can give an adversary much more early warning.
- Long range or high time-to-target enhance aggregation potential.

- Low time-to-target's poor aggregation potential can be compensated by having very long range (ASBM/Hypersonics)
    - Low time-to-target reduces potential for waypointing tactics.
- (Retargeting section's paragraph on Tomahawk waypointing….)
- Short range and high-time-to strike is an especially slow missile

low time to strike but long range means you will be less susceptible to preemption]....low time to strike allows the salvo to grow less predictably….less time for retargeting support, for aviation to maneuver after launch…..

The possible dispositions of a distributed force will be heavily affected by the speed and ranges of the weapons that can be combined into massed fires. Certain dispositions can rule out the ability to use certain weapons and platforms in aggregated fires, while other dispositions can ensure every weapon has some potential for aggregation even if it incurs risk. (**unsure)**

How does aviation affect distribution:

For many situations, having aviation or bombers on call hours away will not suffice for the timely aggregation of anti-ship fires. A Maritime Strike Tomahawk flying to the limits of its range could take a little less than two hours.

This example is fairly linear, and clearly there are many vectors and lines of approach bombers could take to contribute to such an aggregated salvo.

[Graphic of overlap….the threshold….SM-6 and Tomahawk overlap map range ring…]

[Nebulous video animations]

- **Include a couple lines to introduce the animations. They represent how various types of aggregated U.S. anti-ship missile salvos could look. The distances and weapons ranges are not precise and are only meant to give a sense of how these salvos may look.**
- **Tomahawk and Harpoon aggregation…..the waiting**
- **same time fire and same time strike**
- **State what each animation resembles…. E.g. Similar to Harpoon and SM-6….. ("LRASM and MST" . Distances are not precisely representative.**

The speed of these weapons is not so expansive and flexible that they can compensate for the great disparities in range. If the Maritime Strike Tomahawk was a supersonic weapon,

To effectively contribute to such a salvo for overlapping effects, the warships would have to fire the weapons as aviation crosses the line of departure for its own launch.

Long range does not guarantee long time to strike. Short-range does not guarantee short time to strike, but usually does.

Pros/cons of longer time to strike: more opportunity for aggregation, but more opportunity for preempting contributing fires.

Shorter time to strike: less opportunity for aggregation, less opportunity for getting preempted.

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China DMO Part:

Even if U.S. forces can reach this 1,000 mile ring from land-based targets, those standoff fires may need to be strongly supported by aviation on the way to their targets. Otherwise there will be plenty of opportunity for copious amounts of PLA aviation to attrit the salvos while they transit to their targets.

If the U.S. can effectively contesting the airspace around the archipelagos that flank Taiwan – mainly the Ryukyus and Batanes – China's ability to apply airpower against U.S. salvos traveling over the Philippine Sea will be severely limited. If the stand-in forces occupying these island chains are lacking the anti-air weapons that can reach high altitudes, then they may be limited to passing early warning information to other forces.

...most of the mainstay PLA Navy anti-ship missile can be fired from beyond the range of U.S. air defenses……sending large ships beyond 1,000 miles would also make it more challenging for frigates (?) and corvettes to keep up logistically, and bolster the ASW and AAW capabilities of the SAGs….if both sides suffer depletion of AAW and ASUW respectively….the Chinese ships would have to retreat, but Americans would have the option of Advancing, but as a more concentrated force, more dependent on carrier air and the carrier as the deepest remaining magazine…..while China still retains air and land-based options for massing fires…..PLA surface fleet concentrated inside of 300 miles around a target, about the range of an E-2 Hawkeye radar…if one force has to concentrate to mass its firepower more so than the others, what does that imply?.... 1,000 miles for MST-equipped warships, much more able to use the waypointing tactics to feint, while China has little ability to do the same. Not only are they outranged, but there is ample room to employ waypointing tactics to feint attacks and trigger wasteful last-ditch salvos…..but if Harpoon equipped, or NSM-equipped ships have to face off against YJ-18s, then the situation is reversed….)...……..caveat on closed seas, and also many major naval battles have been directly triggered by key land-based events that commanders seek to influence with seapower, which can limit the geographic space of naval maneuver…….. Set the 1,000 mile mark a few hundred miles further behind to give the aircraft more combat radius….

….it's one firing sequence against another, one scheme of distribution and massed fires against another….

Many range rings come from a fixed point in central China, which can understate how far coastal units can reach into maritime depths, and also doesn't effectively account for how the basing of land-based firepower is distributed across the mainland…..bases for land-based aviation, and ballistic missile forces…..Louis CIG's graphics?

U.S. versus China DMO: what are the critical interactions, moves, and counters….how does DMO fit with their respective ways of war…..how does DMO apply strength to weakness…….U.S advantages/disadvantages and China's advantages/disadvantages, applying these against each other…..this is an attrition focused concept of massed fires, where is the maneuver to this?......What kind of reactions and counters does this provoke, what is the counter strategy, what is the "two steps ahead?"..........how does this shape behavior, affect options, perceptions, and decision-making…...how do you put them in an untenable position so they do what you want, without making attrition the central focus?....what targets should mass fires prioritize?......attacks against land-based naval and port infrastructure (U.S. own style of systems destruction warfare, destroying the ability to fight…critical enablers…..this is even worse than blockading, rather than spreading yourself thin all over the place catching merchant ships, attacking where they are offloaded…..)….important asymmetry… would play to their high sensitivities…..a country whose naval forces and ports would be defeated would contain eerie resemblance to British defeats inflicted through the Opium wars (check this)....attacks against this infrastructure is more than just military value or escalatory value, but a direct challenge on the Chinese effort for national rejuvenation and threatening a repeat of national humiliation (play with this, how does the narrative of humiliation and rejuvenation translate into military-operational sensitivities….nationalism….Party sensitivities to control…tie down forces by showing a willingness to strike such targets, a fleet-in-being type of concept…..a critical asymmetry, but could endanger the ports and bases of regional allies)....at stake for the U.S. is rules-based order….submarine force may also be the only survivable way to deliver aid or infiltrate/exfiltrate people from the island…..striking Taiwan which is considered Chinese territory can open up strikes against U.S. territory and allies……an expeditionary naval force that is predominantly arrayed for massing firepower against forces enforcing a Taiwan blockade (as depicted in these graphics)...is not a fleet that is well-postured to defend the maritime approaches of various allies against missile attack…..broadening the conflict may dilute distribution to the point of being stretched thin, if U.S. forces have to be on hand to defend U.S. allies…..having very long-range weapons could allow U.S. forces to still fire from peripheral allied territory while providing air defense to that territory…..attacking the Philippines for example would bring in a U.S. ally that could create substantial demands for defense while offering relatively little added combat power from Fillipine units, but the terrain could be helpful for launching fires, e.g. fjords (do a range ring for those fires)….. U.S. naval forces can also be tied down by protecting allied land objectives, which limits their freedom of maneuver substantially……U.S. DDG forces could be stretched thin by the needs to cover maritime approaches, ASW needs, having long range weapons would allow them to perform these missions while also being on hand to contribute to massed fires…..systems destruction warfare making systems not work: C2 degradation, logistics degradation, ability to surge and mass, expending missile interceptors, carriers and air wings, political support, ability to coordinate strikes…..Maybe U.S. is counting on submarines sinking the PLA Navy's best air defense warships to pave the way for carrier strikes……..what are the allied dimensions?......disproportionately sensitive to casualties, because the stretched thin nature of the U.S. Navy to serve existing peacetime interests, PLA Navy can afford to lose more ships because they do not maintain consistent and extensive far flung deployments…have a section for advantages and disadvantages, or spread it throughout? What are the trends in advantage and disadvantage….estimates of weapons expenditures and inventory depletion in the scenario…open with a narrative of the interactive competition…..assumptions include China has large surface combatants to match U.S. large combatants, hypersonics are more common and widely fielded, U.S. naval force structure is largely unchanged, although frigates and BlockV Virginia class are available in low numbers, the most core assumptions in terms of force structure is that the F-35 is commonplace across carrier air wings, and MST is commonplace across the surface and undersea forces…..what is the systems destruction concept of how the U.S. would apply this? The pain points to prioritize, rather than just attrition…….active defense can involve luring the enemy in to then create favorable circumstances for attacks and counterattacks, the A2/AD range rings sometimes give the impression that those A2/AD forces will attempt to keep the enemy out at all costs near the limits of the range of weapons, which is "rigid defense" (cite german generals net assessment concept)….China will need to protect maritime approaches to Hainan Island and Beijing, secondary theaters to Taiwan, splits their Navy…..how many missiles would the U.S. have by 2035, maybe 1,500 or enough to fill how many DDGs and last how many engagements?

U.S.-China DMO, or a separate part?: How do Human factors manifest in these DMO fights: Courage, boldness, fear, foolhardiness, will to fight…..war is a human endeavor, and we cannot view the optimization of massed fires as a clinical act that is devoid from human factors…..how does DMO target the will to fight….as these missiles fly, we must consider the pressures that may be brought to bear on people at the unit level and at the commander level….the shock factor of seeing a CSG go under a salvo….12 billion dollars of capability gone…..that would be 2,000 tanks? There is no parallel….the extraordinary concentrated nature of naval capability….escalation management…..in an environment where forces are firing first, firing many, and only minutes to live or die……once everyone is revealed and emitting, things escalate and the chips fall where they may?

China DMO: …division of labor between forces directly involved in the invasion, and substantial covering forces meant to deter and interdict outside intervening forces, the fleet-in-being posed by the

USN creates the need for substantial Chinese covering forces for the distance, calculate the average combat range of china's land-based aviation that is modern….. this is not just about what the U.S. Navy can do, but what can be done to the U.S. Navy by its adversaries. China especially….from whose perspective does this tactic undermine their strategy and their way of war? U.S. or China? The U.S. can strike at China's critical home infrastructure with these tactics if applied to land-attack….near-term risk versus long-term risk…. "Davidson Window"......how do these capabilities and tactics factor into slowing each other's mobilization…..ASCMs targeting shipping supporting an invasion would have to be fired in significant volumes to overcome considerable air defenses and to not be effectively diluted by so many ships, overflight of Taiwan itself versus waypoint flights approaching the strait from elsewhere…….Chinese are putting ASBMs on bombers and warships…..frigates and corvettes could go further afield in secondary theaters but logistical concerns keep those legs short….their ships blockading Taiwan may be spared from having LACM in their magazines and focus a greater proportion of their loadouts on dealing with air and naval threats……the effects of the division of labor across joint forces and what this means for the Chinese naval missile loadouts, and what asymmetries may develop relative to the loadouts of U.S. forces…..will they be tied down by being fixed to a land objective? Or will they be employing active defense in the Philippine Sea?...... …..the risk……"luring the enemy in deep" as a method of exposing supply lines, don't allow enemy to fire from standoff ranges, carrier example of having to split the air wing's capability…..letting forces getting in close enough to use offensive firepower, get them deeper within your WEZ…..more opportunity to put fires on them…..you're not always firing to the edge of your range….relative strength versus relative weakness in US vs China?

Shipping Lanes: taking advantage of shipping lanes to conceal distributed forces? Keeping far out would probably betray forces….having to maintaining a degree of overlap for aggregating fires may also do the same…….Chinese declare exclusion zones…..freedom of navigation helps conceal forces among shipping…..if shipping changes its routes, it could deprive ships of cover…..cool graphic…..https://ciltinternational.org/news/the-strength-of-sri-lankan-shipping/global-shipping-heat-map/

Challenges of protecting SLOCs and maritime trade in this environment? Escort missions, secondary theaters?

2035: Navy hypersonics….mostly fielded in a couple Zumwalts, and Virginia VPMs that won't be in the force in significant numbers until probably the 2040s……

China perspective of the first and second island chain

Probably done with….

Firing effectively first via longer range: If China's surface forces are significantly outranged by U.S. forces, and if U.S. forces can effectively target their longer-ranged weapons to the limits of their reach, then China's ability to leverage surface forces in mass firings will be heavily challenged. Because platforms such as land-based forces, bombers, submarines, and multi-role aircraft cannot be threatened by anti-ship missiles, they are not subject to some of the dynamics of firing effectively first that are exclusive to this weapon type. Instead, the ability of these platforms' to gain proximity to opposing warships can be a function of weapons that have far less range than anti-ship weapons, such anti-air missiles or torpedoes. This can afford them plenty of opportunity to fire effectively first even if their anti-ship weapons have far less range than those of their target warship. When surface forces are steeply outranged by the opposing surface forces, the resulting mass firing scheme can be forced to lean more heavily on aviation, undersea, and land-based forces to contribute fires. Each of these platform types faces some combination of challenges in endurance and platform magazine depth that are the strong suits of large surface warships.

But the desire to maintain a maritime buffer against large volumes of land-attack fires simplifies the search challenge for the attacking force, where they may expect to encounter some sort of resistance in the general vicinity of their launch areas. The buffering force by comparison would require extensive early warning to have a chance of preempting those land-attack fires, and especially to have enough time to stealthily pre-position surface forces so they may be able to offer timely contributing fires.

The PLA could have a strong incentive to place its warships in areas that provoke anti-ship Tomahawk fires under favorable conditions. If future variants of Tomahawk feature both land-attack and anti-ship capability, then every Tomahawk that can get deflected toward anti-ship strikes is one less Tomahawk that could be fired toward Taiwan or the Chinese mainland. **(source Block V capability)** By using warships to draw Tomahawk fire, China could use a combination of air and naval defensive fires to diminish the Tomahawk inventory and preserve its land-based assets and objectives. While this could come at substantial risk to China's warships, the benefits of potentially absorbing hundreds of Tomahawks could be a valuable tradeoff in the eyes of China's decisionmakers.

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If it becomes challenging to sustain land-based multi-role aircraft at a long distance from the Chinese mainland, then bombers, land-based missiles, and surface warships can still work together to maintain a more enduring set of options for massing fires.

By mounting a maritime defense that attempts to put expeditionary surface forces beyond the range of launching standoff fires against land targets, the defending surface forces could put themselves in the crosshairs of standoff fires…..If PLA Navy warships attempt to contest the maritime approaches 1,000 miles away from China, then those warships could be fired upon 1,500 miles away by approaching U.S. warships, which would be too far away for the PLA warships to threaten. **(Too static a concept?)**

It is unclear how far forward the PLA surface forces can confidently operate in such a scheme, especially without carrier aviation. It is especially difficult to maintain a maritime buffer against land-attack fires when the opposing naval force fields anti-ship missiles that substantially outranges the capability of the buffering forces. There may be no range at which a buffering surface force can forestall land-attack fires without risking itself against anti-ship fires.

The graphic below illustrates this relationship. The red ring centered on Taiwan illustrates the area from which U.S. surface forces could strike the island with Tomahawk. The blue ring illustrates how far PLA surface forces can strike with YJ-18, if they are stationed along the red ring to provide a buffer against U.S. forces. The yellow ring illustrates the area where U.S. forces can fire upon PLA surface forces stationed along the red ring by using Tomahawk. The disparity between the blue and yellow rings highlights the standoff advantage an anti-ship Tomahawk offers over YJ-18.

(Three-ring buffer graphic.)

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Force Development Part

Next Steps

- New section on certs, schoolhouses, etc….
    - Finalize paragraph on content/character
- First and last paragraph of Series Conclusion
- Make sure it is not just "Navy," but U.S. Navy, don't be too U.S.-centric
- **Major Sections**
    - **Intro**
    - **Certs/Schoolhouses/etc…**
        - Change not just the content, but the character…
        - (Similar to interwar NWC….)
        - Use wargaming and simulation….like the NWC games where everyone got to play as fleet commander….learning by doing…..
        - It is not about being good on the first try…..we are measuring how well people learn, and for that you need to organize things as series and multiple attempts….

Intro/Conclusion….

Even if the concepts do make practical sense, that does not guarantee it is attainable for the U.S. Navy. Navy is severely challenged in its force development, from this to that to this, the Navy is…suffocating requirements, chronically guarantee victory and deliberately enfeeble the opposition force, exercises, poor cross community integration siloed tactical development…..the force development shortfalls of the U.S. Navy are numerous, widespread, and deep-seated….(Too angry?   Too at wit's end….Probably….)

….If the Navy is unable or unwilling to undergo serious reform to its force development, then it could consider pursuing a less ambitious concept.

As it stands today, the true realization of DMO for high end warfighting is fundamentally incompatible with many norms of the U.S. Navy's force development. Hopefully DMO can provide the impetus for change.

Poor force development blocks the path toward meaningful change rather than facilitates it….

Its okay to exercise and train with notional capability, the Navy needs to hit the ground running…

Conclusion

Heavily kinetic focus….massed fires is just one piece of DMO, and this series has had a heavy kinetic focus…

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Learn how the schemes of massing fires will change if….offensive/defensive balance trends in a certain way….

New standardized force packages can set new baselines of capability, such as magazine depth for massed fires.

Massing fires…..too rigid? What are ships to do when their organic sensors cannot find targets? What are aircraft to do when they can find warships but cannot muster enough volume of fire? Default to finding each other, one for information, the other for missile capacity….

Much of the act of massing fires today remains highly conceptual, only an experiment in its infancy. And massing fires is only one part of DMO.

Existing norms of force generation and demand signals may make it impossible to leverage these force packages in peacetime operations….but they can offer a frame of reference of what formations the Navy would yield if it has to surge forces in a major crisis….wargaming

Series Conclusion and Ending caveats

- A tactical deficit can quickly escalate into a strategic liability, and this is especially true for navies, as Wayne Hughes emphasized….it is the logic that governs how fleets are destroyed….
- Ending paragraph with a quote from Clausewitz

- “What we say in fact is this…the tactical results of the engagement are assumed to be the basis of all strategic plans…He will endeavor above all to be tactically superior, in order to upset the enemy's strategic planning….[strategic planning] therefore, can never be considered as something independent: it can only become valid when one has reason to be confident of tactical success…That is why we think it is useful to emphasize that all strategic planning rests on tactical success alone, and that - whether the solution is arrived at in battle or not - this is in all cases the actual fundamental basis for the decision.” – Carl Von Clausewitz
- “In peacetime, every strategist must know the true combat worth of his navy, as compared to the enemy, or he risks deep humiliation with or without bloodshed…In wartime, every strategist must know the relative fighting value of his navy – so carefully nurtured and expensive to build and maintain in peacetime. When committed in battle, the heart of a fleet can be cut out in an afternoon.”- Hughes
-

Possibly Done With….

Personnel who repeatedly fail to demonstrate tactical improvement in warfighting crucibles, should be designated for early retirement….don’t script things since you will want to weed these people out in peacetime, rather than be like the submarine force that was forced to engage in the highly disruptive practice of firing dozens of submarine captains because of their incompetence, disruptive in wartime…..

….Despite public declarations, the modern U.S. Navy's ability to execute this tactic [of aggregated] fires is virtually nonexistent. It will not be able to effectively execute it until perhaps the next decade when modern anti-ship missiles are fielded in significant enough numbers to make the tactic viable. But that does not mean that forces should wait for mass numbers of new weapons before reforming their force development. The history of force development has examples of militaries, including navies, conducting robust tactical reform for critical new capabilities that are on the way. (Hank Mustin source, German military tank source)

The Navy is also in the unique position of being perhaps the only service that receives very little in the way of ready forces for the purposes of its force development agenda. For the other services, hundreds of aircraft go through the Air Force’s Red Flag exercises, and a third of the Army’s active duty brigades rotate through its National Training Center annually (**source).** By comparison, almost as soon as naval forces are finished with maintenance and are certified ready for high-end operations, they are turned over to the operational command structure. This has deprived the Navy of much of the capacity to conduct major series of large-scale exercises for force development, which are necessary to conduct enough rounds of trial and error at sea. The relentless churn of the next inevitable deployment has also pressurized much of the Navy's train/man/equip functions into structures that heavily optimize efficiency at the expense of effectiveness, which is hardly ideal for the more open-ended structures that are needed to experiment with novel warfighting methods.

This points to a broader theme that must characterize how the Navy practices and experiments with these warfighting methods. A massed firing sequence can be a highly exquisite operation, with numerous points of failure and interlocking dependencies across kill chains. Heavily scripted events that ensure seamless execution by removing a variety of frictions will make for brittle warfighting methods in real combat.

The many kill chains that encompass a massed firing sequence offer critical points of failure that must be reinforced and harmonized across different weapons, platforms, communities, services, and allies. The trial and error that must accompany the concept's experimentation should target the critical enablers a massed firing sequence depends on. From network reliability to warhead seeker discrimination, to heavy jamming and electronic deception, these dependencies must be thoroughly investigated as major sources of friction that can potentially derail a massed firing sequence. Critical enablers cannot be assumed to function well all the time. A keen adversary would know to target these enablers, understanding that they are critical pivot points for combining broader capability. By rigorously probing and interfering with its own critical enablers, the Navy will gain valuable insight into how to do so against its adversaries and disrupt their own massed fires.

….

Refining Critical Missile Behaviors and the Role of Aviation (Read this and consider cancelling it in favor of more important force development lines of effort)

An anti-ship salvo that can self-organize into a saturation pattern just before it breaks over the horizon of a target warship will pose a daunting threat. An aviator that knows how to quickly issue retargeting and waypointing instructions to a friendly salvo will be a significant force multiplier. An electronic attack aircraft that can effectively jam a salvo into the ocean without firing a shot will preserve copious amounts of munitions inventory. An anti-ship missile salvo that employs a variety of pop-up maneuvers to scout and confirm targets while triggering last-ditch fires can pose an amplified threat.

Mastering many of the tactics of massed fires depends upon an in-depth understanding of anti-ship missiles and their complex behaviors. Modern anti-ship missiles are intelligent kamikazes, able to execute a variety of activities and decision-making through autonomy and networking. **(LRASM source)** These specific autonomous behaviors constitute much of the lethality at the tip of the spear of modern naval capability, and are deserving of extensive force development. Competing navies will continuously work to improve their ability to interfere with the targeting logic of their competitors' missiles while making their own missiles highly resistant to such interference. Warfighters must understand the behavior of these missiles if they are to counter them or configure them for the greatest lethality. But the potential offered by these methods can only be unlocked through extensive and rigorous force development.

How well do missiles network their behaviors within a salvo and between multiple salvos? How well can an LRASM salvo autonomously network with a Tomahawk salvo to combine fires? How do these weapons behave to enhance their survivability once they have been illuminated by the adversary's sensors? **(unsure about this paragraph)** These kinds of tactical dynamics can make or break a salvo's success, and will mark a key area of focused force development.

The enhancement of missile capability must be focused on achieving particular tactical advantages. It can still take only one anti-air weapon to shoot down an allegedly smart missile compared to a less-smart missile. Improving missile capability could therefore focus on achieving better penetrative performance, and better networking and autonomy. The former will allow missiles to better defeat the many layers of warship air defenses, and potentially earn with more efficient volume of fire.

Autonomy and networking can work to generate and preserve the volume of fire. Missiles that can effectively communicate within a salvo and between salvos can better collect themselves into a coherent mass of fire. They could self-organize into lethal attack patterns for the terminal phase, or work together to search a maritime expanse by networking their seekers into various search patterns. A missile's multi-modal seeker can help discriminate true targets from decoys, use networking to communicate this to the broader salvo, and prevent a wasteful loss of firepower. A missile that is trailing the mass of fires could relay critical battle damage assessment information back to the network as an engagement unfolds before its mechanical eyes. By witnessing the fate of the salvo in front of it, such a missile could relay the critical insight of whether the target was destroyed, or how the vast majority of the salvo was shot down without affecting the target.

The smarter the missiles are, the less they will depend upon non-organic assets to relay critical information. Many of the air wing's information-centric roles described in Part (X) could be delegated down to missiles if the weapons are intelligent enough to perform some of these functions themselves. Therefore the survivability of the air wing grows alongside the refinement of missile autonomy and networking. Smarter missiles will lessen the need for valuable aircraft to sortie deeper into the contested battlespace to provide critical enabling information to salvos.

But this dependency on the air wing may prove uneven across different missiles and the differing sophistication of their autonomy and networking. The more common and less sophisticated missiles may act as a sort of lowest common denominator that forces the hand of aviation. Aircraft may be forced to sortie deep into the battlespace to enable a part of the salvo that constitutes a major portion of the overall volume of fire. An LRASM salvo may need much less information support from aviation than a Tomahawk salvo. But if an LRASM and Tomahawk salvo are looking to combine into massed fires, aviation may need to assume more risk to ensure the Tomahawk salvo can effectively contribute. Therefore it would be critical to harmonize the networking and autonomy functions of different missile types that may combine together into massed fires.

The proposed concepts of operation demand significant force development on the part of the aviation community. The E-2 and F-35 communities in particular will need extensive trial and error so they can quarterback massed firing sequences. An F-35 could simultaneously be issuing retargeting information to waypoint a friendly missile salvo, defending itself from aerial interdiction, while relaying information about the last-ditch firing sequence of its target warship, and other functions. The extensive sensor fusion and autonomy of the F-35 clearly makes it an excellent candidate for executing some of the most critical enabling functions of modern naval salvo warfare. But unlocking this potential will demand extensive force development for pilots to master these roles and work out the many details of managing contested kill chains in real time.

DMO…..is it built on some kind of assumption of how the enemy will fight? Or is it a more fulsome paradigm that can endure across contexts?

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Force Structure Part

Steps

- **Optimization/distribution of fire concern,** if you are so tightly concentrated that a salvo can optimize itself across your forces….the radar horizon dynamic concentrates forces in this way, that naval forces that are operating as part of a force package often remain within a horizon view of one another to ensure some mutual defense…..how far do warships have to spread out so a single salvo can only kill one ship at a time compared to the whole formation? It's a core goal of distribution in warfighting, in that if hits are taken, the losses are minimized….. the ability of missiles to search and optimize fire across the breadth of their seekers would stretch warships thin as they diminish their mutual defensive capacity for the sake of minimizing the losses that could be incurred….the fear of greater destruction drives units so far apart that they are deprived

> of one another's mutual support….where superior ability to concentrate firepower stretches forces thin….radar horizon does this regardless, but with respect to offensive firepower, a warship with a short-ranged weapon could be displaced beyond the 100 or so miles it would need to be within of friendlies….remind of the point, when you're taking a hit, you're not just getting hit once….does the distribution of the firing package exceed the ability of a volume of fire to search and optimize targets on its own….is this even what I'm trying to get at, with the distribution of fire question? A salvo may not be directed toward a specific target, but a specific area where it can find targets…..

A key defensive goal of distribution is to minimize losses if hits are taken. A key offensive goal is to compel targets to distribute so far from one another that they stretch themselves beyond the range of mutual support as they attempt to minimize the potential attrition…..the desire to minimize attrition is made to outweigh mutual support… When deciding a distribution of firepower across the force structure of an adversary, a commander has to consider what forces have their dispositions bound by the need to have options for combining fires with one another. This need is a key factor of mutual support that limits how far forces can distribute from one another, and the distribution offered by the range of their offensive weapons can be great enough that the various contributors to a firing scheme cannot all be threatened by an individual volume of fire……

Large combatants receive a larger share of firepower….small combatants receive a lower share…

As a salvo distributes itself across contacts within a shared field of fire….would that cause the salvo to stretch thin? Would the defenders operate at a better efficiency of defensive fire? A salvo that has to divide itself among more or less ships……..

can you pull apart a mass firing scheme by prioritizing certain platform targets? How do you get targets to stretch beyond mutual support through selective fires? By targeting specific groups of forces with targeted groups of salvos? There is still some sort of force package dynamic? Although it is much harder to ascertain that when there are many, and when they all field long-range weapons, and the distributions are so far apart……work from the inward and go outward…..create a belief that your ability to target fires is best near a given area, and then work outward to push distributed forces beyond their ability to support?.....you can't achieve stretching with a single volume of fire, but by establishing a pattern of a field of fire…..distribution and its relationship to suppression…..if you get them to stretch thin beyond support, make them afraid to emit or fire, is that suppression?

The factors that bind the distribution of a force go beyond hull counts, and include things such as weapons range, inventory depletion, and combined arms relationships. Simply building more ships may not improve distribution unless the new hulls are equipped to further expand a functional design of applying naval power.

Distribution of fire, what do you decide to shoot first? Small or large?

Warships that are operating as part of a force package would have to maintain themselves within a horizon view of one another to provide mutual defense against sea-skimming salvos. If those salvos strike home, the concentration of warships is tight enough that all members of the force package could be destroyed. If warships are to separate themselves to a distance that they would not be destroyed by the same volume of fire, they would easily be deprived of the ability to offer mutual defense. However, capability trends may one day yield the ability for a single volume of fire to threaten warships that are fixed to provide mutual offense, which can occur at much greater distances than mutual defense in naval salvo combat.

- Read Saved but unsorted takeaways in the main doc and in this doc, and consider what is worth including, and be very very sparing.
- Consider highlighted sections from this doc into main Doc.
- Three refining passes.
- Upload, add sources.
- Refining passes until conclusion.

- Read
  - Jeff Kline recommended NPS study on distributed force structure
  - HFFF Pt. 7
  - Hudson/CSBA force structure studies
  - Force structure perspectives series
  - FDMO Pt. 6
- Read DMO google doc thoughts for this part

<u>Thoughts Sorted</u>

Conceptual framework: Have some sort of conceptual framework for relating fleets, force packages, platforms, payloads, and salvos and formations to DMO…..how does this platform, this force package, contribute to massed fires? How does it enhance distribution? What force structure is the ideal manifestation of DMO? What does it mean to be well-rounded?

- **Combined Arms relationships.** Apply that set of criteria that was generated for the various platform types, and consider how they may come together to reinforce one another and cover for one another's weaknesses, to focus on a specific kind of leverage, for combined arms relationships…
- **Inventory/Payloads.** Information advantage may mean little if it cannot be capitalized on with firepower…..

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Regenerative and risk-worthy…. Small combatants can be built a lot quicker, can be risked a lot easier, if they do offer an edge relative to bigger platforms…unless they can be taken out en masse….**If you lose a naval war, will a fleet have to wait 30 years to rebuild its numbers, or it can regenerate itself in a quicker timeframe without having to make radical compromises in force structure? (Put in conclusion section?)**

Add: Wayne Hughes quote from strategy and tactics relationship piece: "In peacetime, every strategist must know the true combat worth of his navy, as compared to the enemy, or he risks deep humiliation with or without bloodshed…In wartime, every strategist must know the relative fighting value of his navy – so carefully nurtured and expensive to build and maintain in peacetime. When committed in battle, the heart of a fleet can be cut out in an afternoon."

The belief that if you think you are a big target, you should divide yourself into smaller targets **(re-read FDMO part one…)**….does this derive from the land warfare example though? It is enough to put fire on a target in land, but in naval, it is not enough, you have to be accurate and you also have to have enough firepower to overwhelm….sometimes you are easy to target but hard to overwhelm in some examples, like tanks in WWI (in some cases)....you can afford to be seen if you can count on your defensive firepower being superior….you can also afford to be seen if there are many of you, and they do not know where to begin?

Theory of victory: Is launching and withstanding mass fires a reasonable basis for force structure? What requirements could stem from this? **Hudson: Rest on decision-making advantage…..**having scouting focus and sensing platforms, e.g., rather than using F-18s for scouts, buy more F-35s, or E-2Ds, or drones, etc….F-18 could be going the way of the battleship…. **Is my concept of this too broad-based, too expensive, too attrition focused, and not focused on specific points of leverage? What are the dilemmas being imposed?**

Distribution is an ideal balance of the density of capability: What is the proper density of capability in platforms, platform types, fleet-wide? A density of capability question, but not necessarily in physical terms only, return to the fundamentals established in Part One….Consider beliefs about the physical density of capability, the targetability of that concentration of capability, and the commensurate expenditure of weapons to destroy it….lowering density by building larger numbers of smaller ships, or distributing them across a battlespace….methods to manipulate and optimize density…

Distribution of fire:

- How are you sourcing your firepower, how are you withstanding their firepower, what is more difficult to target firepower against….
- Distribution of launch platforms…..distribution of fires…. If you need 10 distributed platforms to launch 100 missiles, versus three platforms….
- Some sort of tree graphic…..kill chain against multiple small force packages…..kill chain against one large force package, but broadens outward because of the volume of fire that needs to be mustered against it….
- Distribution of fire problem against small combatants versus aggregation of fire problem from across small combatants

Small versus large combatants:

- Small ships warrant bombs not high-end missiles…..not worth it to strike small combatants with those weapons if there are too many aimpoints, unless they have very little defensive capability…Would not spend especially high-end weapons on small combatants….like ASBMs and hypersonics….the one hit one kill thing comes into greater play when there is more inventory pressure…..
- The survivability of inventory versus the efficiency…..more efficient to build a giant VLS ship but less survivable….
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    - more overall individual salvos also gives the adversary the ability to increase their understanding of the offensive-defensive balance of salvo warfare, more time to learn and adapt and calibrate their firepower….
- Preponderance of striking power, how do we want to manifest that
- Mass makes up for shortcomings in intel and scouting first….defensive mass, if you have to absorb those strikes….**the problem is that much of the impetus to distribute stems from how an expeditionary force may be challenged to have a more robust mass firing scheme than what a homeland-based force can assemble near its doorstep….that the expeditionary force runs the risk of being heavily outgunned….**

- Defense of small combatants: more combatants firing at the same time within the same formation can mean more defensive inefficiency unless tightly networked and integrated….
- This is all relative…they will struggle to muster large volume of fire if their primary targets are large ships…..if it is small versus small, that will be more manageable, I think….
- May change tremendously if weapons like hypersonics become more fielded….and the volume of fire that is required to score a kill is dramatically reduced……?
- Lower magazine cell count per force package, but more force packages, supposedly results in more favorable ways of withstanding and generating massed fires…
- LCS, destroyers, frigates, have the offensive firepower of small combatants….
- **Short magazine depth is the key concern**: higher-susceptibility to last-ditch dynamics, greater dependence on aviation and large warships for defenses and to reduce their last-ditch susceptibility, less complex threat presentation, more transient presence….

Fragmentation: combined arms relationships can be fractured by network attack and jamming....fragmentation can also take the form of a lack of combined arms relationships…. ….the challenge of providing aerial enablers for numerous small combatants may stretch air wings thin…..the U.S. is prepared to build small combatants, but will it keep large carriers? How does the air and surface combined arms relationship manifest itself differently if surface ships become smaller and more numerous? Would that stretch the air wing thing…..more widely distributed small combatants may mean more warships that are beyond the scope of airborne coverage, which increases the risk of defeat in detail….

???risk worthy has been defined as being able to push deeper into the battlespace, stay longer, afford to make more aggressive moves, but such things can quickly convert into being stretched thin???

if those relationships are too unwieldy or too unworkable in practice from a force development standpoint, then it may be better to procure multi-mission platforms, so as to minimize combined arms dependencies….

General

- How does a force optimize its density and variety of capability to present a challenge to the adversary's decision-making while not being stretched thin, while preserving the density of its massed fires?
- Distribution is interpreted by many as smaller forces, for more force packages…lower launch cell count per force package, but more force packages overall…

- Disaggregating in the face of capability, or ISR….the adversary has achieved an effect by simply looking at you, if it is enough to make you disaggregate….if they can make drive toward being stretched thin just by the latent threat posed by their mass firing capability, then they can be setting the stage for defeat in detail….
- **The interaction between force structure, modularity, and force employment:** Battleships forced to escort carriers, instead of original roles, they had enough space to be converted into massive AA platforms, but big guns remained…..flexibility was maintained through a combination of platform modularity and force employment….force employment especially compensated for poor force structure prediction, how does this apply today? Maybe less so, in the of missiles, a payload not platform centric way of looking at it… warship margin is not just leaving room for future capability once it becomes possible, it is wartime margin of adaptation as well….modularity via missile cells is also critical…. and a lot of modularity is through software updates rather than hardware changes, software that can update targeting logic, decision aids, pre-programmed doctrines….It is conceivable that the answer to a warship type that keeps dying to missile salvos is not a platform or force structure redesign, but a software update.
- High numbers of survivable platforms with long endurance? Longevity of distribution not through survivable platforms, but through graceful attrition….
- **Intro:** We are not offering specific ship counts, but aim to provide important frameworks and operational dynamics for debating future force structure….This is hardly definitive…a lot of this centered on the magazine depth of the individual platform, which is a fundamental attribute for a platform's ability to contribute to and withstand massed fires….
- Don't rehash all platform advantages of Part Six and Seven, make some reference to acknowledge them but don't spend too much wordcount on repeating the thoughts…
- Force structure has to preserve combined arms relationships….larger combatants preserve these better somehow, and can survive better in their absence?

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Thoughts Unsorted

Jon Solomon's comment: "The most important piece of 'theoretical DMO' is the distribution of launchers across many platforms, vice their consolidation in a small number of platforms. If I have many launchers in just a few platforms, and RED kills one of my platforms in its first salvo, I lose a lot of launchers quickly. If I've distributed my launchers across a force of many platforms, and RED kills one or several in the first salvo, I still retain lots of launchers at the force-level. **It's the combination of force dispersal with distribution of launchers**….make it **harder to find and conduct disarming attacks against a preponderance** of BLUE's striking power…the single most important one is that 'theoretical DMO' emphasizes **the distribution of a force's launchers across many platforms, rather than concentrating the launchers in a few platforms.** It's not just about geographic dispersal of platforms in and of itself, though that is certainly also important. The reason why surface Navy is pursuing FFGs and LUSVs to augment DDGs is exactly the above: to distribute launchers across dispersed fleet forces. And likewise to distribute offensive strike capabilities such that the CVN isn't the only asset that can throw a high-volume punch at range." Rubel's similar comment…. "The other means of force defense is splitting it into many small units **so that when hits are taken, the force degrades gradually rather than catastrophically…."**

[…..here they are worried about having a preponderance of firepower destroyed, but what if the distributed force renders their own preponderance of firepower ineffective by being stretched too thin…..how does attrition affect the distributed force's ability to mass fires? They are assuming the distributed force will take hits to its individual elements sequentially rather than in parallel, possibly because of the ISR challenge….limited ISR resources, limited kill chains, limited numbers of what can be targeted at any one time….]

Bryan's comments: "An alternative or complementary approach would be to take a page from the Ukrainian and Russian playbooks and use USVs, UAVs, and USVs deploying loitering munitions to attack enemy ships. These vehicles can operate over relevant long ranges and be used for mass attacks that overwhelm adversary defenses, as penetration aids that enable smaller numbers of preferred munitions (e.g. SM-6, Tomahawk, LRASM) to be effective, or simply to interfere with enemy surface operations. Although UxS have potential long ranges, however, they are generally slower than their manned counterparts, though. The Navy can mitigate this impact by deploying them from shore near a littoral conflict or a larger platform like a LPD offshore. I used the attached slides at the NDIA expeditionary warfare conference that summarize the argument. We will be working some of these ideas into our reports on undersea warfare and deterrence that will be coming out over the next month."

Can we truly believe in a warfighting concept when there is a poverty of evidence? More live-firings, more unscripted crucibles, more simulations, etc……

Small combatants….smaller magazines….more episodic presence….more frequent reloading needed to stay in the fight for long……define small combatant as forces like small missile boats like Houbeis that can carry anywhere from 2-8 ascms, or corvettes that feature around 8-16 vertical launch cells for long-range fires….complex force presentation could be this as well….how do we know who is leaving to actually reload or just feinting it? How can they be sure, of how you distributed the sources of your contributing fires….. Five combatants of 32 VLS firing salvos of a given volume, versus an equivalent volume of VLS spread across more numbers of small combatants, how does a similar firing scheme shape the evolving nature of distribution and concentration….steeper drops in distribution due to larger ships getting out of the fight or being killed? Smaller combatants losses or reloads result in more incremental decreases **(consider this closely…see what makes sense)** ….more combatants, more force packages, means more individual salvos have to be targeted by the adversary, even if they are smaller salvos, it's not about diluting their inventory, it's about forcing them to make more decisions….small combatants that field weapons of limited range may create concentrated force packages that remove this advantage of forcing more salvos….the idea of building small combatants is closely tied to fielding a higher number of overall force packages…but it may be easier to organize several small salvos against smaller targets than a single large salvo at a bigger target, larger force packages and force concentrations create complexity by driving up the volume of fire required, which means more forces, more kill chains, more contributing fires are needed to be welded into an aggregated salvo….the complexity of this is hard to know for sure without detailed knowledge of how these kill chains work, broad inferences about the contours of the engagement may not be enough, could be a matter of context….., more kill chains goes both ways, who has the harder C2 challenge?

Do we really need new force packages if the force is inherently flexible enough?

Ultimate synthesis/putting it all together: What force structure, array of force packages, and payload loadouts, and tactics, best manifests this? **Putting it all together: Firing sequence, depletion, massed fires, distribution….**

Fleet, force package, platform, to the payload….the payloads themselves can be a sort of force package (strike package?), something to be launched on demand and configured to a type of threat, in terms of the capability of the salvo and its volume of fire, similar to an air wing……consider the time horizon for each of those elements….

The formation: Of how the fleet arranges its force packages, of how the platforms are arranged within a force package, and how a force package can arrange its contributing fires into a formation of missiles…..Each superior element is supposed to be an effective point of departure for the flexibility of the lower elements, and often minimizes the strain of transitioning into various formations that are tailored to the tactical context…..keeping options open, maintaining positional advantage….a fleet and its elements, force packages within force packages, a squad a platoon a company etc etc……a force package can have many formations and not just one, but the force package provides a measure of C2 coherence across formations…..right now the "fleet-level" is more of a command echelon than a physical force package of warships…..measure the quality of a force structure by the quality of its force packages….

What payloads can be carried by what platforms, what platforms and missile loadouts should constitute certain force packages? What force packages enable DMO and massed fires, how to best array these force packages across a battlespace, and can this array of force packages be reasonably described as a singular fleet?

Modularity and force employment allow commanders to compensate for the shortcomings of force structure. Consider the fate of the battleship in WWII. Once envisioned as the main offensive combatants of battlefleets, they were instead repurposed into defensive escorts for carriers. Their modularity allowed copious amounts of new anti-aircraft weaponry to be installed on the platforms, and new force employment schemes allowed them to put this new weaponry to good use. But the large guns that were the primary motivation for their procurement went largely unused in major fleet combat actions.

Distribution is about….it's about challenging decision-making, once a platform is detected, does an adversary think it is worth the expenditure of inventory?....typically the larger the combatant, the easier the answer becomes yes, and the faster the adversary will move to initiate mass firings…. Wrestling with that question when they lack information about other parts of the theater and other forces that may be at large….Small combatants may make that decision-making more difficult, sometimes, in the right context…the adversary may also be hesitant to expend very high-end weapons on individual small combatants, such as hypersonics and ASBMs, but more comfortable against capital ships and large combatants…..a lot of the signature of a platform is not its physical size, but its electromagnetic footprint, such as the radar waves that make it identifiable at hundreds of miles away…..small combatants have less of a signature in this respect as well…..distribution of capability, both in terms of the density of force structure, and how that force structure positioned across a battlespace, is meant to have an effect on the enemy's decision-making, whether or not those forces are detected. A force that is fully detected by an adversary can still pose major decision-making challenges for the distribution of fire and judging what is worth weapons expenditure….

Small combatants as pickets?

How do you value the combat power of a fleet in this DMO architecture?.......read the chess analogy….more options for massing fires, shorter time to strike, faster ability to cycle through salvos, the ability to build dense kill zones………the value of distribution within magazines, hard to ascertain without them firing……..Chess positions and maximizing advantage….preserving as many options as possible for the massing of fires….preserving as much inventory as possible….preserving fundamental pivot points of advantage that can ease a variety of tactical successes…..maximizing overlap involves managing careful tradeoffs, one limiting factor of a given type of weapon can constrain the broader arsenal if different kinds of fires are to be combined…….swarming is a form of concentration using individual low footprint assets…..…

small combatants typically lack enough organic sensing and command and control for resilient long term ops (?)…..some medium between having enough defenses and capacity but without being too concentrated….

Chess analogy: How are distributed forces positioned to generate favorable offensive and defensive options? How do you maintain positions of strength that endure….

Force packages: Provide a useful point of departure for a distributed force that is fragmenting, so it can still retain some semblance of structure, where local forces can assemble themselves into something useful….

The combined disposition of these striking arms can allow long-range firepower to be waypointed across one another's dispositions, challenging the adversary's ability to form estimates of expenditure and trace the signature of the salvo back toward an individual striking arm….

These suggested force packages are conceived using current force structure. This illustrates the challenges of transitioning into a new warfighting concept and generation of warfighting. There can be at least two force structure constructs – one that depends on a force employment scheme to leverage the modularity of existing force structure to implement DMO as much as possible, or an entirely new force structure that is deliberately optimized toward DMO. The practical reality is that no great power fleet is purely optimized for a single warfighting concept, nor should it be.

The Navy is attempting to manifest DMO with existing force structure, while building newer generations of ships like frigates and unmanned ships that reduce the average platform density of the force.

Thoughts Possibly Done With….

Implications of new frigate not having Tomahawks? Similar to Chinese frigates…mainly ASW and AAW but no long-range ASUW….

Providing small warships with vertical launch cells will considerably widen the ranges at which they can distribute from one another and still combine fires, and offer more maneuver space to aviation to offer support. But by offering small warships more distribution space for offensive efforts, they may put themselves beyond the range of combined arms defensive support. Long-range weaponry fielded in numerous small combatants will supposedly make those warships more risk-worthy…

Griff Hetrick comment: 'My only feedback is that I come to a different conclusion - if modern warships require us to have an inventory of thousands of very expensive missiles to take down even a few of them, it is worth making an asymmetric approach. One of the problems with a huge budget is the argument "We need to buy lots of expensive upgrades to existing kill chains" sounds attractive to both the pentagon and industry. If we need 10,000 weapons and they cost $1-10 mil each and have a limited shelf life then the pressure is always going to be towards buying fewer of them to bring the cost down below $10-100 billion for a single kill chain. I'd suggest instead looking at a way to take down a modern warship that it can't counter well, such as weapons that go so fast they can't be shot down, or swarms of smaller drones/munitions that quickly overwhelm the number of munitions that the ship can fire in self-defense. The latter of which is probably even scarier for ship COs. Our adversaries are smart about going asymmetric when we make a single portion of a kill chain difficult to overcome. The US would be wise to follow suit."

Warship: Large capacity, can't see below horizon, slow reload….not so much capacity that they attract priority targeting? Fractures into units of large firepower and significant organic sensing except below horizon….can put some of the largest missiles on ships like ASBMs, but that would make for extremely concentrated capability as well, land is more distributed…..
Land-based: Distributed like small boats, but with the longest range firepower, the most survivability, and with reload speed similar to that of aircraft but not the small missile limitation………but by far the most dependent on outside sensors and cueing

Submarine: Secure efficiencies, complicates battlespace, gives enemy no respite within their WEZ, slow reload….
Aircraft: Help with below horizon, can't be countered by ASCM, episodic transient presence, flexible maneuver, fast reload….And lots of carriers for naval aviation, bases can be held at risk by ballistic missiles (carrier or airfield).... You either operate from fixed airfields, have massive in-flight refueling capability to project at super long distances, or have carriers… distributed austere bases may not generate the capacity or endurance as more concentrated airbasing can…..try to maximize the amount of organic aviation the resides with the surface force, rather than concentrating the bases from which aircraft operate, even if a surface combatant can launch a high-altitude, high-endurance drone, this would go a long way toward facilitating its fires….can the current helicopters reasonably provide this? Large infrastructure is typically needed to field a modest number of capable fixed-wing aircraft….the need for airpower over water makes it hard to decouple from carriers……..
Land-based….more enduring than naval? WWII? (RAND report on employing land-based ASCMs)....

Aerial: Massive requirements stem from major demand for enabling and defeating salvo, maintaining situational awareness across broad ocean areas….considerable sensor fusion, sensing, and battle management capability…..

Undersea forces are especially important for advantage because of efficiency….

CNO on distributed fleets: "we can't come at the adversary, we can't mass forces like we have in the past….a number of war games, a number of exercises, tabletop exercises – led us to believe was that a distributed force coming at an adversary across all domains and many vectors was the way to go.".....''We took a look at the fleet today and we felt that, you know, does it meet the parameters that's required to fight in a distributed manner and be successful? We're not satisfied that it is. We feel like we have too many capabilities that are jammed onto too few ships, and those ships are too big."

Weapons that feature a combination of long range and low time-to-strike, such as hypersonics or ballistic missiles, are not carried by small combatants, or at least not to date.

The location of one target can be shared and rapidly inputted into many killchains….but the location of many targets, less so?

When organizing massed fires, a force has to consider the distribution of contributing fires across its force structure and how that affects risk. What proportion of the contributing fires will come from bombers, from land-based

forces, from large warships or small warships? A massed firing sequence that heavily depends on the success of small combatants is a firing sequence that employs heavily concentrated formations.

It likely takes only one hit from an anti-ship missile to put a small combatant out of action, but the same is probably true of most large warships as well. A force confronting numerous small combatants will know that the number of missiles required to sink the force will be at least equal to the number of combatants themselves. But sinking the force is not the only way to achieve operational benefit.

Complexity of Threat Presentation: density plus variety of capability, how do you multiply variety of capability to complicate calculus….. (Variety: Different types of platforms, missiles, waypointing capability, emissions)......in terms of presenting variety, it may not be the platforms, but the potential varieties of the distribution of fire across platforms, the adversary struggles to predict how exactly the next salvo will be assembled from across diverse options….variety of capability and force presentations may diminish as forces fight perhaps, as they demonstrate their limits and preferences….Make sure the force structure criteria is crisp and clean and clear and defensible……

- **Aviation and complexity of force presentation:** Aviation, diverse aircraft, diverse sensors, diverse loadouts, diverse maneuver and force packages, current aircraft, with their mobility and many types and rapidly changeable loadouts, can help with complex force presentation better than warships
- **Payloads and complexity of force presentation**, **what is in the magazine?**
    - Dual-capable Tomahawks would certainly add more complexity to things…
    - Weapons depletion is a major element of evolving threat presentation
- **Undersea forces** by their aloof and hard-to-detect nature….
- **Surface forces, by their numbers and varied magazine loadouts…**
- **Multi-mission forces versus specialized and complexity of presentation**
- Complexity of force presentation, and diversity of threat presentation? Are they one and the same, or are they something else? better force complexity presentation via ubiquitous capability or highly variable capability?
- Complex force presentation, **through the platforms, the force packages, their loadouts and capabilities**…..…..
- **How does complexity of force presentation diminish as mass fires are exchanged? Magazines deplete, what else….**
- Complexity of one's own force can also be self-defeating…..that a commander can have a better grip of the complexity of his own forces compared to the adversary…..be wary of

> the idea that U.S. naval forces can rapidly integrate and improvise their task organizations in the midst of a complex battlespace….open-ended ideas of the flexibility of naval power…..

??If elements of a distributed force witness a friendly warship launch a last-ditch salvo moments before it is destroyed, those elements do not impulsively launch their own fires to bolster the volume of fire. Commanders with broader authority to initiate mass fires should the skill to tell when a last-ditch salvo from one of their units is worth supporting with further fires, or worth letting go on its own. In turn, a distributed force is skilled at manipulating its adversary into wasteful last-ditch fires by firing from non-surface domains, employing waypointing tactics, and using weapons that out-range the capabilities the adversary could retaliate with.??

Distribution in land warfare encourages the many and the small when it comes to platforms:

Land and naval warfare manifest the hider-finder competition and the offensive-defensive in different ways. For much of land warfare, there is relatively little in the way of a salvo dynamic, where a given volume of fire power has to be mustered to break through strong defenses. Instead, forces can achieve lethal effect with relatively low volume of fire, especially with direct-fire weapons. This allows accuracy to be enough to achieve lethal effect regardless of the relative strength and size of opposing forces. A smaller force can take a bite out of a larger force.

For naval forces, accuracy is not enough. To be the smaller force in naval salvo combat is not just to be outnumbered, but to have one's offensive firepower completely negated by the adversary's stronger defenses.

(I like this section plenty, but maybe not totally necessarily…) Think WW1 dispersal in the face of artillery and machine gun fire….there is no salvo-counter salvo dynamic, you can't shoot down someone else's bullets, you can a little bit with artillery but you get the idea…..missile warfare is different, it's different when its defensive firepower defeating offensive firepower mid-air, rather than offensive firepower being defeated by armor, or staying power, the ability to absorb the hit…….this allows land forces to have much more magazine depth relative to their targets, no need to salvo things as much….a single infantryman, tank, or artillery piece can still kill several other equivalent units even if those units outnumber them, the small can still take a bite out of the large in ground warfare……..what does this imply for force structure?.......ground forces can distribute enough that only one loss can be suffered for each tank round, artillery round, ATGM, etc…..they know they will take the hit, so they will distribute, but naval forces can concentrate to negate offensive firepower….one shot one kill is the ideal for ground distribution, in that if they are going to take a hit, they minimize the loss taken, and when they take hits they degrade more gracefully, naval is much more catastrophic….salvo warfare it is not just one shot and one kill, if you are getting hit at all, then you are likely to get hit by more than enough to outright kill the platform…. the emphasis is on not getting hit at all, either through complicating decision to strike, or having enough defensive firepower…

Being seen does not automatically convert to being destroyed as readily as it does for much of ground warfare, because of naval salvo combat's dependence on achieving enough volume of fire to have any lethal effect. A naval formation that knows it is in full view of an enemy force can feel barely threatened by that force if it knows that force cannot muster the volume of fire. However, the risk comes from that force being able to provide targeting information to assets that are beyond the ability of the naval formation to sense, assets that could help with mustering the volume of fire. Only one missile hit is enough to destroy a warship, but if a warship is going to get hit at all, it is very unlikely to take only one. In a form of combat that consists of numerous missiles attempting to overwhelm warship defenses, a very minor advantage in offensive firepower will rapidly translate into extreme overkill.

The ability of naval forces to defeat offensive firepower before it strikes means there is less of a guarantee that a naval force will be hit if it is found. But if it is hit, there is more of a guarantee that it will be decisively destroyed.

(Putting it all together into a formation and a force structure with overlapping fields…..)

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Weapons depletion Part

Last-ditch fires can contest an adversary's interruptive strikes, and help preserve the firing sequence…

(Graphic/Animation/Table/Chart? Of prolonging distribution by spreading depletion…)

Inventory: .forces can fire on forces they have no expectation of actually overwhelming and striking…..but can fire to deplete the inventory of the adversary and shape their behavior in ways that benefit one's situation…..fires launched in this manner, distinguishing between fires that are harbingers of a massed salvo bearing in, and versus limited standalone fires, adds another dimension of uncertainty to an adversary's calculus….

Last ditch fires are ordered by a higher-echelon commander, or initiated by the unit leadership that is specifically under attack?

The act of aggregating fires better preserves a distributed force posture against depletion than having standalone force packages launch large-scale salvos individually.

How does a distributed force massing fires better inflict depletion against an adversary?....defensive/offensive asymmetry

Jeff Kline comment: ''The U.S. preconceive notion is a well-timed massive coordinated full spectrum strike. The other way is to exhaust defensive magazines through stream raids of many small offensive strikes and decoys…."

Uncertain as to who is depleted or not…..what if they reverse course but still have munitions to fire….that enhances distribution…

[An animation/map image contrasting these two scenarios of depletion…….]

And naturally, inventory will be lost before it can be leveraged, whether due to engineering failure of their host platforms, ships being sunk before they could discharge their magazines….and other things….what enhances the speed of discharge, comes at expense of greater depletion?

Offensive/defensive inventory?: A target that survives and fires….most likely deprived of all of its offensive firepower fired on incomplete information, and likely deprived of much of its defensive firepower as well. Simply prompting an ineffectual last ditch salvo can be enough to remove a warship as a source of substantial threat until it reloads……..Hoping that their final salvo may at least help diminish the adversary's inventory of defensive weapons and provoke responses that enable counterattacks.

Possibly done with…

How can commanders and force ascertain how much is enough when it comes to generating large enough salvos? How can they ascertain the effectiveness of adversary air defenses, especially short-range electronic warfare and laser dazzler systems?

The concentration and distribution of the force will flex and evolve as magazines are depleted.

Inventory: evolving calculations of risk and opportunity, remaining distribution and concentration,

(Mini intro) In the broader context, the dynamic of asymmetric depletion can make a distributed force more brittle, more tempted to fire on incomplete information, and forced to spend more time risking assets to put offensive firepower to use.

Not only do commanders need to maintain awareness of an adversary's numerous distributed contacts, they must track hostile weapons expenditures and update estimates of remaining magazine depth. Target priorities, calculations of risk, and projections of behavior can fluctuate depending on the volume of missile exchanges and how magazine depth estimates are evolving.

Uneven depletion/Tracking dimension: Which type of payloads ease or complicate the expenditure tracking effort…..longer-range? Platform-based? (LRASM versus Tomahawk….knowing what kind of missile can come from what kind of platform…..can they figure out what missile it is in real time just by radar sig?).....**the salvos themselves add to the ISR burden of the adversary**…..large salvos of Tomahawks flying hundreds of miles would draw considerable ISR interest……low time-to-strike versus high? Places a stronger burden on carefully tracking the launch platforms themselves since there is hardly any time to think and react to such a fast salvo….longer-range makes it harder to track or ascertain the launch platforms…do salvo patterns have an implication in the tracking dimension of this? Unclear…**tracking is made simpler by knowing what kinds of platforms field what kinds of weapons…., such as how certain weapons are exclusive to certain platforms, aviation and surface differences….to ascertain the platform type is to narrow down the potential fires….**

Example of using pure ASBM versus mixed salvos….only one interceptor to kill needed regardless of the quality of weapon? Yes but may need more to shoot down faster weapons?

Uneven depletion: Aviation can rearm much more quickly than warships, but their relatively short endurance makes aviation more likely to discharge their entire magazine depth in individual strikes. Aviation's ability to contribute to a distributed posture can have more frequent fluctuation compared to warships enduring on station. But the fluctuations of aviation are not as steep and prolonged as that of depleted warships traveling days to rearm deep magazines.

Warships that significantly change operational behavior after depleting their munitions can give their depleted status away to an adversary and reveal the remaining force to be more concentrated.

Small combatants typically lack robust air defense capabilities and would be dependent on other ships to provide such capabilities at range. But because of the sea-skimming missile threat, these ships could largely be on their own. This risks both defeat in detail of the small combatant force and their salvos as well. As each small combatant feels on the verge of being destroyed, relatively small last-ditch salvos may be fired in response.

The tactic of aggregating fires from distributed forces magnifies the total amount of collective firepower that can be combined against a shared target.

Inventory interaction: How does operational behavior change if one side believes it has an inventory advantage, and with respect to offensive/defensive fires? Asymmetry…..if one side is full on defensive but low on offensive, the opposition (if it manages to survive the attacks) is low on defensive but high on offensive….who wins, whose behavioral change is closer to achieving operational objectives of their side? Both have adequate reason to withdraw, but one has a much longer trip home than the other to replenish….

Inventory depth is also needed as insurance. Commanders who attempt to precisely optimize their salvos for efficiency will be at greater risk of failure. Commanders who seek greater margins of confidence will expend larger amounts of weapons, and can choose to run the risk of overkill rather than not killing the target at all. Greater inventory is also needed to preserve magazines and volume of fire in the face of command and control degradation that prevents the employment of fires, and losing ships with fuller magazines to enemy fire or engineering casualties. Superior inventory depth is one of the most important methods of sustaining overmatch and having insurance for a fleet's combat capability.

This central logistical consideration is especially challenging for the U.S. Navy. Many U.S. naval forces will have to surge thousands of miles from home to respond to a major Pacific crisis in significant numbers. If these forces deplete enough of their magazines, they will be forced to take long voyages home to return to safe ports to rearm, and then take long voyages back into the theater. The Navy does not yet have a capability to rearm vertical launch cells at sea. Adversaries by comparison enjoy much shorter journeys to rearm and reenter the conflict.

Forces must generate volumes of fire that are large enough to overwhelm warship defenses. But not so large that munitions are needlessly wasted, and not so few that no hits break through defenses. **(A table illustrating this numerically, against a task force….)**

It may be especially challenging for warship commanders to fire effective last-ditch salvos when they are under attack from aggregated firepower and salvos are coming in from multiple lines of bearing.

Note SECNAV at-sea reload capability

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Carrier Part

(Graphic showing overlapping counter-air roles and salvo support…..)

(Range ring graphics for the three examples mentioned: Tomahawk, SM-6, and protective screens, show distributed fleet formations and the extent of information coverage…)

The need to provide retargeting and air defense coverage for friendly salvos on their way to the target, and the need to keep surface warships close enough to the carrier that aircraft can interdict opposing bombers before they are within range of firing, can combine to considerably concentrate the disposition of a distributed fleet, as depicted in Figure X.

Revisit Negus NWP-2, chapter III, intel at tactical level of war

Chainsaw tactics… (source)...**(second source)**

A single scouting aircraft….can be a harbinger of massed fires…..

The distances….400nm for E/A-18 unrefueled? 600nm unrefueled for F-35? Do the math of the overlap….how far can they be "stationed" from the carrier, and is that too static of a concept for airpower? They have to be stationed if the warships are within range of being struck, since there will be little time to surge airpower in response to a salvo launch…..if a bomber can fire on a warship from 300nm away, they need to be interdicted at what, 100nm away from that? Defeating aerial archers before arrows will be very difficult for carrier aviation, given how long-range the missiles are, and how short-range the aircraft are…..they may need to emphasize defending the warships rather than interdiction….Doing anything beyond defending warships in the local area may be difficult, and ideally the aircraft could operate at least 100nm in front of the warships to trim the salvos before the warships have to fight it themselves….a naval force can enjoy greater dispersal if it is willing to forego aerial support, unclear how survivable that is…..this geometry is quite ugly…..warships may have to forego carrier protection in order to keep the carrier further out from the battlespace, or be limited to only ship defense and not the forward operations that are extremely important, maybe in the force packages devote a squadron to buddy tanking to help keep up the dwell time? **(source for super hornet combat radius…I'm seeing 4-500 miles).... "The ceiling on the usefulness of long range strike is sortie rate, which goes down drastically on long range missions. [time to strike on that?] If a CVN can't support but a handful of sorties per day due to very long strike ranges**, then the whole need for a CVN goes away."....carrier gains more flexibility when it isn't tied down by needs to protect and enable warships, and the fleet's disposition becomes less predictable, but support to fires goes down….how aloof can carriers really be….in terms of range (and what other factors?) this approach may only earn marginal extra survivability for the carrier (moreso for the air wing), but greatly increases the offensive and defensive ability of the broader fleet….

Consider combined arms warfare at sea, and devising a mutually supporting relationship between aircraft and warships especially, and how the tactics of one could endanger the other….

Have the capacity of the surface force guided by the awareness of the aviation force.

Aviation: Still needed to take care of more numerous, less exquisite targets….smaller but more numerous aimpoints….leave the cruise missiles to the higher-end targets….aircraft carrier magazine depth?, assuming they are carrying 2,000 Harpoons/LRASM, they could have enough for 20 air-wing sized strikes…..Make sure to credit Griffin Cannon with the many aimpoints insight….

Intro: mention…. Crucial combined arms relationship for making DMO and massed fires possible.

Massed fires is an information heavy tactic….long range targeting, classification, searching…..and then in flight retargeting to reinforce….massed fires involves significant amounts of information needs be met to function……

Retargeting: Fixed platform location alleviated by range of weapons allowing for more platform maneuver…..but also retargeting…..don't forget to mention added range buys flexibility for maneuver…..

Air defense: The larger shipboard interceptors are less about defeating archers before arrows, but more about having missiles capable enough of defeating missiles with high-diving flight profiles, the higher-end threats like ballistic missiles... and holding aircraft at risk in the hotly contested aerial battlespace between fleets, including aircraft that are attempting to enable salvos as they close in on their targets…

Bomber interdiction: Without air support, surface formations can be picked off by bombers firing from far away….only aircraft stand some chance of picking off bombers

Carrier section: Being proximate enough to provide these information centrics is also proximate enough to provide air escort to bombers that must surge far forward to contribute fires….

Carrier aviation: Aviation can help with having wide area awareness to facilitate interruptive strikes…..

Largest afloat concentration of Intel, planning capacities is in capital ships….

BDA: Intel, a wide variety of overlapping capability comes to bear at the same time during a defensive missile engagement for a ship….need to be able to collect data on that, data for both friendly and enemy engagements…..

Carrier aviation: These information functions may seem to argue that carrier aircraft are better suited for striking targets because they can more readily provide information support to their own salvos compared to ships hundreds of miles away from their own targets and missiles…..but the extreme concentration needed to achieve volume of fire and everything else makes it self-defeating…..

Weapons/carrier section: Risk of attrition is even higher if there are land-based aircraft operating CAP for warships, they have longer range and easier access to refueling….

WWII esque…. Having CAP for defending against anti-ship strikes….and concerns over having CAP drawn into certain angles and opening other potential approaches and angles that are left uncovered…..

Possibly done with…

Steep downward intercepts: **Graphic: SM-2 launch from US DDG (full caption here) Gfycat link. Use to show minimum engagement range.**

Air defense: How useful are these standard SM-2 interceptors when many if not most anti-ship weapons will strive to be below the horizon as much as possible, and when aircraft can fire upon warships at ranges that greatly exceed the range of those warships' defensive weapons?....Depends on somehow putting them in positions where they must fly higher to perform some function or earn some advantage….making them fire earlier, complicating their terminal search, etc….aircraft that can trigger premature salvos from other aircraft can help with this…..

Air Defense: Steep intercepts section….relegated to point defense weapons…RAM-type missile launchers can more easily manage these steep intercepts by having turreted launchers, but they have low magazine depth, with common variants featuring only 21 or 11 missiles, probably only enough to defend against a single sizeable salvo, Phalanx magazine is 1,500 rounds and similarly limited in magazine depth to a single salvo. If a ship survives the first salvo by a narrow margin, further missiles that cross beneath the minimum engagement range of VLS would be considerably more difficult to counter….While turreted point defenses may be better at defeating especially close-ranged missile threats, their relatively small magazines could be quickly depleted by

Surface launched missiles go upward….aircraft-launched missiles have to drop and then kick off….how low can aircraft fly while still affording their cruise missiles enough space to drop and then fly….

Retargeting offers a payload-centric dimension to missile aggregation and adds another layer of opportunity for combining fires.

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Platforms Part

- **Read the platform-specific sections in the new major section.**
  - § Do a finalizing pass and number the sources along the way. Consider making cuts to bring wordcount down where feasible. Add the sources to the references section.

  - **§ Do a finalizing pass to see what elements of the framework are captured in the platform-specific sections, and**
  - **§ Describes what happens to the dynamic of a mass firing sequence that is deprived of that platform type**
  - **§ In each platform section have a paragraph or two that combines the traits described in the framework?**
  - **§ In the major platform subsections, describe what role each plays in the combined arms team…**
  - **§ Review the thoughts in the Thoughts document.**

Last-ditch: Shorter notice versus longer notice?

Is this a step back….. Platform attributes are not an adequate point of departure compared to functional context or integration….there is some concern here…

One out-ranged the other….they will always be pushed back….or the most rebalance their firing sequence to be ready to absorb hits rather than hit them first…..Principally oriented against one part of the combined arms team, the surface force, but these frameworks are not meant to be a full conception of future combined arms naval warfighting….

Land-based launchers lack organic sensing more so than any other platform type, and require a combination of other sensors to cue their fires. But the relatively high difficulty of targeting land-based forces with **long-range missiles reduces the circumstances that can yield launch last-ditch fires, at least those last-ditch circumstances that are a direct function of the survivability of the launch platforms themselves….**.

Bomber range source here too: [Maritime Strike, by LtGen David Deptula]

what do these last-ditch firing dynamics portend for a mass firing scheme and the resulting configurations and asymmetries? Who has to launch contributing fires in support of last-ditch fires? **The challenges of anticipating last-ditch fires from other platform types**, and making quick adjustments in a timely fashion? ….aircraft can also use maneuver to help bolster last ditch salvos….last ditch salvos or mass firing organized hastily in al?general

early warning is key to effective last-ditch fires, but can the platform's organic sensing provide enough early warning to itself to do so?

Frameworks:

Platforms: platform survivability and their ability to contribute to a firing sequence….a firing sequence that depends more on X platforms is more or less durable, similar to how the proportion of weapons that make up massed fires, risk profiles will change depending on the proportion of platforms contributing those fires…..

The **dependability** of a warship in a firing sequence stems from its capacity, endurance, and numbers…for aircraft, their survivability and maneuverability…for a submarine, for its stealth, for a bomber, endurance and maneuverability…

Standalone salvos: The ability of standalone force concentrations to launch standalone salvos that can muster enough volume of fire…a function of per platform depth and organic sensing….

Combining fires:..Mutually supporting relationship, where each platform type that is contributing fires hedges against the unique risks other contributing platforms can face. If a mass firing sequence is combining fires from bombers and land-based forces, then there can be more bombers and more land-based forces to compensate for loss of the others….

Endurance: Function of platform range, magazine depth, and reload speed…..

Introduction includes framework for what to assess:

Surface warships: What about the offensive dimensions of attack and massing fires? No more goal-line defense….

Bombers: Add mention of rapid dragon capability, example of it floats it fights, adding hundreds of long-range high-endurance, aircraft that could deploy cruise missiles, including C-5s, C-130s, and C-17s, insert Gif from this video …..easier to sustain them….easier to get numerous tankers out to a bomber compared to getting a tanker to a warship, it's a lot faster…..bombers have longer range than warships in terms of refueling? See ship stats here: (B-2 bomber is 6,000 miles unrefueled, B-52 is 8,800 miles, source with all bomber ranges but sourced from an almanac)

Platforms: In surface warships, make explicit the focus on large surface combatants….focus on small combatants as well, or at least say that it will be addressed in the part on force structure…..

Platforms: Amphibs…..make note that we are looking at anti-ship missile armed combatants….

Platforms: Source for thinking late 2030s Submarine block V production run completion and delivery…see here…

Platforms: Submarine anti-ship missile firepower is stretched extremely thin….talk about how firepower is distributed across these types and classes of ships….are all eggs in one basket? Firepower distribution across platform distribution…..Submarines,, such small magazine size that may have to completely devote their vertical launch magazine to land-attack or anti-ship weapons to have a chance of launching enough volume of fire against high-end targets, even if the submarine earns considerable proximity to the target….

Land-based: struggle to use maneuver to create new combinations of massed fires, unless they can be transported by other assets…

Carefully managing the disposition of a maritime strike bomber force being maintained over the open ocean is critical to DMO, and logistically intensive and dependent on refuelers.

Aircraft are also the only platforms that have the organic sensing capability to potentially target anti-ship missiles out to hundreds of miles. Altitude gives aircraft a commanding view of surface and sea-skimming spaces that all other platforms struggle to sense beyond the nearby horizon limit, and also gives aircraft useful positioning to utilize passive detection against distant emissions. By combining superior speed, an excellent vantage point, and powerful organic sensing capability, aircraft are among the best platforms for managing the risks of emitting and seizing information. This allows them to more confidently launch standalone fires and satisfy the information needs of their own kill chains with organic capability. But more importantly in the combined arms context of massed fires, aviation can compensate for all the other platforms' heavy dependence on outside cueing. Airpower can serve as critical connective tissue by meeting the information demands that allow mass fires to come together from platforms that are severely limited in their ability to sense warship targets hundreds of miles away.

Possibly done with…

Alternatively, submarines could be ideal for lying in wait and firing on warships exiting a fight, whose relatively depleted magazines could create enough opportunity for the smaller salvos of submarines to break through.

Land-based forces, mainly those based on the mainland of a nation, can also provide a valuable base of fire for an overall scheme of massing firepower given their availability of fires on a force-wide scale. But this only applies to a certain extent. When facing expeditionary naval forces that can launch cruise missile weapons featuring a thousand miles of range or more, land-based forces must compensate for their small scope of platform maneuver with especially long-range weapons, such as ballistic missiles or hypersonics. These weapons are especially intensive to procure and manufacture in large numbers, and are among the most high-end weapons that could join a scheme of massed fires. Other platform types can meaningfully field less capital-intensive weapons because their greater scope of maneuver allows them to gain closer proximity to targets. Despite their considerable reach, land-based platforms provide a base of fire that is much more geographically fixed compared to that of a maneuvering surface fleet.

The lack of speed relative to attacking weapons also reduces the stealth of the platforms. If a surface warship is localized, it may have to travel for hundreds of miles to reestablish a tactically stealthy posture on the open ocean.

If the launches occur close enough, sub-launched missiles could even spend most of their flight at supersonic terminal sprint speeds, a capability peer competitors have but not the U.S. Navy.(source)

Submarines can also provide cueing information themselves by shadowing targets and relaying the information to higher echelons.

High altitude bomber interdiction would be very helpful from stand-in forces if they could pull it off?

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Gen/Misc

Ultimate synthesis and Doctrine: What does it actually look like when you put it all together…..how does it fight……..put this in the China-U.S. DMO fight part? Assume converge toward these methods for the sake of argument [but this is mirror imaging]…..10-15 years from now, same timeframe as MST, what else will have changed? Hypersonics are more common, but still rare….China has similar in-theater carriers as USN….some sort of Nebulous animation of two fleets going at it….

Distribution and defensiveness….picket warships can provide early warning at a distance from the main target of a major strike (SNAF bomber example/Kamikaze example)…..pickets have to be picked off to blow holes in coverage, but even then, that provides some form of warning to a defender…..concentrating around a carrier means surface ships can contribute little to early warning, or diverting strikes against higher value targets toward themselves……

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Caveats

Caveat: The visceral devastation of an impacting missile salvo obscures the digital, nonkinetic foundations that make the capability possible.

Ending caveats: Amidst this deceptively simple and elegant logic of combining fires will be a mass of confusion…..it does little to affect the day-to-day competition, gray zone tactics, and other measures of subversion that change the status quo in ways too subtle to provoke major conflict…Large-scale naval salvo combat has never happened before. See Steve Wills examples of small salvos…. Performance on paper or in simulations versus performance in reality in the field, this analysis assumes things work the way they were intended to work, that sailors and ships are ready and prepared…..it doesn't deal with a lot of left-of-kill chain type challenges and solutions….it focuses primarily on kinetic exchanges…

Wayne Hughes quote on tactical complexity peacetime disease…..pg. 206

To force an unworkable concept onto a service is a recipe for disaster……

Every recommendation for how to fight better contains within it the seeds of defeat….whether it actually works or not will have to be figured out in wargames, simulators, at sea evolutions, and in the minds of rigorous tacticians who prize practicality above all else.

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Last Ditch

Range advantage of Tomahawks one of U.S. Navy's biggest advances with respect to trigger last ditch fires….

Last-ditch can apply to land-attack inventories as well..

Last ditch circumstances and susceptibility: When a platform is ready to fire but must wait because the need to achieve enough volume of fire demands patience on its part…. There can be many opposing forces in view of one another, who may be forced to wait for enough fire to be organized and brought to bear….When there is overlap between anti-ship capability between forces, the opportunity for last ditch fires is magnified, but **much less so when there is no overlap in range…**.

Possibly Done With…FS

Last ditch: Surface ships that carry a minimal amount of long-range anti-ship firepower, like most Chinese frigates, will be less susceptible to the temptations of last-ditch dynamics because the bulk of their missile firepower is defensive. U.S. surface warships also have minimal long-range anti-ship firepower, but can carry substantial long-range land-attack firepower in their magazines. Last-ditch firing dynamics can apply to these land-attack missile inventories as well.

Is this about explicitly countering China's force structure and ways of war?

Threat-based versus capabilities based?

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Unsorted

Sequence (subsection name, Distribution Across Time and Firing Sequences): they have to know the target is out there for it to factor into their interruption assessment….a submarine is not as helpful to distribution in this sense.. ..surface warships are especially priority targets for interrupting strikes….what is the relationship between interruption and last ditch fires….shorter firing sequences are harder to interrupt, but diminish the ability to enhance the threat via a distributed firing sequence. Rather than destroying archers during the firing sequence, the pressure grows to destroy them before it can commence…..replace destroy archers with disrupting kill chains? **...….ideally those who are targets of potentially interruptive strikes have enough information flow that they can continually update their salvo waypoints in case of them being targeted…..**

Detection challenge….once you detect a target, how long does it take you to assemble the massed fires before initiating it, and will the tracking and targeting hold for that duration?

NIFCA: Does it need active seekers missile to work, like SM-6? Probably not worth it considering how expensive and rare that missile is, maybe it would be better used with SM 2 3C variant (see weapons procurement books)

Aggregation Framework: Less time-to-strike can still mean waypointing is viable, it just traverses the waypoints faster….and if the trajectory is flexible…..glide vehicles and ballistics not so good at waypointing…?

Strategy: Not everything will be a matter of winning missile duels….what kind of conflict are you in, what kind of crisis, what kind of situation…..

Sequencing: Intro/outro This stuff can't be left to models and decision aids. They have to understand the dimensions of risk, they are ultimately responsible for the engagements they set in motion. A commander must be able to look at the laydown of distributed forces, and understand how massed fires can come together from various laydowns and formations, and how these schemes of fire risk incur to those distributed forces.

Sequencing: "Reaching weapons release lines"

You need to include hypersonics….

If a massed firing sequence is initiated from a thousand miles away…..an adversary may not know that, they may only see a portion of a firing sequence unfold and be unable to discern how much time remains for interruptive fires……the act of a single launch can force an adversary to intensify their scrutiny across a broad area in an attempt to discern if massed fires are taking taking

place….high fidelity understanding across a broad, even theater-wide area is needed to have an awareness of an adversary's firing sequence from start to finish, and to discern opportunities for interruptive strikes…

Time to strike for hypersonics with 1,000 mile range cited at 12 minutes by USAF…..Blake Herzinger quote in H I Sutton piece quoted at 25 minutes for ASBM strike….

Platforms: Seeing DDGs is not enough, you do not know what they are carrying, that is a form of distribution, their payload variability….air wings are easier to tell by how they take flight, the disposition of aaw should be much different than asuw,

Land-based missile size: DF-26 is ten times the weight and twice the length of a Tomahawk. (source)....“In 2020, the PLARF launched more than 250 ballistic missiles for testing and training. This was more than the rest of the world combined.” 2021 China Military Power report…larger missiles can also carry more penetration aids such as chaff, decoys, etc…..

Carrier air defense: The multi-mission capabilities of surface combatants can give an illusion of security from multi-domain threats….multi-mission capability of naval platforms does not eliminate the need for combined arms warfare at sea…some have suggested that SAGs could be comfortably operate independently…. there is still a role for combined arms in naval warfare…..integration, not just coordination…..

Reflex of destroying recent shooters doesn't do much in the near term, they have already fired their salvos

Advanced missiles can transition into terminal sprint once they break over the horizon, compressing reaction time, placing a premium on early detection….aggregating between missiles with terminal sprint and those that don't will be fine….they will stress defenses with complexity

Sequencing section….Aggregated versus aggregated salvos and forces…..faster time to target means better opportunity for preemption strike….it means more pressure for the target to fire off a hasty last ditch salvo….but to achieve these advantages, faster weapons need to be standalone rather than mixed…..faster time also means less temporal opportunity for aggregation, but also gives the enemy less warning of what they are facing…..they may think they are dealing with a salvo of subsonic until much higher speed missiles arrive in those final minutes and enhance the threat…..imagine Chinese DFs complementing subsonic salvos……..

A framework for how to assemble missile salvos into overwhelming fires against heavily defended targets.

You achieve volume with timeliness….

Writing meta: What are the most crucial questions for diagnosing the challenges and opportunities? Are we being prescriptive or strictly diagnostic?

Opposing time to target…..if a YJ or ASBM can hit you this fast, you won't have much time to preempt…..??

These tactics are almost completely dependent on MST to work….that is the foundation of these frameworks and concepts, is having a missile that is that long-ranged and built in large numbers.

DMO is real today for U.S. military with respect to land attack fires, but not anti-ship fires.

Carrier section: But between salvos and different contributing fires, an outside architect will be needed…….The case for carrier aviation is most strongly made in the case for critical information related to naval conflict and aggregated fires. With respect to survivability, radar horizon etc….

reverse range ring and regular range ring to show archer before arrow disparity…..the gap in range….also show the range of the radar horizon at about 20 miles (carrier air defense section, and/or outranged section)

Carrier air defense: Firing weapons with a long flight time like Tomahawk, could give plenty of warning to vector aircraft to chip away at the salvo. Short flight times means aviation will be hard pressed to provide flexible on demand AAW support against salvos….

Even if you can't assess effects, if you fire a large salvo….you made them waste a lot of defensive firepower and launched a last ditch salvo at a minimum, assuming it's accurate and no airpowe to attrit volume…..comprehensive depletion

Change time-to-target to time-to-impact?

Carrier section: "Lieutenant General Sokerin, once an operational officer on the Northern Fleet NAF staff, always asked the fleet staff 's admirals just to assign him a target, not to define the time of the attack force’s departure; that could depend on many factors, such as the reliability of targeting data or the weather, that generate little attention in non aviation naval staff work.” If you can’t define the timing of the attack, then that’ll make aggregated fires struggle and put more burden on the air wing….less mission planning requirements for using missiles instead of aircraft?

Platforms: Submarine anti-ship missile firepower is stretched extremely thin….talk about how firepower is distributed across these types and classes of ships….are all eggs in one basket? Firepower distribution across platform distribution…..Submarines,, such small magazine size that may have to completely devote their vertical launch magazine to land-attack or anti-ship weapons to have a chance of launching enough volume of fire against high-end targets, even if the submarine earns considerable proximity to the target….

Sequencing section: Similar to how a naval formation must steam at the speed of the slowest ship, an aggregated salvo must combine at the range of the shorter-ranged weapon.**(consider this more..)**....speed allows for more latent threats as a salvo is building….mention hypersonics and sea-based ASBM like China’s Type 55? **Sequencing will be natural unless you want to tightly control positioning….explicitly state the assumption of similar speeds…differing speeds make this very complicated (like combining an ASBM salvo with supersonic weapons)....**

Operations section?: All this complexity of massing fires, sequencing, retargeting, can be made a lot simpler if you can bring a lot of organic firepower to bear in individual formats… Large VLS cells, larger formations of bombers, standalone formations with large amounts of organic firepower…..rather than figuring all this stuff out, send out a big salvo….the bombers of Soviet naval aviation didn’t expect to aggregate their fires with anyone but themselves, but this demanded raids of up to 100 bombers to break through the defenses against carrier battle groups…

Stand-in forces: numerous roles including ISR and air defense, whereas deeper land-based forces like PLA Rocket Force can focus exclusively on managing kill chains for long-range fires, much less concern for managing force survivability…..radar horizon considerations apply to stand-in forces as well, (but they can take higher ground to lengthen the radar horizon) and will often have to rely on aviation for wide-area situational awareness… . But unmanned aviation assets in the proximate threat environment highly unsurvivable and poor ability to defend themselves….will require tactical solutions…. (stand-in can’t produce volumes of fires, they will struggle to sense, they will struggle to resupply)

What you are paying for with additional missile capability: Point defense penetration capability and target discrimination, not damage potential…. (from Mazer)....cheaper to use a few expensive missiles than a lot of cheap ones?

Final conclusion: As navies consider how to develop themselves as they become capable of ever more devastation.

Strategy and Policy: Warfighting concepts can have many aspirational elements. Warfighting concepts whose effectiveness require too many pieces to align are more likely to be brittle and self-defeating. Resilience through simplicity…..how does DMO offer policymakers options short of war, transition into war, transition out of war…..what are the faults and seams that develop if expedience is favored or forced, if mass is favored, if longevity of operations is favored…..are senior civilian policymakers and political leaders aware of just how imbalanced these U.S.-China forces are? Has this factored into their psychology, and their willingness to risk the U.S. Navy? The yawning anti-ship missile gap is a serious threat to the credibility of U.S. security guarantees…. ……how do these forces contribute to enhancing the U.S. position in political-military crises short of war?.....this construct is predicated on an ability to surge a quantity of forces that may be doubtful…..what are the budgetary and political implications for a distributed warfighting doctrine….

Strategy and policy: The challenge of knowing when to commit forces to battle…more flexible with DMO….standoff distances and breaking away from things if needed and dispersing….

Strategy and policy: Critical elements for success can be deprived by specific context and political-military imperatives driven by senior civilian leadership, "most irrational elements of this war plan/force employment is driven by political imperatives" Michael Kofman on Russia-Ukraine…..if policymakers demand that forces move more quickly into a conflict before they achieve a level of mass, etc….1973 crisis and the rules of engagement concern, what if the navies are not widely separated but very close due to posturing in a crisis? How does that affect aggregation potential?.....Political imperatives can demand speed, they can demand you hold your ground when you should retreat, trying to avoid embarrassment, trying to avoid the appearance of being driven from somewhere…..

Defeat in detail….Air defense is already extremely localized by the radar horizon, to concentrate for defensive effectiveness is to ask for a very high degree of concentration….

When coherence is lost, who comes out on top of the melee?

How ubiquitous are sea-skimming flight profiles for anti-ship missiles?

Weapon section: LRASM isn't compatible with launch cells? Built first for aircraft then have to do some weird engineering to make it work for MK41?

surface warships largest volume individually….least dependent on outside fires….

Degradation: What happens if the links are disrupted? What happens if they can't communicate? Does the concept degrade gracefully, or catastrophically? What happens when it descends into a melee, into a free-for-fall, unit-level emissions and fires are employed out of unit-level initiative…..extremely poor distribution of fire, what does that look like when standalone shooters

are firing off of their own initiative? Do they have a broader sense of the other salvos that are in flight and who they are directed at?

Having more launch platforms doesn't just increase the size of the salvos that are possible or the vectors of attack, it allows the distributed force to remain in the fight longer and at scale……..How do two distributed forces counter one another?.......multiple missile salvos directed against a force, prompting last-ditch salvos, which prompt obligatory aggregation, dominos, everyone is trying to fire effectively first, is it really this bad and escalatory? What do the opening shots and transition to war look like? How do you set yourself up for good opening shots, especially with the level of peacetime presence/surge capability that is available?

Does attrition encourage distribution or concentration of remaining assets? You concentrate for pooling defensive capability, you distribute to complicate calculus?

How does defeat in detail work against a distributed force?

Take all Chinese VLS, 50 percent, that's how many missiles it takes? to overwhelm?

Deception and DMO? Making them fire at false contacts? And once your cover is completely blown and all ships' positions are known, how hard of a nut are you to crack?

"Influences and effects beyond ordnance…."

Submarines: Independently can't fire volumes of firepower to threaten modern destroyer-sized warships….unless they get close.

Platforms section: read A concept for stand-in forces, add throw weight table to intro

Tactics: It's hard to know which targets to prioritize when everyone has VLS….you can't tell what offensive payloads they have until they fire them….you have to err on the side of assuming they all have some offensive capability? Only later in engagements can loadouts be ascertained and prompt operational adaptations…..while you want to know what they are packing, you also want to hit them before they fire anything at all…….a DDG fires a large load of ASCMs and empties its magazines of that weapon…..you're just wasting your own ASCMs to an extent…..not only will you need volume of fire to break through remaining air defenses….but once you break through, it's not like you're depriving them of much more offensive capability in the near term……if you're going to go through the trouble of building volume of fire, you ideally want to destroy ships with full magazines……maybe it's unlikely to do this because of last ditch firing doctrines becoming widespread, but there is still value in forcing their hand and prompting less organized fires…….2nd best to destroying firepower in magazines is forcing them to waste their fires in haphazard shooting……very important to have some sense of magazine depletion of the adversary, to measure and sense volumes of fire to understand how the nature of how the hostile force is depleting itself……a depleted naval asset (of offensive weapons) is one that could warrant less tracking and surveillance and therefore reduce the benefits of distribution…..(platform based warfare also faces an important tradeoff, the more time you take to mass forces, the less surprise you can take advantage of, and also giving the enemy more time to mass their forces or to surprise you in turn…..the tradeoff between exploiting initiative versus achieving mass….what balance of these two works well….in the case of distribution/aggregation,....**think more about this….).......**massed fires absolves one of the constants of naval warfare, the lack of a role for reserves…..while more platforms is better for more distribution, firepower and payloads can be held in reserve…..**Distributed fleet formations, how would you actually set this up?.....**linear nature of things, you go after the targets that have the lowest time to strike? How do you set up a distributed fleet formation and what do you prioritize?.......ideal to have shooters on hand who can contribute fires if the planned salvo didn't unfold as believed…..warships may be tempted to radiate if they believe aviation assets pose a risk to the warship's salvos….if a warship wants to be able to cover its own salvo, it will want to be closer to a target and sacrifice much of the range of the anti-ship weapons to…..Volume and Aggregation, what affects what you pull firepower from?.....large volume of fire can betray capability and platform type, aggregation helps maintain an element of obscurity, where an adversary can't be sure if a handful of missiles were fired from a smaller or larger ship, telltale signs, etc….You would not let an enemy get into position to launch these fires and establish these interlocking lanes of fires, attacking effectively first means deploying into battle formation first, and preventing the enemy from doing the same?

Counting on highly classified capabilities working out and using them as a crutch for wartime success is not a feasible strategy, a military still needs viable broad-based tactics and firepower.

Mixing payloads partly because you have to, to achieve overwhelming volumes. But also because it can complicate the calculus of the adversary and make defense more challenging.

900 square miles? It's not a square, it's a circle,....what's the area? 2800 square miles….. If it's 30 mph for a 30 radius….then that has to be an hour flight time….

For platform sections, include the defense and offensive dimensions. Defending Against missile attacks from said platform…..

What does the range of anti-air versus anti-ship weapons imply for the collective magazine?

Platform section introduction: examining the potential of types of platforms for distro and aggro of anti-ship firepower, and roles in DMO.

High powered microwave weapons as point defense?

Make a calculation of how many would be needed to sink the whole Chinese Navy, have some sort of basic formula….

Range is important because maneuver doesn't matter nearly that much in the missile age for ships……theater-level maneuver is tactical maneuver….

Aviation doesn't need to be "gathered" if the weapons are long range enough

If sub force really is all they've got, they will be met by the 120 or so Chinese frigates and corvettes that can be expected to play a major role in PLA asw ops.

Even if one is first to fire, but cannot score hits….there is still meaningful operational value to be gained by depleting defensive missiles…

Weapons section: Include potential weapons, like MALD and microwave missile (?). JASSM-ER is the only modern air-launched weapon of the Air Force that has a range similar to Tomahawk….[modern excludes ALCM). This would make it much easier for aviation to aggregate with MST, rather than having different launch times and aviation lines of departure that are far forward….. [Use reverse range ring graphic and animation to show this…..surface ship launches……bomber has to travel with the missile salvo until it crosses over the threshold of its own weapon's range….]

Even if a salvo is not well aggregated, even if it does not kill the target, it's possible it depleted enough of their air defense weapons to force a withdrawal or change behavior. Or, after having weathered a salvo and calculated that the opposition has depleted a significant portion of their anti-ship weapons, adversaries may feel emboldened.

How would you have done without MST and a lot of surge units? Just a lot of cluster around carriers and some spread out for land attack?

Sensing: It means that targeting information from a single asset, if it can be plugged into a broader network, can be enough to leverage the capabilities of a much broader force….

What happens to a distributed force's ability to aggregate once units are destroyed or deplete their offensive firepower?

Range is resilience in this respect….greater range, greater opportunity to overlap, assuming fires can be effectively targeted and combined…

Doing animations with Nebulous, or with Seapower? Unsure when the latter will come out…..

Contesting links….between concentrated and distributed…..who has the advantage?

U.S. vs. China section: "Tactics must advance from a solid strategic foundation"......if other parts of joint force can take on the LACM burden, USN can focus more on the AAW and ASUW challenges….

Missile section: Is it uneconomical to do topside mounting of missiles ("deck mounted box launchers") compared to VLS? VLS could be more expensive, rather it is inefficient way to mount missiles…..

Doctrine: Is a distributed fleet really a "fleet" in the traditional sense? Not in terms of numbered fleet organizational constructs, but in terms of the fleets that have traditionally gone to war, the massed main battle fleet? Distribution marks a major change in how naval forces organize their formations and fleets, and it reflects a particular philosophy of how fleets should be revolutionized by the missile and networked age of warfare.

How do you handle land-based missile forces…..? You can really target them….you can just affect them by changing your disposition….mainly a question of defense….if a distributed force is targeted completely, the adversary may still hold back on pulling the trigger…..

Consequences of lost communications and unit-level commanders making anti-ship missile decisions? Could waste massive amounts of firepower or fire inconsequential amounts, could amount to very close range attacks (knife fight in a phone booth)......

Destroying a distinct center of gravity causes a force to degrade more catastrophically….distributed can be more gradual….unless many distributed forces are destroyed simultaneously…..(the burden of that? Assess the burden of attacking distributed forces….)

[Section on real-world contingency….aggregated fires are easier in the open seas…..if naval conflict is transpiring within the archipelagos of Southeast Asia, from the Philippines to Australia, surface warfare is more likely to take the form of a "knife fight in a phone booth…" where forces may feel they have to fire as fast as they can to stand a chance….using the Philippines as a launch pad for fires against Taiwan/Philippine sea, similar to Norwegian Fjords concept….account for small-unit actions and aggregation (don't make the interwar period mistake of focusing only on large set-piece battles, consider the potential of future Guadalcanals)....Baltic/Mediterranean……Smaller and more numerous combatants like frigates and corvettes could be sent further afield in the theater and where larger combatants focus on larger fights in the main front….This gives a place for smaller salvos like NSM and Harpoon…]

[End section, is this all too good to be true?] Aggregated fires are very dependent on complex coordination and are extremely sensitive to timing to work. Is this too complex, are these tactics too

brittle, too dependent, where is the resilience in simplicity, and what would that look like? Standalone strike packages?

The shape and signature of an air wing-sized strike against targets…..ties down way too much….it is not as distributed as you would want it to be….Putting all squadrons within 300 miles of a ship…..that's like 45 planes within 300 miles…..that's very concentrated, hardly distributed…..

Firing effectively first….it is better to have ships with magazines empty of offensive weapons and full on defensive weapons rather than the reverse.

Strategyand policy……transitioning into a distributed force and transition to war phase…..what does a distributed fleet look like…. "Fleet-level" warfare is something higher than the CSG…disaggregated operations in the forward area is not anything like DMO…splitting up a strike group so each asset can do low-end missions is a lot different than splitting up the strike group, yet still working the fleet as an integrated weapon systems in a high-end conflict. The difference is stark…..the amount of forward presence the Navy has in the Pacific constitutes the bare bones of a distributed fleet (find these numbers….how many ships are deployed and forward stationed in the Indo-Pacific….wikipedia suggests there are 11 large surface combatants in Yokosuka….SURFPAC homeport index…21 LSCs from Pearl to Japan….).....tattletales…..war opening first salvo

Conclusion….it is not enough for debates to be theoretical, to stay at the vague level of missions, the nature of specific tactical and operational employment is a core crucible through which things must be validated, argued…. "Tactics quote from Wayne Hughes"

False Allure of push-button, checklist warfare…..too neat and tidy….unimaginative operational and tactical thinkers who simply think winning naval campaigns is a matter of organizing overwhelming firepower.

Strategy and Policy: DMO and irregular forces, maritime militia and chinese merchants, gray zone operations….DMO and deterrence (by denial or punishment) and graduated escalation or posturing (surging a flotilla of small missile combatants could come across as more escalatory than fielding the equivalent firepower in a few destroyers (?)….deployment tempos and surge…..being ready on Day 1 and forward presence….allied dimensions, contributions, etc…..impact on maritime shipping and global issues…..

Defensive drawbacks: How well can you really aggregate for self defense in the face of sea-skimming threats… (NIFC-CA can change this)....CEC can work but only to a limited extent because the missiles are semi-active and still need illumination.....and even if you could aggregate heavily, you lose economies of force for defensive firepower. If you want to be close enough to pool softkill countermeasures….then that's really close aggregation….

Interior versus exterior lines of maneuver in assembling aggregated salvos?

Crossing the T of a naval formation….consider how small combatants would have to be form up around a large combatant to maximize air defense coverage….would the missiles see the formation, and not go directly for it, but choose to attack it at an angle that minimizes the overlap and density of defensive capability they would have to break through?

Higher echelon authority as a weakness….how do you aggregate effects with disaggregated authorities? A central brain is a weakness….how do you decide who gets to call in all that firepower from all those units?

Shorter-range missiles: But also many of the Navy's shorter range missiles that can be fired from ships (like Harpoon and NSM) are only carried in very small quantities because they are not VLS compatible. This makes them the missiles that would be most dependent on outside aggregation to achieve effective volumes of fire.

Contesting large-scale Land-based anti-ship fires: They can overwhelm you and destroy you. They can find you and detect you. Distribution introduces pause left of firepower, left of detection and sensing, and tries to make an adversary hold their firepower through uncertainty, even though they can be certain in their ability to find and destroy individual naval formations at will. [Read the battleship versus chess piece]

Should HELIOS really be mentioned? Seems more technically limited…here: https://www.usni.org/magazines/proceedings/2022/july/now-arriving-high-power-laser-competition

Air Force ACE doctrinal document: About distribution of assets to improve survivability….

NIFC-CA and the radar horizon problem….still requires aircraft….but could allow for ships to mutually support each other defensively…..

Nuance: Differentiate overly aggressive versus overly cautious behaviors

DMO on DMO fleet combat? Two distributed forces doing this against one another….

You can kill a ship by: firing enough missiles that they run out of air defense hardkill weapons….firing enough missiles that their hardkill air defenses get overwhelmed…being able to mass effects in a timely fashion is a more efficient solution…..

If a ship manages to evade torpedo strikes, it can still remain a credible combatant….if a ship survives against an intensive salvo, it may have to be withdrawn because of depleted ammunition. What percentage

The wider the potential saturation pattern of a responding last-ditch salvo, potentially more fuel will have to be burnt to attack at a greater offset angle, so they don't snapshot the last-ditch salvo on a viable bearing

EW, laser dazzler softkill point defenses great unknown….how effective will they be? They could prove decisive, even revolutionary….because why? Because even if a ship depletes its defensive weapons, it can still remain in the fight because of highly effective softkill defenses….softkill defenses also may not produce the lethal shrapnel effects of nearby missile detonations…

Combined arms relationships are best described as a narrative, a sequence of events and tactical behaviors, consecutive or in parallel…..recall the examples from *Dying to Learn* and Jonathan House book….

The messiness of trying to coordinate bombers with warship strikes….bombers hold enough that if you get just five or six together, that's enough to launch a threatening salvo from a standalone strike package…..what other platforms have enough magazine depth to form standalone strike packages? Surface ships yes….alone submarines hardly…..air wings yes but not worth it….stand-in forces probably not…..china's land based forces yes….**[add to volume generation table]**

[Who fires first and second section]. Aggregating fires means some forces will have to wait for other forces to hurry up.

"this problem is often referenced as '5th generation aircraft carrying 3rd generation munitions'"

Surface warships and submarines can still be something of use even if they are out of anti-ship missiles, so long as they still have torpedoes or AAW capability….bombers once they are out of anti-ship weapons, they should be immediately pulled from the fight to rearm…..

[Where you talk about small ships not being a threat on their own\ Similarly, if a larger ship is low on magazine inventory, it still cannot be discounted as a threat, because of the potential for aggregation….

Expending AAW missiles of a ship, forcing them to do that, is that a mission kill if it takes them out of the fight? This is why decoy missiles can be so valuable…..they can not only enhance the survivability of a salvo, they can force the defender to waste a lot of precious missiles…..

Stand-in forces and submarines forward most sea deniers, how can we make them work together?

If a salvo is launched and detected, there may be uncertainty as to where other contributing salvos may come from, even if potential launching assets are known in advance. Who is going to contribute to the salvo, and where from? What about submarines? What if airpower is tied down by attempting to take out a salvo from one vector, opening up another vector to attack? What if the possibility of multiple vectors/waypoints constrains airpower's ability to push out the distance at which it can intercept salvos, reducing the amount of opportunity to diminish those salvos?

Defensive EW and certain softkill systems can effectively blanket an area regardless of the number of incoming missiles….saturation in this respect…

Playing defense against aggregated fires.....DMO has critical defensive and survivability elements, which is arguably its major logic based on public statements.

How is China and Russia poised to execute this tactic?

The overarching narrative and log line for DMO: The Navy of a maritime superpower is developing a novel operational concept to deter or fight the Navy of another maritime superpower in its adjacent waters. This concept is to ensure relevance....and to take advantage of new capabilities....

Submarines: can be helpful in cueing fires……but again, it a sub can cue a fire, easier to just use torpedoes….subs can help with battle damage assessment….

Dynamic interplay between missile seekers, the autonomous logic that leverages info from those seekers, and various defensive systems…

Even if surface forces have little in the way anti-ship weaponry, they must be honored as a threat if they possess long-range land-attack missiles. Even if the U.S. surface fleet at present has little capability to threaten enemy warships, it can still threaten to bring significant precision bombardment to bear on China's territory, including its major naval bases, shipyards, and shore infrastructure. Likewise, China's Navy can bring similar capability to bear against U.S. allies.

The Navy needs to distribute striking power partly because its main ability to strike ships with missiles is concentrated in carriers…..which cannot be confidently sortied forward enough to do these things…

Various axes of fires….airpower is the great challenge in terms of which vector for a contributing salvo may be put at risk dynamically….warship missile defenses are relatively static and cover 360 degrees [but dazzlers, RAM, EW? What is directionally limited?]…..vectoring airpower is the only way a commander can dynamically reinforce warship defenses in a timeframe that is tactically meaningful against speedy incoming salvos.

Aviation line of departure animation: range rings and lines for warship range, line of departure, and line of fire for aviation….warship is ready….ready….ready while aviation is being gathered at the line of departure…..line of departure is crossed by aviation, launches MST….MST in flight……planes fire at their line of fire….overlap over target

Assess DMO aggregated land-attack fires……..

Defending Against DMO aggregated fires……..

DMO Series Follow-On Efforts

- Analytics check
- Chinese readership, citation and sourcing
    - Ask experts to see if these articles or my name were read or cited somewhere
        - Toshi Yoshihara
        - Ryan Martinson
        - Conor Kenedy

Readings

Priority

Decision-centric warfare

Decision-centric warfare 2

Distributed Maritime Sensors

Maritime Competition in a mature precision-strike regime

Carrier survivability article.

Regaining the high ground 2

Regaining the high ground 1

Inventory management and effects on strategy part one and two

How a destroyer responds when it is shot at

Jeff Kline's recommended study on distributed firing

How does someone defeat massed fires and DMO? "How does Saddam win?"

Chinese Lessons from Pacific War

Navy electronic warfare systems (multiple pieces from The Drive)

Major Naval Operations by Vego

Maritime Deception and Concealment

NPS Thesis on DMO and Unmanned

Definitions

DMO Hard to find

DMO Breaking Defenses

China DMO

U.S.-China systemic conflict

Ops/Tactics

Tomahawk DTIC

JHUAPL Tomahawk

Case for carrier-based UCAV CSBA

MOC Salvo Equations

Air defense of the carrier task group

Defending against hypersonics CSIS

NWP 3 Fleet Warfare (See 9/27 email)

Galdorisi AAW missile series
Agile Wargaming (3-part series)
USNI Tactics Wheelhouse Book

General

Taking Back the Seas

What was Nimitz thinking?

Teaching naval tactics through wargaming

Photos

F-35
Carrier stern
E-2
E-2 - 2
Eyeglasses
Eye glasses 2
Carrier full deck
Submarine
Amphib assault ship
PLAN Decoy firing
PLAN Decoy firing
Submarine pt. 5 cover image
LCS
DDG
ASROC launch (Pt. 4 cover image)
SM-6 missile launch (Pt. 2 cover image)
VLS reload (caption)
VLS reload
Bomber over ocean

Carrier (Pt. 7 cover image)
Carrier 2
DDG live fire (Pt. 3 cover image)
Cool Chinese Navy photo album
Distribution Pattern 2 (Part 1 featured image)
Distribution pattern
Distribution pattern 3
Submarine harpoon loading (Pt. 5)
Zumwalt live fire
Zumwalt
Nice amphib
Nice LCS bridge

China Type 55
China Type 55 and 54
China YJ-12 photo
Chinese bombers

Second steam account for Nebulous animations: Neboolus1

Animations (Best versions, all Gyfcat links are now broken)

Part 1

Nebulous1 Overkill via Combined Naval Defense
Link: https://gfycat.com/amusingancientafricancivet
Embed Code: <iframe src='https://gfycat.com/ifr/AmusingAncientAfricancivet?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous1 Concentrated Fleet Missile Aggregation
Link: https://gfycat.com/clearsourantipodesgreenparakeet
Embed Code: <iframe src='https://gfycat.com/ifr/ClearSourAntipodesgreenparakeet?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous1 Distributed Fleet Missile Aggregation

Link: https://gfycat.com/sociablecheeryemperorshrimp
Embed Code: <iframe src='https://gfycat.com/ifr/SociableCheeryEmperorshrimp?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Part 3 Assembling Mass Fires and Modern Fleet Tactics

Nebulous3 Fast and Slow Missile Aggregation
Link: https://gfycat.com/caringspryindusriverdolphin
Embed Code: <iframe src='https://gfycat.com/ifr/CaringSpryIndusriverdolphin?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 Waypointing to Prevent Interruptive Strikes
Link: https://gfycat.com/lightheartedforsakenanophelesmosquito
Embed Code: <iframe src='https://gfycat.com/ifr/LightheartedForsakenAnophelesmosquito?hd=1 frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 Fully Waypointed Mass Firing Sequence
Link: https://gfycat.com/farslipperybream
Embed Code: <iframe src='https://gfycat.com/ifr/FarSlipperyBream?hd=1frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 Waypointing to Feint Origins of Fires
Link: https://gfycat.com/periodicdentalkissingbug
Embed Code: <iframe src='https://gfycat.com/ifr/PeriodicDentalKissingbug?hd=1 frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 More Predictable Mass Firing Sequence
Link: https://gfycat.com/graciousunequaledbeaver
Embed Code: <iframe src='https://gfycat.com/ifr/GraciousUnequaledBeaver?hd=1 frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 Less Predictable Mass Firing Sequence via High/Low Payload Combo
Link: https://gfycat.com/loneplayfulcatfish
Embed Code: <iframe src='https://gfycat.com/ifr/LonePlayfulCatfish?hd=1 frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 Recovering Lost Volume of Fire
Link: https://gfycat.com/tautindelibleanemoneshrimp
Embed Code: <iframe src='https://gfycat.com/ifr/TautIndelibleAnemoneshrimp?hd=1frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous3 Interruptive Strike Against Waiting Archer
Link: https://gfycat.com/revolvingsimilarafricangoldencat
Embed Code: <iframe src="https://gfycat.com/ifr/RevolvingSimilarAfricangoldencat?hd=1" width="640" height="404" frameborder="0" scrolling="no" allowfullscreen="allowfullscreen"></iframe>

Part 4 Weapons Depletion

Nebulous4 Last-Ditch: Prompting Last-Ditch Salvos via Waypointed Feints
Link: https://gfycat.com/wideeyedgrossatlanticbluetang
Embed Code: <iframe src='https://gfycat.com/ifr/WideeyedGrossAtlanticbluetang?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Part 5 Salvo Patterns

Nebulous5 Shape: CIWS versus stream salvo
Link: https://gfycat.com/defenselessunrulyfieldmouse
Embed Code: <iframe src='https://gfycat.com/ifr/DefenselessUnrulyFieldmouse?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous5 Shape: CIWS versus saturation salvo
Link: https://gfycat.com/bowedpepperybanteng
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Nebulous5 Shape: Stream Salvo Pattern
Link: https://gfycat.com/impartialfailingatlanticridleyturtle
Embed Code: <iframe

src='https://gfycat.com/ifr/ImpartialFailingAtlanticridleyturtle?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous5 Shape: Stream Salvo Seeker Profile
Link: https://gfycat.com/keenlimitedamazontreeboa
Embed Code: <iframe src='https://gfycat.com/ifr/KeenLimitedAmazontreeboa?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

Nebulous4 Shape: Stream Salvo Waypointing
Link: https://gfycat.com/coldspanishbluebottlejellyfish
Embed Code: <iframe src='https://gfycat.com/ifr/ColdSpanishBluebottlejellyfish?hd=1' frameborder='0' scrolling='no' allowfullscreen width='640' height='404'></iframe>

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Awaiting to hear back from

Dan Simons DMO series and ONR maritime fires program office (6/13)
CDR Genest on DMO series and Maritime Fires Course (6/13)
Col Rauscher DMO series and Army Fires Center of Excellence (6/13)
Col Lee DMO series and Army Fires Center of Excellence (6/13)

2023

JR Dinglasan on SMWDC consideration (12/6)
William Backsheider on Army LDS course interest (11/21)
SMWDC on Re-Blue event DMO presentation idea (11/6, 10/25)
Mark Gunzinger (10/19)
Jeff Kline/Randy Pugh on NPS Makalapa course adoption idea (8/26)
Benjamin O'Donnell EWS syllabi adoption idea (6/29)
Megan from Air University on possible interest (6/28)
Sam Tangredi on black book idea (6/28, 6/12)
LtCol Van Zummeren/Craig Giorgis MCU SAWS syllabi adoption (6/19)
Bryan Clark on improving series reach (6/16)
Tom Culora on course adoption ideas (3/6)

Gene Kamena and Joint Warrior Studies Seminar (11/6, 10/19)
Capts Baker and Dradzynski Air War College (11/6, 10/19)
Michael Bratton UWDC (7/17, 6/29)
Capt Clark on SMWDC interest (7/17, 6/28)
Capt Pops on NAWDC interest (6/28)

Peer Review (Archived)

Dave Fields **(accepted)** (11/13)

Barney Rubel **(accepted and feedback given)** (12/16)
Jon Solomon **(accepted and feedback given)** (11/18)
Jeff Kline **(accepted and feedback given)** (11/14)
Frank Hoffman **(accepted and feedback given)** (11/12)

Matt Danehy **(had to decline)** (11/14)
James FitzSimonds **(had to decline)** (11/16)

Peer Review Feedback

Frank Hoffman

- Review his attachment for in-text comments
- Read his suggested readings on defeat mechanisms
-
-

Jeff Kline

- Read his NPS attachment, and consider his arguments for the force structure section
-

Jon Solomon

- Review his attachment for in-text comments

Barney Rubel

- Read his 12/15 and 12/16 emails for comments.

Introduction

Modern naval combat can consist of forces firing dozens if not hundreds of missiles at one another's fleets and salvos. These volumes of fire can be unleashed within mere minutes as forces look to launch offensive and defensive salvos that are large and dense enough to kill and defend warships. Yet these sophisticated weapons are available in limited numbers and require long lead times to produce.[1] Only a fraction of these inventories are available for immediate use given how the magazines of the operating force's platforms are distinct from the weapon stocks they draw from. Militaries can be limited to using the weapon stocks they had shortly before conflict broke out, and a short conflict may be decided by what was mainly fielded in platform magazines. Unless the conflict becomes especially prolonged and the industrial base grows significantly, the inventory of precision weapons will steadily diminish and pose critical constraints. A core operational challenge is how to carefully manage weapons depletion while still unleashing massed fires.

Weapons depletion is in its own right a powerful force for shaping warfighting behavior and securing major operational advantage. The larger consequences of depletion can include steep decreases in unit availability and overall operations tempo on a theater-wide scale. This challenge is especially severe for the U.S. Navy given how long it would take a depleted U.S. warship to travel out of a Pacific battlespace, rearm in safe havens, and return to the fight.[2] In a short, sharp conflict featuring intense salvo exchanges, a warship that depletes itself only once may very well miss the rest of the war.

The concentration and distribution of a force will flex and evolve as its platforms suffer depletion. As commanders look to employ mass fires, they must be mindful of how to spread depletion across the force, how to interpret the adversary's expenditures, and how inventory pressures can be manipulated through the last-ditch salvo dynamic.

Distribution and Depletion

One of the critical advantages of massing fires from distributed forces is the ability to more effectively manage depletion. A distributed force fielding a vast array of overlapping firepower makes for an especially large and shared magazine. This offers a much greater chance of mustering enough firepower to overwhelm robust defenses while achieving a better spread of depletion. Depletion can be spread across a broader scope of platforms and occur more gradually across the force, rather than all at once for individual strike platforms and force packages. Spreading depletion prolongs distribution, because every depleted asset makes the remaining force less distributed and more concentrated.

Some platforms and force packages certainly have sufficiently deep magazines to launch large enough volumes of fire on their own, with less of a need for outside contributing salvos. But large standalone salvos diminish a core tenet of distribution – maintaining many spread out threats to complicate adversary targeting. Forces that fire large standalone salvos can quickly give away that they just depleted most of their offensive firepower, reducing their value as targets and diminishing the distribution of the broader force.

The more a platform has to discharge a large number of missiles to contribute fires, the more easily an adversary can ascertain the composition and depth of their remaining inventory. A U.S. destroyer that fires 30-40 Maritime Strike Tomahawks in a single large salvo can give away that it has little remaining long-range anti-ship weaponry. By comparison, massing fires from a broader array of distributed forces makes it harder for an adversary to ascertain when platforms and formations have depleted their individual magazines.

Aggregation allows firepower to be combined in smaller portions from individual launch platforms. Ideally each launch platform can afford to expend only a small fraction of its magazine at a time, if many other platforms are doing the same with proper timing and coordination. Individual platforms will be able to sustain distributed offensive threats for longer than if they had fired off large, independent salvos of their own.

However, as inventory begins to dwindle across a distributed force, mass fires can cause larger portions of the force to reach the end of their magazines around a similar timeframe. This could radically collapse the offensive posture and capability of the distributed fleet if not carefully managed. By delaying magazine depletion at the individual platform level, mass fires risk magazine depletion across a broader portion of the force at a later time.

Consider a fleet that has four distributed warships available for contributing fires. If one warship emptied its entire offensive inventory per strike, then the remaining force becomes increasingly concentrated and predictable as to where the next several strikes may come from. Instead, if those four warships combine fires to launch a quarter of their offensive inventory per strike, the distributed force posture endures for more time and across more attacks. But all of those warships would deplete at a similar time, triggering a larger drop in force distribution compared to depleting only one platform per strike through the first scheme. By spreading depletion to prolong distribution, mass fires trade smaller decreases in distribution earlier in the fight in exchange for larger decreases later on.

Having deeper magazines or more strike platforms reduces the share of magazine depth each attacker must deplete to contribute to mass fires, and further delays the broader depletion of the force. A distributed force posture can be preserved by having a large number of assets with overlapping firepower, or rotating assets quickly enough to replace those that have depleted their magazines. The goal is to maintain enough available firepower over time so the distribution of the force can endure.

Asymmetric Weapons Depletion and Operational Risk

There are important asymmetries in how warships can deplete their offensive missile firepower versus their defensive firepower. One asymmetry is that commanders may be deeply uncomfortable keeping large surface warships in the battlespace when they are low on defensive firepower but fuller on offensive firepower compared to the reverse situation. Another key asymmetry is that defensive firepower is mostly drawn from the local magazines of the naval forces under attack, while offensive firepower can be drawn from the many magazines of a broader distributed force. Leveraging these key asymmetries can secure operational advantage.

Even if a ship survives an intense attack, being on the wrong side of firing effectively first can take the form of being low on defensive firepower while still full on unused offensive firepower. These units can still remain offensive threats, but the volume of fire required to overwhelm their defenses is substantially lowered. This can force commanders to pull these units out of the fight for the sake of survival and replenishing their defenses.

In this sense, firing effectively first is not only defined by scoring successful hits and kills, it can also mean depleting enough of the adversary’s defenses that commanders no longer feel confident in pressing their attack or maintaining warships in a contested battlespace. If those depleted warships are in escort roles and are responsible for defending other ships, then those ships could be forced to withdraw as well. By depleting defensive firepower to the point that warships must be withdrawn before they can attack, those warships’ offensive inventory can be removed from the fight before it can be used, thereby suffering depletion indirectly.

The battle of nerves in naval salvo warfare is partly a function of accepting risk for the sake of minimizing weapons depletion. A more efficient missile exchange tolerates more risk, demanding stronger nerves on the part of commanders. Otherwise, the desire to build more confidence into offensive or defensive engagements can make commanders waste their munitions. A defending warship that fires too many anti-air weapons per incoming missile wants to bolster its odds of near-term survival, but it can deplete itself earlier than warranted and increase risk in follow-on engagements. A warship that fires an excessive amount of anti-ship weapons can risk too much overkill and leave it with little offensive capability for later in the fight.

But commanders who attempt to precisely optimize their offensive salvos in a bid to just barely overwhelm targets with enough fire will risk much greater uncertainty than those willing to accept overkill by expending more volume. Indeed in a form of combat featuring salvos with dozens of missiles that only need to strike a single hit, overkill is more likely than not. Instead, it is the degree of overkill that separates what is sufficient from what is wasteful. Achieving a small degree of offensive overkill can be the more efficient outcome, since attacking with an insufficient volume of fire can lead to waste by making follow-on salvos once again pay the price of breaking through strong defenses to threaten a target. With too much overkill, a unit or commander witnessing a heavy volume of fire pouring into a dead or dying friendly warship may take some small satisfaction in knowing the enemy just suffered depletion far out of proportion to their target.

A key asymmetry is how the risk of depletion through overkill is much more manageable for offensive fires because of the greater ability to mass those weapons from across many forces. Defensive inventory has far less margin to work with because of the isolating effect of the radar horizon on ship self-defense, where there is little ability for ships to leverage a broader shared magazine against sea-skimming threats. An attack on a naval formation can consist of fires pulled from a wide variety of forces, but the formation will often have only its own magazine to defend itself. And with that magazine, the formation may not only have to match the incoming volume of fire, but exceed it to ensure survival. Matching the attacking volume with only one interceptor fired per incoming missile may not be enough to confidently survive a dynamic where a warship cannot afford to take a single hit, yet the attacker can afford to have every attacking missile take a hit except one.

For defensive volume of fire, there can be a thin line between what is sufficiently dense and what is wastefully excessive. Firing just one more interceptor per incoming missile can dramatically increase expenditure in a single engagement and result in a warship facing follow-on threats with a far more depleted magazine. But as mentioned, defensive depletion not only increases risk to the individual platform, it threatens to take that platform’s offensive fires out of the fight prematurely. The broader offensive inventory that is available for massed fires can therefore be threatened by the localized manner of defensive engagements and their especially depleting nature.

Range advantages convert to depletion advantages, where forces with longer-ranged weapons can inflict asymmetric depletion against their shorter-ranged opponents. These threatening dynamics are more probable for navies that can be up against anti-ship weapons with much greater ranges than their own, such as the current range disparity the U.S. Navy is suffering against many Chinese anti-ship missiles.

If two opposing forces have a major disparity in the range of anti-ship weapons, then the forces with less range can be forced to travel hundreds of miles while under fire before they can finally be in a position to attack. These warships can be depleting their defensive firepower while still pressing forward in an increasingly risky bid to bring their offensive firepower to bear. By comparison, the longer-ranged side will deplete far fewer defenses to make their attacks, if they have to deplete those defenses at all. Warships with a significant offensive range advantage are not only in a much better position to fire first, they can fire their salvos and then simply reverse course to keep themselves out of reach while preserving their defensive firepower. The outranged fleet can be pressing forward without much of its defensive firepower left, while the other fleet can be in the much more comfortable position of pulling back with most of its defensive firepower remaining. It is unlikely that the fleet with shorter-ranged weapons would be in a position to catch up to the opposition in many circumstances. Because of the vast distances involved and the large speed differential between anti-ship missiles and warships, it seems improbable that surface warships will run each other down on the open ocean in the age of missile warfare.

Increased payload range can also translate into increased reload speed, where shifting more of the burden of maneuver onto the payload shortens the logistical lifeline of the platform. The longer the range of the weapon, the less the platform has to travel between its launch areas and rearmament points, shortening the episodic drops in force distribution while offering higher rates of fire. This effect is especially potent for aviation, such as how aircraft firing JASSMs at 230 miles can have much lower reload rates and availability of fires compared to aircraft firing the 1,000-mile extreme range variant of JASSM (Figure 1).[3] An asymmetry in weapon range between opposing forces can translate into asymmetry in reload speeds, and make the distribution of a force more resilient against depletion than its adversary's.

[caption id="attachment_56685" align="aligncenter" width="708"]

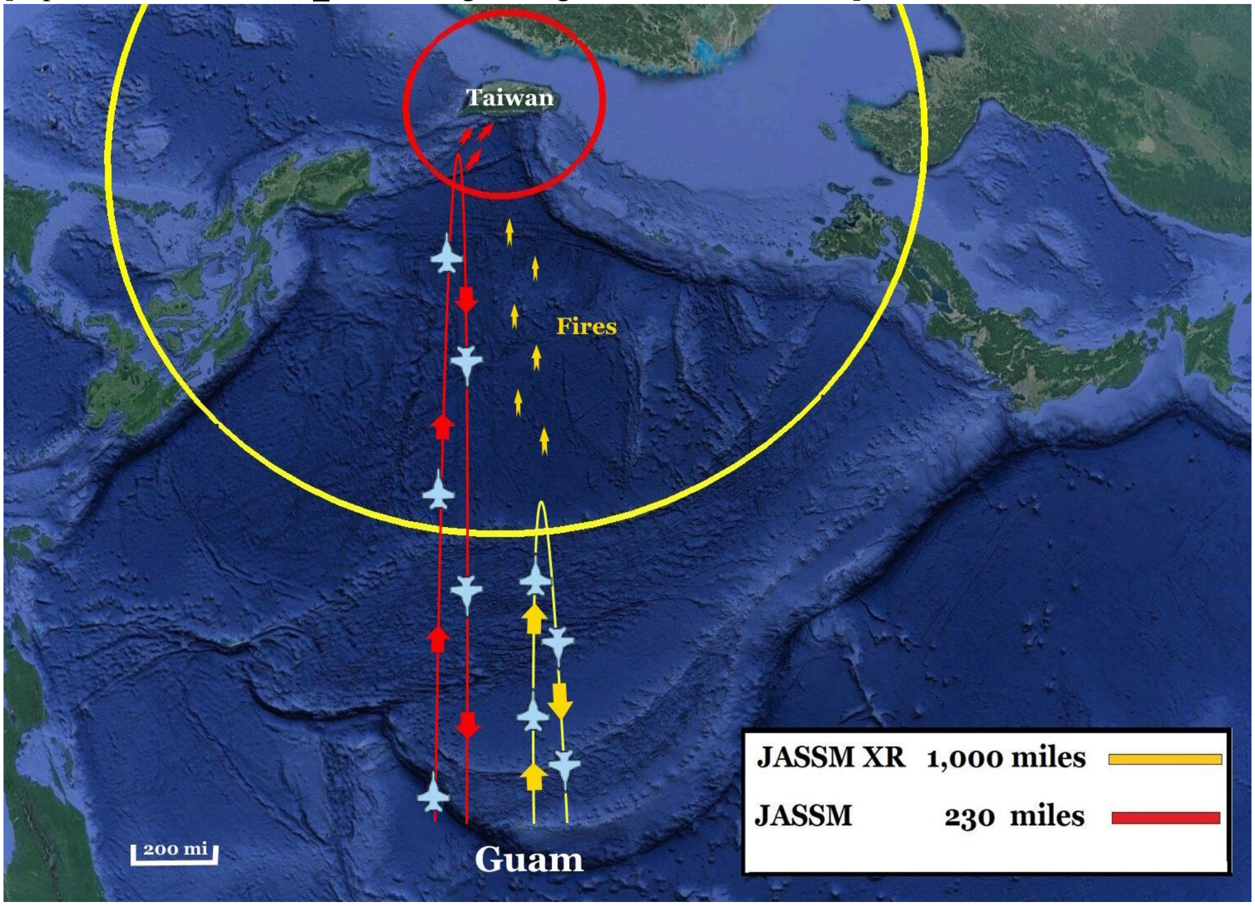


Figure 1. Reverse range rings centered on Taiwan illustrate the area from which targets on the island can be fired upon by 1,000-mile and 230-mile variants of JASSM. Aircraft firing the longer-ranged variant can benefit from shorter journeys between launch points and airbases, such as those on Guam, allowing for quicker rearmament, more enduring force distribution, and higher rates of fire. (Author graphic)[/caption]

Massed Fires and Uneven Depletion Across Platform Types

As waves of massed fires ensue, the distribution of depletion across the platforms of a force can become uneven. A distributed force may prefer to prioritize its longest-ranged fires, its most common weapons, or other payloads for other reasons, which depletes the specific platforms that launch them. This sets the stage for operational tradeoffs and an evolving risk profile, since one type of platform's fires can preserve the inventory of another's, and different platforms have different magazine depths and timeframes for reloading. Uneven depletion can gradually shift the burden of massing fires onto platforms that must assume more risk to continue the fight, encouraging a force to carefully consider how to distribute weapons depletion across platforms over time.

The anti-ship Tomahawk will offer long range and broad magazine depth across many platforms, making it an ideal weapon for massing fires. But heavily prioritizing the use of the anti-ship Tomahawk can make surface forces and submarines among the first to deplete their anti-ship missile inventories, and where these platforms can take many days to reload and return to the fight. The weapons that can contribute the most to mass fires can suffer the most depletion, putting the distribution of the force at risk down the line.

As the fight continues and warships become more depleted, more of the U.S. burden of assembling mass fires against warships can gradually accrue to aviation because aviation can reload much faster than warships. This is especially true for carrier air wings, and carriers have the deepest magazines of all afloat combatants, potentially making them the last warships standing when it comes to remaining inventory after intense exchanges.[4] Yet this would pose an especially concentrated posture to an adversary and force air wings to take major risks in deploying the remaining firepower. Preserving the anti-ship inventory of warships is therefore critical in forestalling a need to rely more heavily on aviation-based strikes, which would tie down numerous aircraft to muster volume of fire, pull carriers deeper into the battlespace, and assume more risk.

Yet this relationship is paradoxical. Preserving warship-based inventory can also take the form of leaning more on aviation fires earlier in the fight. Therefore a balance can be defined between the proportion of fires to come from different platform types at different phases of the fight, in order to manage how the risk profile of depletion evolves. A commander that carefully balances a combination of air wing depletion and warship depletion earlier in the fight can better delay the prospect of air wings shouldering more of the burden. Or a commander could heavily favor bombers in the opening phases, which can preserve warship-based fires for later phases, which preserves carriers. Depletion does not necessarily mean firing options have to get far worse as time goes on, depending on how commanders balance risk with regard to what combinations of launch platforms they favor depleting at different periods of the fight.

Submarines offer one of the most critical advantages in managing depletion through the highly favorable tradeoffs that come with sinking ships with torpedoes instead of missiles. The undersea domain is far less saturated with warship defenses compared to above the waterline. The cost of a missile salvo large enough to credibly threaten a group of several warships could easily exceed $100 million and require expending dozens of missiles.[5] Credibly threatening the same group would require only several torpedoes, which could cost ten percent or less of the missile salvo.[6] A single lethal torpedo strike can substitute for the dozens of missiles that could be required to overwhelm the same warship from above water.

By sailing far into contested littorals and laying near ports, bases, and maritime chokepoints, submarines are much more likely to be in a position to sink ships with fuller magazines compared to other platforms and deprive the adversary of inventory. However, closing the distance for torpedo strikes increases risks to submarines. The operational implications include weighing tradeoffs in the amount of risk commanders are willing to accept for their valuable submarines, versus the risk that could be incurred by depleting the broader missile magazine of the distributed force. Risking submarines in torpedo attacks can spare broader missile inventory and vice versa.

Aircraft and ground-based launchers certainly carry far fewer missiles per loadout compared to a large surface warship. Their shallower magazine depth substantially shortens the interval between launching fires and reloading, even if each of their fires is limited to a few missiles. But these platforms can typically access weapons stocks to rearm at a fraction of the time it takes a warship to do the same. Their shallow magazine depth can make their availability for fires more episodic than warships, but their episodes of depletion are not nearly as steep or prolonged. Land-based forces in the form of Chinese launchers on the mainland would have particularly more endurance than expeditionary stand-in forces that heavily depend on lengthy logistical lifelines to sustain their fires in a long fight.

The nature of uneven depletion will make for especially challenging command decisions. Commanders may face pressure to maintain depleted assets in the fight for the sake of posing some semblance of a distributed posture to the adversary. Commanders weighing such decisions would have to consider whether the adversary’s tracking of expenditure may have been accurate enough to provide the critical insight that portions of the distributed force are depleted. Operational behavior may significantly change based on one’s estimate of an adversary’s depletion and if asymmetric depletion has emerged between opposing forces.

Tracking adversary depletion is a critical operational imperative, but the desire to understand the specific composition and volume of missile salvos can place major demands on ISR and decision-making. Forces may struggle to distinguish between different types of anti-ship or anti-air missiles at long range and in the midst of battle. But knowing the type of launch platform narrows down the potential type of fires, where the tracking challenge is simplified by how certain weapons are exclusive to certain kinds of platforms. An F/A-18 firing on a warship is most likely firing Harpoons or LRASMs, and a Chinese warship firing on a ship is most likely firing YJ-83s or YJ-18s. Weapons that have longer range and are compatible with a broader variety of launch platforms will complicate the adversary’s ability to track expenditure and form estimates of depletion.

Defying Destruction and the Last-Ditch Salvo Dynamic

The adage of "firing effectively first" may be better described as striking effectively first, since two opposing naval formations can still destroy each other even if one fires after the other. In defining what it means to fire effectively first, an ideal kill of a warship or platform can include putting it out of action before it had a chance to use its offensive firepower. Similar to how it would be ideal to destroy a carrier while it is still embarking its air wing, it is ideal to destroy a warship before it has depleted its magazine of offensive missiles. This creates profound psychological and operational pressures that come into play when commanders of individual platforms and formations feel on the cusp of being destroyed. The critical phenomenon of last-ditch fires can threaten to destabilize distributed fleets and massed fires.

Commanders can be extraordinarily pressured to unleash most if not all of their offensive firepower if they believe there is a real risk of imminent destruction. Once a ship or fleet realizes that a potentially fatal salvo is incoming, enormous pressure can quickly force commanders to discharge their offensive firepower soon or else risk losing it permanently. Similar to how a carrier commander would be tempted to launch the air wing before the salvo hits the carrier, warships can make similar decisions with their missile magazines.

Last-ditch salvos are meant to deny the enemy one of the most critical benefits of firing effectively first. Launching a last-ditch salvo right before ships could be destroyed gives those offensive weapons a final chance of somehow contributing to the fight and deprives the adversary the benefit of sinking ships with fuller magazines. Last-ditch fires aim to ensure that archers are never destroyed before they can fire arrows. Concerns over losing limited weapons inventory are sharply intensified by lethal inbound salvos, making the last-ditch salvo a critical protocol for making the most of friendly losses moments before they are incurred.

A last-ditch anti-ship salvo cannot be an act of self-preservation. Commanders can be completely confident that an incoming salvo is dense enough and capable enough to overwhelm their defenses and destroy their warships. Launching their own anti-ship salvo in response is not going to change such an outcome. Anti-ship missiles cannot save warships from anti-ship missiles that are already incoming. These weapons can only save warships from anti-ship missiles that have yet to leave their magazines.

Many platforms that can threaten warships with anti-ship missiles cannot be threatened by those same missiles in return. This creates an asymmetric dynamic where some forces can enhance the effects of distribution by threatening to trigger last-ditch salvos that are futile. Since airborne aviation, submarines, and land-based forces cannot be directly attacked by anti-ship missiles, a warship launching a last-ditch salvo could very well be firing at perceived targets it can do nothing against. Even a single incoming torpedo from a submarine attack could trigger a last-ditch salvo fired in futility. Warships must strive to maintain awareness of candidate targets they can actually threaten with last-ditch salvos if a fatal attack comes from a domain they cannot effectively retaliate in.

A last-ditch salvo may be fired despite a lack of quality targeting information, since the method of simply firing down a line of bearing suggested by the incoming attack may be more than enough for a desperate warship. But warships ideally need broader situational awareness to launch effective last-ditch salvos, and especially to know whether they are under attack by a last ditch salvo themselves. If a warship does not recognize it is facing down a last-ditch salvo and simply reciprocates the attack, it could be firing on a warship with an empty magazine or even a warship that was already destroyed minutes earlier. This is even more wasteful than firing on a depleted warship, and a worthy result for warships whose final actions caused an adversary to waste precious firepower.

Last-ditch salvos are therefore a double-edged sword. This desperate act is meant to prevent precious weapons inventory from being permanently lost, yet this desire can be manipulated to prompt wasteful fires. An adversary can be made to take self-defeating actions in the crucial battle of nerves that infuses salvo warfare.

The simple appearance of an inbound volume of fire can be enough to trigger last-ditch firing protocols. Weapons with longer range and waypointing ability will have more opportunity to feint attacks on the way to their true target, multiplying the combat potential of salvos. If a weapon has enough range, attacking salvos may be waypointed to appear to threaten multiple targets in succession and provoke last-ditch fires from each (Figure 2).

Figure 2. A waypointed salvo triggers last-ditch fires from multiple formations by feinting attacks along the way to its true target. (Author graphic via Nebulous Fleet Command)

The U.S. may eventually have a substantial advantage in this regard by fielding a cruise missile with especially long range. The Tomahawk has enough range to where a salvo can threaten multiple naval formations through waypointed feints, even if those formations are distributed across hundreds of miles. If several Chinese naval formations are concentrated within 300 miles so they can mass YJ-18 missiles, then it becomes even more feasible to waypoint Tomahawks to trigger last-ditch fires within this radius. If one side's naval formations have to concentrate within shorter distances to mass their fires, they become more susceptible to this waypointing tactic than their opponents, and they may not even have the range to launch viable last-ditch salvos at all.

Salvos used to trigger last-ditch fires may have to risk a degree of attrition by allowing themselves to be seen by warships. Networked missiles could coordinate pop up maneuvers to rise above the horizon and make themselves known, but only briefly enough before they can be struck by defensive fires. Otherwise the salvo could suffer enough attrition that it loses both its psychological and kinetic potency. Decoy weapons that can project the signatures of multiple aerial contacts, such as the ADM-160 MALD, can be used to inflate the appearance of mass while reducing the ability of defensive fires to chip away at the salvo.[7]

[caption id="attachment_56657" align="aligncenter" width="697"]

Two Miniature Air Launch Decoys (ADM-160 MALD) sit side-by-side in the munitions storage area on Barksdale Air Force Base, La., March 21, 2012. (U.S. Air Force photo/Airman 1st Class Micaiah Anthony)[/caption]

Posing the appearance of significant mass may not be a hard requirement for inducing last-ditch fires from a target. There may be a significant disparity in the volume of fire required to actually kill a platform, versus the volume of fire that is enough to manipulate it into firing prematurely. This disparity can stem from commanders being uncertain about the capability of enemy salvos or their ability to defeat them, or the strain of combat operations taking its toll on decision-making. The last-ditch dynamic can therefore magnify the tactical value of salvos that lack enough volume of fire to destroy targets. Commanders that are limited to local awareness may struggle to differentiate between a small salvo that was only launched as a standalone attack, versus a small salvo that is a harbinger of incoming mass fires. A small salvo can leverage these uncertainties to score outsized tactical benefit by triggering last-ditch fires despite not being able to actually threaten the target.

Even if a salvo cannot strike a target due to limited range or other constraints, it may still provoke emissions, signatures, and other reactions that could be exploited. Commanders may struggle to distinguish between different types of incoming missiles in real time, where last-ditch salvos consisting of low-capability, short-range, or non-anti-ship weapons can still manipulate reactions. A warship launching a last-ditch salvo could certainly fire its land-attack cruise missiles toward an enemy warship, who either can't tell the difference or won't take the chance. The prospect of wresting any sort of non-kinetic benefit can encourage platforms under heavy attack to launch last-ditch salvos regardless of capability or volume of fire.

And non-kinetics can prompt last-ditch fires themselves. Actions such as heavy jamming, blinding attacks against networks, aggressive posturing, and other methods that could be interpreted as a prelude to an imminent attack could also provoke last-ditch salvos. Last-ditch fires can be triggered by much more than just other fires.

The act of firing last-ditch salvos is extremely sensitive to timing given how warship launch cells are often carrying both offensive and defensive firepower, and how some cruise missiles require a minimum amount of lead time to be programmed for launch.[8] A warship under attack from a subsonic anti-ship missile fired at a range of 250 miles has barely more than 20 minutes to react. And this assumes the target warship has knowledge of the launch. If the warship becomes aware of the incoming salvo only after it crosses the horizon, it can have roughly two minutes or less to prosecute an intense anti-air engagement while simultaneously discharging the whole of its offensive firepower in a last-ditch salvo. Those final moments would be characterized by an intense outpouring of the ship's firepower in all-out offensive and defensive warfare. But these vast volumes of firepower would be bottlenecked by the rate of fire, of how many missiles can be fired by a warship's launch systems in short periods of time. The volume of outgoing offensive and defensive firepower would be diminished as missiles of both types are primarily being fired from the same sets of launch cells, making them compete with each other for brief launch windows.

These challenges can be mitigated by having situational awareness over sea-skimming spaces that go beyond the radar horizon of a warship. Aircraft can provide early warning of incoming salvos and help warship commanders determine whether they must initiate a last-ditch salvo. Effective warning can allow commanders to discharge their last-ditch salvos early enough so that offensive missiles are not competing with defensive missiles for launch windows when it comes time for the warship to defend itself. In any case, warship commanders should strive to have a variety of pre-programmed responses at the ready so they can initiate last-ditch fires as fast as possible, and to have the subjective tactical judgement to know when it is time.

Warships under attack could be forced to fire their final salvos alone and in isolation from the broader distributed force. Yet last-ditch salvos may hardly be enough on their own to overwhelm concentrated defenses. This can put pressure on other combatants and commanders to add contributing fires in the hopes of growing enough volume to credibly threaten targets. A cascading domino effect could threaten to unravel a distributed force's firepower as last-ditch salvos prompt hasty contributing fires from other platforms. The pressured nature of last-ditch salvos will exacerbate the timing challenges associated with combining fires and potentially rule out a variety of options for growing the volume of fire.

A commander of a distributed force must weigh the risks of attempting to combine fires with a last-ditch salvo. A last-ditch salvo may force a commander's hand in adding contributing fires to a salvo that was fired on insufficient targeting data, lacks the volume to penetrate defended targets, or features other deficiencies. A commander could hold off on launching contributing fires, conserve the inventory of weapons, and allow the last-ditch salvo to play out on its own. But this may come at the risk of failing to support a salvo that could have effectively put opposing warships out of action if it had received just enough outside fires to tip the scales and cross the thresholds needed to overwhelm defenses. Commanders have to be ready to weigh these options as missile exchanges unfold in real time, and decide if a last-ditch salvo should remain a standalone attack, or leverage it through adding contributing fires.

Conclusion

As distributed forces unleash massed fires against one another, their desire to decisively overwhelm the opposition will be tempered by the need to minimize depletion. Depletion can threaten to break naval operations and yield major advantage to an adversary. Effectively massing fires from distributed forces can help manage depletion, but the need to achieve overwhelming volume of fire will make this risk a pervasive consideration at all levels of warfare.

A Combined Arms Framework for Massing Fires

The act of massing fires across forces is inherently a function of combined arms. Individual platforms should be understood in the broader context of the mass firing schemes they fit into, and a mass firing scheme should be understood as a composite integration of multiple platform types. These mutually supporting relationships are not just a matter of adding more missiles to increase the volume of fire. Rather, the different platforms are working together to compensate for each other's tactical weaknesses and pose combined arms threats that are far more lethal than what the different platforms can pose individually.

By organizing force-multiplying relationships, combined arms warfighting also highlights critical dependencies. Combined arms warfighting often means that one platform type must allow its operational options to be circumscribed by the limits of another platform type, if they are to work together. By understanding how different platform types make allowances to fit together for massed fires, operational behavior can become more predictable, including to the adversary. But behavior can also be more predictable to one's own forces, which can enhance doctrinal cohesion in this form of warfighting where cross-platform fluency and coordination is especially critical.

Modern warfighting can feature concepts of operation that focus on splitting these relationships apart to gain leverage over the adversary. Defeat in detail is often conceived of as small detachments falling prey to enemy forces, but it can also take the form of homogenous force packages falling prey to an adversary that asymmetrically leveraged a platform-specific weakness that could have been mitigated by a combined arms relationship. By understanding the purpose of these relationships, a force can know how to take advantage of their absence.

It is critical to recognize that the individual platform communities can be their own worse enemy when forming these combined arms relationships. The act of instituting or reforming these relationships can stimulate friction between communities because combined arms warfighting sets the stage for compromises in concepts of operation and time-consuming cross-community force development. Historically, combined arms debates have sometimes yielded community "purists" who are resistant to cross-community integration. These purists tend to strongly believe in the self-sufficiency of their own community's capability, and their proposed combined arms concepts of operation often take the form of assigning spheres of activity to the communities that are operationally complimentary but tactically separate.[1]

The aforementioned need to circumscribe options according to the limits of a different platform type can cause different communities to view each other as a drag or a nuisance rather than a force multiplier. A naval aviator may be loathe to limit their scope of maneuver so they can provide local sea-skimming air defense and sensory coverage for a much slower warship. A warship may be loathe to delegate release authority for weapons in its deep magazine to an aviator flying above, who may be better able to cue and direct long-range fires. Yet these relationships can be a core operational necessity that must be ironed out in combined force development. The current U.S. Navy construct of having carrier air wings conduct deep strikes while surface warships conduct what amounts to a goal line defense against air and undersea threats is a more divided method of warfighting than a truly integrated combined arms relationship. The fact that genuine integrated training and exercising is a very small fraction of the workup cycle compared to community-specific training is reinforcing this construct.[2]

The challenge of community purists may be encouraged by the breadth of multi-mission capability that already exists within the individual naval communities, especially in U.S. naval aviation and surface forces. In the absence of such multi-mission capability, the need to join specialized forces into integrated force packages would be more clear. But the multi-mission capability that is organic to these naval communities cannot mitigate many of their fundamental platform weaknesses, or the fundamental need for a revamped combined arms relationship that is geared toward launching and withstanding massed fires.

A framework can be established to help understand the strengths and weaknesses of the various platform types as they relate to massed fires, and understand each platform's unique contribution to the combined arms team. This framework can shed light on how the overall scheme of massed fires can shift and reorganize when a certain platform type cannot contribute due to operational circumstance or lack of capability. This framework can also be used to understand platform traits in isolation to understand key factors of resilience. Understanding the organic capabilities of an individual type of platform can shed light on that platform's potential for standalone fires, last-ditch salvos, and the usefulness of homogenous force packages. It can also shed light on how these platforms could be taken advantage of when they are cut off from the broader combined arms team. Understanding these capabilities in isolation offers a glimpse into how much effectiveness may be retained if a distributed force fractures into individual force concentrations and units.

Relevant platform traits include but are not limited to: magazine depth, on-station endurance, organic sensing, reload speed, ability to gain proximity to warship targets, and maneuver speed. Each platform's set of advantages bolsters an overall mass firing scheme in certain respects, while each platform's disadvantages may be compensated for by other platforms, and possibly circumscribing their behavior in the process.

[caption id="attachment_56979" align="aligncenter" width="1190"]

Platform	Magazine Depth	Endurance	Organic Sensing	Reload Speed	Ability to Gain Proximity to Warship Target	Maneuver Speed
Large Surface Warship	High	High	Moderate (low against sea-skimming threats)	High	Low	Low
Bomber	Moderate	Moderate	Moderate	Low	Moderate	High
Multi-Role Aircraft	Low	Low	High	Low	Moderate	High
Submarine	Low (excluding SSGNs and VPMs)	High (moderate for diesel-electric)	Low	High	High	Low
Land-based launcher (Stand-in Forces)	Low	Moderate	Moderate	High	High	Low
Land-based launcher (Mainland-based)	Low	High	Low	Low	Low	Low

Click to expand. A table of platform attributes and their relative ratings. (Author graphic)[/caption]

Magazine depth is how much volume of fire can be fielded on a single platform. Higher magazine depth allows a platform to preserve force distribution for longer, because it can contribute many rounds of small salvos while still remaining on station. If a platform is isolated or under duress, high magazine depth allows the platform to contribute a substantial volume of fire in standalone or last-ditch salvos. Shallower magazine depth translates into higher frequency of reloads during the duration of a conflict, which disrupts force distribution. Shallow magazine depth also results in last-ditch and standalone salvos featuring small volumes of fire that are less likely to be overwhelming.

On-Station Endurance is how long the platform can stay on station as a function of its unrefueled range. The longer a platform can remain on station, the longer it offers options for contributing fires, and the longer it preserves force distribution. Low endurance diminishes the availability of fires and how much a platform can contribute to a distributed force posture.

Organic sensing is how much targeting information a platform can gain through its onboard sensors alone. A high degree of organic sensing better allows a platform to target its own fires directly and manage a killchain that is less distributed across multiple authorities. High organic sensing can also allow a platform to cue the long-range fires of other platforms, if it can reliably deliver its sensor information to a broader network. Low organic sensing makes a platform much more dependent on outside sources of information to target its long-range fires. In the context of standalone or last-ditch salvos, organic sensing capability can help make those fires more accurate, and better preserve the resilience of the platform if it must continue the fight without a network.

Maneuver Speed. Maneuver speed is how fast a platform can travel. High maneuver speed allows a platform to more flexibly fit into mass firing sequences and manage the risks of emissions. Higher speed can allow platforms to concentrate in larger numbers in shorter timeframes than slower platforms.

Ability to Gain Proximity to a Warship Target allows a platform to build more resilience into a firing sequence. The more proximity a platform can gain, the more it can add to fires launched on short notice. Closer proximity translates into a better ability to insure a firing sequence against attrited fires, preemptively destroyed archers, and improve the distribution of launches across the duration of the firing sequence.

Reload Speed is how quickly a depleted platform can be rearmed and returned to the fight. Faster reload speed preserves force distribution and the availability of fires. A high reload speed as described here means it takes a platform longer to reload. Reload speed is also understood here as a function of maneuver speed rather than magazine depth, where the transit time is usually longer than the reload time. The availability of fires is not only a matter of how fast a platform can be reloaded with new weapons, but how fast the platform can travel between its weapon stocks and its launch areas.

Each platform features some combination of these traits, and a combined arms framework would seek to cover the weaknesses while maximizing the strengths. These advantages and disadvantages illuminate what circumstances constitute favorable terms for launching fires for each platform and their broader operational options. If a platform must shoulder a disproportionate burden of contributing fires, then the effectiveness of the overall mass firing sequence may be defined by that platform's strengths and weaknesses, and offer an adversary disruptive points of leverage.

The Uneven Nature of Massed Fires and Anti-Ship Combined Arms Teams

These concepts of massed fires have principally focused on organizing forces for anti-ship strikes, and these concepts are by no means a complete conception of combined arms naval warfighting. But the act of striking warships is a challenging priority objective that demands combined arms methods. Aside from managing weakness and earning force multiplying advantages, combined arms methods are compelled by the need to muster the significant volume of fire required to breach the especially dense defenses of warships. Organizing for anti-ship strikes can therefore yield combined arms methods that bring together multiple communities for the sake of targeting a single type of platform.

This results in critical asymmetries in how platforms can come together to mass fires, and how competing schemes of massed fires can interact during combat when one side has an advantage in anti-ship fires. When a massed firing scheme is deprived of its surface force, or its surface force is substantially outranged by the opposition, then the resulting asymmetry becomes especially risky to manage.

While warships can be fired upon by multiple platform types, anti-ship missiles cannot threaten many of those platform types in return. These include aircraft, submarines, and land-based forces. Platforms such as aircraft and submarines are only threatened by weapons that have much shorter ranges than anti-ship weapons, challenging the ability of defending warships to threaten these archers before they fire arrows.

Certain platforms have a superior ability to fire effectively first against warships because their survivability is not governed by the same dynamics as symmetrical surface-on-surface engagements.

Yet platforms that cannot be threatened by anti-ship weapons usually face critical disadvantages in on-station endurance and magazine depth, with bombers being somewhat of an exception. These factors are the strengths of surface platforms, allowing them to compensate for the shortfalls of aircraft and submarines, who in turn compensate for the surface forces' disadvantages in rapid near-term maneuver and ability to gain proximity to an adversary. Surface forces can undergird a scheme of massed fires by being able to bring significant missile capacity forward and maintain it there, unlike most other platform types. Therefore the function of surface forces in the combined arms team is to provide a deep and persistent base of fire for a mass firing scheme, which augments the forces with shallower magazines and more transient presence. By leveraging this base of fire, those other platform types are spared from having to heavily concentrate their platforms, manage the ensuing logistical challenges, and take greater risks. Other platforms and domains can certainly serve as a base of fire for a mass firing scheme if they have the numbers and logistics to do so. But even so, the mass firing scheme is still oriented on launching strikes against warships, and combining multiple communities to take out a critical member of the opposition's combined arms team.

The base of fire offered by a surface force can have its own scope of maneuver limited by the critical roles of the other platform types. A surface force that ventures beyond the range of land-based aviation will be deprived of one of its most valuable partners in massing fires. Perhaps even more importantly, it will be deprived of the partner that can provide critical air defense coverage for both offensive and defensive purposes. Aviation will be needed to inflict major attrition against sea-skimming salvos well before they break over the horizon view of warships. The adversary can reciprocate this of course, creating a requirement for aviation to provide forward air defense coverage to friendly salvos on their way to the target. Aviation can also reload anti-air weapons much faster than warships, helping warships persist in providing a maneuvering base of offensive fire, rather than having warships be forced to withdraw with unused offensive weapons due to depleted defenses.

A surface force should therefore be keen to stay well within the range of friendly land-based aviation to be able to substantially grow and withstand volumes of fire. Carrier aviation can certainly provide these capabilities, but typically not to the same scale and range as land-based aviation. Carriers can provide valuable aerial support in deep oceanic areas that land-based aviation may struggle to reach or loiter for long. But overall, in a scheme of massed fires, it may be wise to ensure that the base of fire provided by a surface force is adequately overlayed by the base of air defense coverage provided by aviation.

When two schemes of massed fires are competing and interacting during combat, the ability for one force to substantially outrange the anti-ship firepower of the other can have a profound effect on how advantage develops between adversaries. If a force can effectively target enough anti-ship fires to a much longer range than the opposition, then the opposition's firing scheme may be deprived of the valuable base of fire their surface forces offer. This deeply affects the resulting scheme of massed fires because it splits apart combined arms relationships.

When a force's scheme of mass fires is substantially outranged by the opponent, then the force can have to heavily focus its aviation on defending its surface forces while the opponent leverages their superior ability to fire first. As waves of massed fires are launched from distant standoff ranges, aviation would need to heavily focus on attriting the incoming volume of fire. The goal would be to inflict enough depletion on the adversary that their ability to follow up on their anti-ship attacks would be diminished, and that one's remaining strike options would be meaningfully preserved via the surviving surface forces, which have more freedom of action against a heavily depleted adversary.

Because aviation has a natural advantage in both its speed and ability to fire first against warships, aviation would be pressed to reach far out and attack warships before they can launch their longer-ranged firepower against one's own surface forces. At these extended ranges, aviation is more likely to be acting alone in mustering the volume of fire instead of as part of a combined arms team. Aviation would have to muster significant numbers and aerial tanking to field enough volume of fire, and then have to assemble aircraft into especially dense concentrations around targets to launch timely strikes. On top of this requirement, aviation may be required to make major contributions to fleet air defense as mentioned. Longer-ranged anti-ship firepower therefore forces the opposition's aviation to shoulder much more of both the offensive and defensive burden, causing aviation to bear outsized responsibility on the combined arms team.

But aviation may not have to be alone in this scenario. When the anti-ship firepower of a surface force is outranged, the combined arms team can still consist of aircraft and submarines, who are both able to bypass anti-ship firepower through their respective domains and earn closer proximity to an adversary. If enough aircraft and submarines can work together to combine fires at the forward edge of the battlespace, then they may be able to strike effectively first against surface forces before they can launch standoff fires against warships.

In similar fashion, the combined arms team in an A2/AD zone can consist of submarines and stand-in forces because of their shared ability to persist deep within a battlespace. While both of these forces may be constrained by their magazine depth, their ability to gain proximity to the adversary can give them opportunities to threaten warships with fuller magazines, and in areas where launching a last-ditch salvo from a warship would be futile.

Different operational circumstances will yield different combinations of combined arms teams. Some platform types may face circumstances that make their ability to contribute fires prohibitive. This can force other platforms to increase the proportion of their contribution to a mass firing scheme, but with the chance of increased risk, and possibly because their platform weaknesses cannot be as effectively compensated for by others. If a distributed force fractures into smaller and individual elements, they would be well-served by seeking out friendly platforms and forming ad hoc combined arms teams to the extent possible. It is critical to consider how to maximize combined arms relationships in a variety of operational circumstances, and to understand how to split apart these relationships for an adversary.

Rapid and Last-Ditch Fires

A key consideration is how different members of the naval combined arms team have widely differing sensitivities to last-ditch firing pressures. This heavily affects the ability of the broader force to leverage the last-ditch salvos of certain platforms with additional fires. These dynamics shape the ability of a force to maintain its resilience and mass firing capability while incurring losses.

Assuming a force has quality situational awareness over a wide area and sea-skimming surfaces, a warship that is under fire from a salvo can have tens of minutes of warning, because that can be the time-to-target of the incoming salvo. This can give the warship a decent window of time to discharge its last-ditch fires, and give the broader distributed force more time to organize contributing fires to leverage the forthcoming last-ditch salvo.

Early warning and last-ditch salvos are different for aircraft and submarines in critical respects. The weapons that threaten these platforms, such as anti-air missiles and torpedoes, have a small fraction of the time-to-target of anti-ship missiles can take tens of minutes to reach a warship. Yet the maneuvering speed of aircraft and submarines is much closer to those weapons compared to the speed differential between warships and anti-ship missiles, where evasive maneuvering is a much more viable method for improving the survivability of aircraft and submarines during the transit of the incoming weapon. But this potentially radical maneuvering can inhibit the ability of those platforms to discharge their salvos in last-ditch fires, where launching those fires could require a steadier movement profile that drastically increases the incoming weapon’s chances of striking the platform. Even if they opted to fire last-ditch fires in reaction, the act of discharging the final salvo may take longer than how long it takes the weapon to reach the submarine or aircraft, unlike in a warship's situation. Unlike long-range anti-ship fires, the broader distributed force would have virtually no time to organize contributing fires in reaction to anti-air or torpedo attacks.

Compared to anti-ship fires, the kill chains of anti-air and anti-submarine fires may be more easily completed by individual platforms, who will often have sufficient organic sensing and magazine depth. A single fighter with its onboard radar and several anti-air missiles is enough to threaten a bomber, or a frigate with its sonar and several torpedoes can be sufficient to threaten a nearby submarine. The proximate nature of these engagements allows a single platform to satisfy their information needs with organic sensors, and the offensive-defensive balance of these engagements requires far fewer weapons to muster enough volume of fire. By comparison, a warship that needs to be targeted hundreds of miles away and requires dozens of missiles to overwhelm can demand a broader information architecture and carefully coordinated fires from multiple force packages. It takes far less capability to put aircraft and submarines into a position where they feel forced to discharge last-ditch fires.

Aircraft and submarines would have to launch last-ditch fires in widely differing circumstances compared to warships. A warship may never detect emissions from the vast majority of distributed platforms that have launched fires against it. But aircraft and submarines can use their organic sensors to detect the organic sensors of the platforms that are targeting them. A bomber can sense illumination by an incoming fighter, or a submarine may get pinged by a warship's active sonar. Aircraft and submarines would not wait for anti-air missiles and torpedoes to be on their way to then react with last-ditch fires. Instead, they depend more heavily on interpreting the intent behind emissions and sensing to have enough early warning to launch last-ditch fires and then take defensive measures. Rather than reacting to incoming weapons, they need to sense the platforms that could launch the weapons, which makes them much more sensitive to last-ditch firing dynamics and pressures that can force them to waste munitions.

An opposing fighter squadron that simply vectors toward a group of bombers and illuminates it with radar can be enough to trigger last-ditch fires from those bombers, without the fighters having to expend any weapons of their own. By comparison, a warship that knows it is being targeted, or even under attack by incoming fires, can still hold off on launching last-ditch salvos. This is because a warship can be confident that the incoming volume of fire is not enough to overwhelm its defenses, a factor that is mostly absent from the survivability considerations of aircraft and submarines. A warship's dense defenses allows it to limit the circumstances that prompt its last-ditch fires to reacting to arrows instead of archers. The existence of launched arrows more reliably indicates the adversary’s intent to strike a target, making warships harder to provoke into last-ditch fires with simpler posturing and active sensing.

Overall, a distributed force can include a variety of platforms, whose different traits and capabilities must be combined for operational effect. As commanders consider how to employ a distributed force in a contested battlespace, they must understand the strengths and weaknesses of individual platform types and how this shapes their options. The following platform breakdowns discuss their individual traits and how they relate to naval salvo combat and mass fires more generally.

Surface Warships

Surface warships embody the ability of navies to efficiently bring mass firepower to sea. Blue water navies field a significant amount of their conventional cruise missile firepower in their surface fleets, with launch cells numbering in the thousands for the most powerful nations.[3] Some of the most critical capabilities surface fleets offer are their considerable numbers, endurance, and missile capacity, which are central attributes for massing fires and distributing forces.

Despite their considerable strengths, surface ships suffer from long reload speeds which harms their endurance in longer timeframes. Their low platform speed increases the challenge of survivability and their ability to mitigate the risks of radiating active emissions. But their high magazine capacity can give their last-ditch fires substantial volume of fire, with less of a need for outside fires to bolster their last-ditch salvos into overwhelming dimensions.

The large missile capacity of surface fleets is a double-edged sword. Defensive missile capacity can be used to negate offensive missile capacity, and vice versa. As the number of launch cells increases, the volume of defensive firepower that can be used to block attacks increases as well, thereby raising the amount of offensive firepower needed to overwhelm defenses. The very fact that a surface warship can field a large number of anti-air weapons across its many launch cells can force an opposing warship to empty most of its own magazine in a bid to overwhelm that target. Surface warships can easily empty most of their magazines in the course of launching or defending against a single anti-ship missile salvo.

This strongly contrasts with the combat potential and staying power of other types of platforms. Aircraft, submarines, and tanks can earn relatively high kill ratios against equivalent platforms because there is far less need to salvo their main armaments to achieve lethal effect.[4] A surface warship may only have enough anti-ship firepower to break through the defenses of a single similarly sized warship, if that. A surface warship can also travel for days and even weeks to enter the fight, only to then expend most of its main armament within a few minutes, and then have to take a long journey back to rearm. Despite the impression of significant capacity, surface warships still heavily depend on combining fires with other forces to limit their depletion and endure in a high-end fight.

[caption id="attachment_56964" align="aligncenter" width="671"]

The PLA Navy guided-missile destroyer Hohhot (Hull 161) steams in waters of the South China Sea during a maritime training exercise in early August 2020. (eng.chinamil.com.cn/Photo by Li Wei)[/caption]

No platform's missile capacity can be effectively understood in isolation from the tactical features of the salvos it may be launching or defending against. An attacking volume of fire can be built across tens of minutes and feature various contributing fires launched from many distributed forces. But when a warship comes under attack by a salvo, the full volume of offensive fire can break over the horizon in a narrow timeframe, while the defending warship must build its own defending volume of fire from scratch within seconds. Because of this dynamic, which will be discussed in more detail in Part 7, there may be some limit to how many vertical launch cells a surface warship can realistically apply to its own defense within the short span of a single engagement. Beyond that limit, additional vertical launch capacity mainly benefits the volume of offensive fires rather than defensive fires. This is partly because surface warships will often have more time to grow the volume of fire when launching an attack compared to defending against one.

The multi-domain nature of modern naval warfighting encourages multi-mission capability and payloads. Modern surface combatants often take the form of multi-mission platforms fielding a variety of domain-specific weapons, and this is partly because they must for survivability's sake. Submarines, land-based forces, and airborne aircraft are not threatened by anti-ship missiles, but each of these platforms can fire anti-ship missiles against surface warships. For surface warships, there are more threats coming from more domains compared to other naval platforms.

These multi-domain threats pose challenges for configuring the missile capacity of surface warships and limits their true magazine depth. Missile magazine loadouts can be stretched thin across a variety of roles, including anti-ship, anti-air, land-attack, and anti-submarine missions. Each one of these roles can require a large number of weapons for the role to be minimally viable and have enough volume of fire, where weapons can easily crowd out missile cells for other roles. A surface warship with its magazine loadout stretched thin across too many missions may not have enough missiles on hand to credibly launch or defend against a single large anti-ship salvo, creating a dependence on massing fires and combining forces. The challenge of having magazines spread thin at the level of the individual warship can be mitigated by leveraging the broader collective magazine of the distributed force, and configuring magazine loadouts on a force-wide level for distributed fires instead of at the level of the individual platform.

Compared to other missile-firing platforms, surface warships have disadvantages in maneuver, stealth, and susceptibility to attack. The range and speed of modern missiles have greatly diminished the usefulness of warship maneuver at the near-term tactical level. A few minutes or seconds of skilled maneuvering made an important tactical difference in the age of naval gunfights, but modern warships can do relatively little through short-term maneuver to significantly improve their effectiveness against missile salvos, with perhaps the exception of bringing mounted short-range defenses to bear. Maneuver will offer little against missile salvos traveling 15 to 50 times faster than warships, reducing the factors of survivability to defensive capability and deception.

In order to prosecute complex air defense engagements and have broad area situational awareness, surface combatants typically feature powerful sensors that can substantially diminish their stealth. Once these sensors radiate, their unique signatures can provide enough information to help localize and classify the warship at long range, potentially to several hundred miles.[5] The usefulness of this information for targeting anti-ship attacks can last for a significant period of time given how long it would take a slow-moving warship to maneuver out of the area it has been localized within. By comparison, an aircraft radiating a signature can use speed and maneuver to quickly put significant distance between its positions, drop below radar horizons, and more effectively manage the risks of emitting.

These high-powered sensors can be employed in defending surface warships against missile attacks, and where missile salvo defense is an especially emissions-intensive form of combat. The ability of these emissions to broadcast the position of the ship could be somewhat mitigated by the short-ranged nature of fighting off sea-skimming missiles breaking over the nearby horizon. But if a warship wants to use its organic sensors to have early warning of aircraft-launched attacks and have the option of defeating archers before arrows, then it will have to radiate at much longer ranges that can paradoxically draw attackers toward its signature.

[caption id="attachment_56965" align="aligncenter" width="1600"]

August 8, 2013 – The guided-missile destroyer USS Halsey (DDG 97) maneuvers off the coast of Oahu, Hawaii. (U.S. Navy photo by Mass Communication Specialist Seaman Johans Chavarro/Released)[/caption]

Launching an anti-ship missile attack can involve little if any organic emissions from launch platforms because of how the great distances involved create a need for outside cueing. But the salvo itself presents a signature that could be traced back to the launch platform, much in the same way that an air wing's physical signature could be traced back to a carrier. But unlike aircraft or submarines, surface warships can do relatively little through near-term maneuver to mitigate the near-term risks posed by the signatures of their recently launched cruise missile salvos. They must heavily rely on the range of the missiles and capabilities such as waypointing, retargeting, and missile autonomy to ensure that enough distance and complex threat presentation does not create a footprint leading back to the launching warship.

All platforms can highlight their positions and platform type through emissions and fires. All platforms can emit signatures in the process of employing offensive and defensive tactics. But compared to most other naval platforms, surface ships cannot as effectively mitigate risk through maneuver, and surface ships can be fired upon from a wider variety of platforms and domains. In a great power navy, surface ships compensate for their higher susceptibility to attack by featuring high numbers and especially dense defensive capability.

Submarines

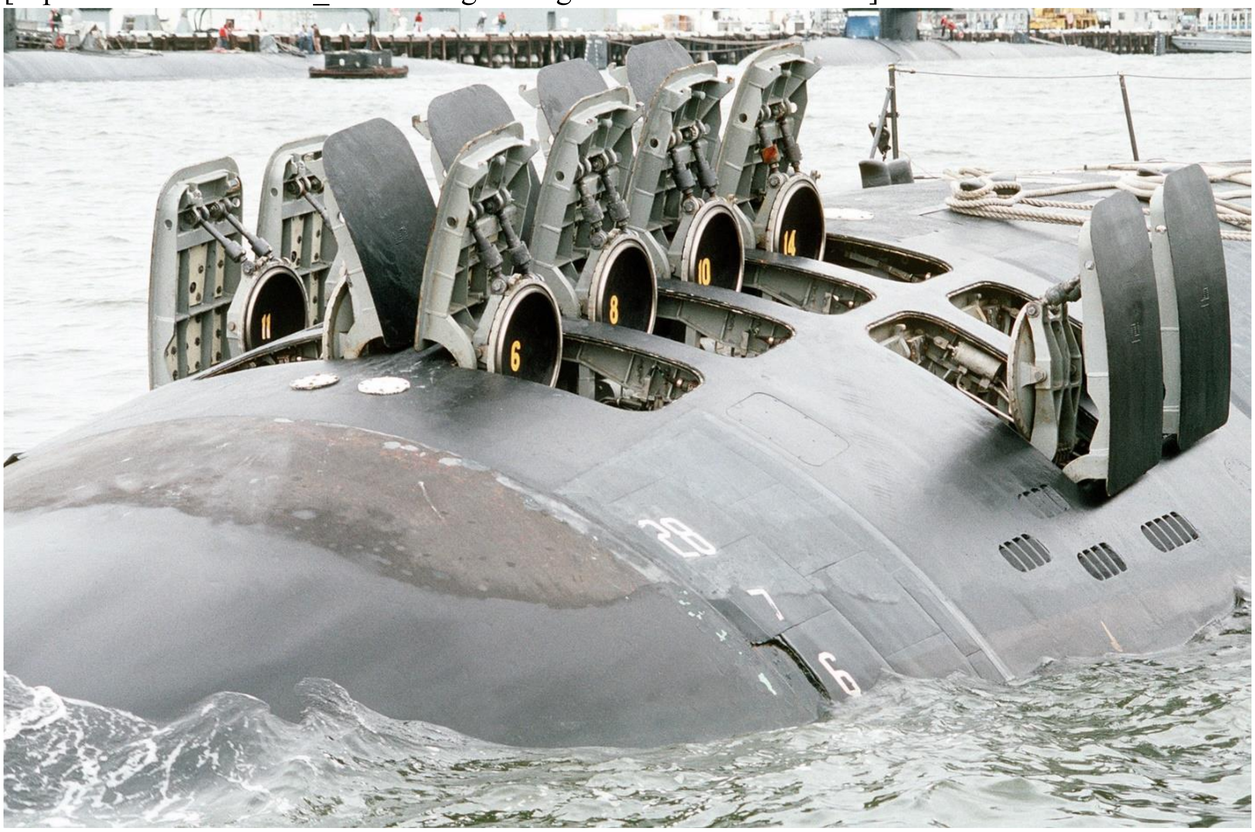
Submarines offer unique advantages in the distributed fight. But their ability to launch useful salvos is heavily constrained by their limited missile capacity and volume of fire, as well as the challenges of undersea communication. Where submarines offer advantage to mass fires is primarily through their ability to gain proximity and the highly favorable tradeoffs of sinking ships with torpedoes instead of missiles.

Submarines are poorly suited for contributing to mass fires in a variety of respects, due to their combination of low magazine depth, long reload speed, and poor organic sensing. Like surface warships, they are heavily dependent on outside cueing for launching fires, but their shallow magazine depth only allows them to fire relatively low volumes of fire, and they are generally harder to communicate with than surface warships.

The solitary nature of submarine operations severely constricts their ability to muster enough volume of fire. Compared to most other platforms, submarines are less likely to operate in groups and are more used to operating solo, which further limits the potential volume of fire. While they can certainly fit into a mass firing scheme or operational-level plan, if submarines do not operate as part of a distinct force package, then they will be less likely to generate standalone salvos or last-ditch fires of overwhelming volume.

An independently fired, close-range submarine salvo is a far cry from an aggregated salvo that is massed from contributing fires launched across distributed forces. If a submarine is to engage warships with missiles in independent circumstances, it will have to rely completely on its own missile magazine, which tends to be very shallow in attack submarines. A submarine's entire vertical launch cell inventory could easily be depleted in a single attack if it is to have enough volume of fire to overwhelm multiple layers of warship defenses. If submarine-launched salvos are to have enough density and volume, then submarines must fire these salvos primarily from dedicated missile cells rather than through torpedo tubes. While torpedo tube-launched missiles can certainly supplement salvos, the fact that submarine torpedo tubes typically number in the single digits makes it highly dubious these tubes can discharge enough volume of fire on their own against high-end warships.

The current magazine capacity of the U.S. attack submarine force is relatively small at only 12 vertical launch cells and four torpedo tubes for *Los Angeles*- and *Virginia*-class submarines. *Seawolf*-class submarines have eight tubes and no launch cells.[6] At 16 missiles, the maximum throw weight of these submarines per salvo is double that of a Harpoon-equipped U.S. destroyer or cruiser, or equal to four F/A-18 aircraft. But that will still be hardly enough to overwhelm alert warships with dozens of vertical launch cells and a range of point defenses. To launch effective missile attacks, submarines may be forced to close the distance to secure advantage at increased risk, or reduce their operational independence by heavily depending on outside fires to combine with their salvos.

[caption id="attachment_56971" align="aligncenter" width="1600"]

February 1, 1991 – The hatches of 12 vertical-launch Tomahawk missile tubes stand open on the bow of the nuclear-powered attack submarine USS Oklahoma City (SSN-723). (Photo via U.S. National Archives)[/caption]

While forthcoming variants of the *Virginia*-class submarine will have 40 vertical launch cells, these submarines will only start entering the fleet toward the end of this decade and will not feature in significant numbers until the decade after.[7] The Navy’s four SSGN submarines have enormous capacity at 154 launch cells per boat, but they will be retired toward the end of this decade.[8] After these four ships retire, the Navy’s submarine force will have relatively little anti-ship missile firepower for the next 15 years.

Submarines can still launch missile attacks against warships on somewhat favorable terms. By launching salvos from relatively close ranges, submarines can diminish the ability of the adversary to bring airpower to bear against the salvo, and can maximize the amount of time the salvo flies at sea-skimming altitudes. The result is a salvo that can spend most of its flight under a target warship's radar horizon, and was fired from a range that is beyond the ability of shipboard anti-submarine weapons to be immediately brought to bear with confidence.

But the act of launching a salvo needs time and space to grow the volume of fire and then organize it into a specific pattern of attack, such as a saturation pattern. Submarine-launched salvos may require a minimum engagement range that is defined by these needs, where a submarine may need to use nonlinear waypointing to purchase enough time and space to grow and then organize the volume of fire before it attacks.

Submarines can earn additional advantages by firing from ranges closer than a target warship's horizon. If a submarine missile attack is launched close enough, then vertically-launched missiles can struggle to reorient quickly enough to make the steeply angled intercepts. This can help negate much of a defending warship's hardkill defensive firepower, allowing a smaller volume of fire to overwhelm defenses and destroying the warship quickly enough that it has virtually no time to discharge last-ditch fires, or even torpedos. However, the visual cues of such a short-range missile launch broaching the water could help a defending warship localize the attacking submarine more easily than a torpedo attack or over-the-horizon missile attack.

Despite their limited magazine depth, submarines play a valuable role in massed fires through their heightened ability to gain closer proximity to targets. This allows submarines to act as insurance against attrited fires and hastily organized firing sequences. If contributing fires are shot down, or if a salvo is fired on short notice, submarines may often be the only platforms that are close enough to a target to make additions to the volume of fire. A mass firing scheme that lacks enough submarines will have less ability to insure its firing sequences against attrition or short-notice launches. And as mentioned in Part 4, submarines can reap substantial benefit by sinking targets with torpedo attacks that are far less depleting than missile salvos, allowing them to substitute a handful of torpedoes for large volumes of missile firepower.

While submarine-launched salvos are especially taxing on their shallow missile magazines, a submarine depleted of missiles is not nearly as much of an at-risk asset compared to a warship or aircraft in the same situation. By operating beneath the sea, submarines are spared from the hefty air defense requirements of defending against anti-ship missile salvos. Even if its missile magazine is depleted, a submarine that has enough torpedoes in its inventory can still endure as a credibly threatening and survivable asset.

[caption id="attachment_56973" align="aligncenter" width="659"]

July 12, 2022 – Los Angeles-class fast attack submarine USS Charlotte (SSN 766) prepares to depart Joint Base Pearl Harbor-Hickam during Rim of the Pacific (RIMPAC) 2022. (U.S. Navy photo by Electronics Technician 2nd Class Leland T. Hasty II)[/caption]

Launching long-range anti-ship salvos from submarines can present challenges with cueing their fires. If a submarine is to attack a warship at a distance that goes beyond the relatively short range of its organic sensors, external assets are likely required to cue its fires. Forms of low-frequency communication could provide this information. Certain platforms, especially aviation, could also be helpful in cueing submarine-launched missile fires within contested electromagnetic battlespaces. But the need for timely contributing fires and the ability of submarines to penetrate deep into contested seas could pose risks to platforms attempting to cue submarine-launched fires. Submarine-launched aerial drones can mitigate this to an extent by having an organic capability for enabling over-the-horizon fires.[9] But submarine-launched drones may still not be capable enough for submarines to contribute especially long-range fires without external cueing.

The nature of cueing submarine launches can present challenges to leveraging contributing fires from submarines. Compared to the variety of platforms across the force, submarines are among the more difficult to communicate with by virtue of being undersea.[10] If a commander wants a submarine to contribute fires to an aggregated salvo, it may involve more complex matters of communication and timing to leverage the capability.

Land-Based Forces and Stand-In Forces

Land-based missile forces can be divided into two broad categories – land-based launchers located on a nation's homeland such as those of the PLA Rocket Force, and stand-in forces such as those envisioned by the U.S. Marine Corps. These distinct types of forces can play critical roles in massing fires.

Conventional land-based forces, such as those typically located on the homeland of a nation, can consist of coastal defense cruise missile launchers, missile silos, and transporter erector launchers. By virtue of being fielded by land-based platforms instead of more restrictive sea-based platforms, these weapons can take on extraordinary dimensions while still being fielded by highly distributed force structure. These attributes allow land-based missile forces to field some of the most powerful and survivable missile capabilities that exist today.

Land-based forces field some of the largest anti-ship missiles known, such as how a Chinese DF-26 is more than 15 times the weight of a Tomahawk.[11] The sheer size of these missiles allows them to maximize two key dimensions of capability – long range and high speed. By having more than a thousand miles of range, these weapons can hold numerous targets at risk on a theater-wide scale and with virtually no maneuver required on the part of the launch platform. Having high speed allows these weapons to travel those long ranges in remarkably short timeframes, which helps preserve the viability of the original targeting data. Through a combination of long range and high speed, these missiles feature a low time-to-strike across a broad area, which gives them a wide array of flexibility for combining fires with other types of missiles. A ballistic missile fired from a thousand miles away can still combine with a subsonic missile fired from a few hundred miles away, because both weapons only need tens of minutes at most to strike the same target.[12]

The anti-ship weapons that feature these especially high-end combinations of range and speed are mainly confined to hypersonic weapons and China's anti-ship ballistic missiles. Weapons like the forthcoming land-based Tomahawk launchers will have similar ranges, but not nearly the same speeds. Yet having widespread land-based Tomahawk launchers will vastly multiply the potential distribution and volume of the U.S. military's missile firepower.

[caption id="attachment_56968" align="aligncenter" width="846"]


PLA Rocket Force DF-26 ballistic missiles. (Photo via Xinhua)[/caption][caption id="attachment_56969" align="aligncenter" width="681"]


April 18, 2019 – A flight test of a conventionally configured ground-launched cruise missile is conducted at San Nicolas Island, Calif. (DoD photo by Scott Howe)[/caption]

Land-based forces can be extremely survivable and distributable. The scud hunt saga of Desert Storm showed how it was virtually impossible to find these types of launchers, even in open desert terrain with total air superiority.[13] It would be even more challenging to attempt direct attacks on land-based launchers well within an adversary's homeland, and copious amounts of effort could be expended in simply trying to pinpoint them for strikes. By being located on their homeland, these forces can benefit logistically from being near their sustainment infrastructure and enjoy remarkably fast reloads despite the size of their weapons.

Because of the steep challenges of inflicting attrition, countering land-based forces and their fires is mainly confined to countering the adversary's broader ISR and C2 architecture. If the broader network is degraded, these forces will have little organic sensing to fall back on to generate standalone fires. Their especially heavy dependence on outside cueing makes these forces less operationally resilient and less likely to gracefully fracture into individual force concentrations in the context of a degraded network. By comparison, aircraft and warships can fall back upon their organic sensors to secure a measure of information for themselves when the broader network is degraded.

The lack of maneuverability relative to the speed and range of their weapons can also challenge land-based forces. If these forces are spread far and wide across an archipelago or the expanse of a homeland, they may not be able to maneuver to create denser fields of fire as easily as aircraft or warships can. Instead, their wide dispersal can yield fields of fire that remain relatively stretched thin in the early days of a conflict. Even if these weapons have extremely long range, dispersing these forces to fixed bases that are hundreds of miles apart can dilute the density of their combined fires.

Stand-in forces sharply differ from conventional land-based missile forces in key respects. Stand-in forces are expeditionary units deployed hundreds or even thousands of miles away from their homeland and onto relatively small islands proximate to the adversary. This results in much more challenging logistical requirements, which bottlenecks their capabilities. The logistical challenge of sustaining an expeditionary force makes it far more difficult for stand-in forces to field especially large, land-based missile launch platforms. Stand-in forces may be confined to fielding cruise missiles that are both less capable and less numerous than forces operating from their homeland.

Compared to most other types of forces, stand-in forces will be especially challenged to break through strong warship defenses using only what they have at their disposal. Instead, they may suffer similar disadvantages as submarines – able to achieve closer proximity to the adversary than most other platforms, but with smaller missile magazines on hand and therefore more dependence on outside contributors to achieve enough volume of fire. If stand-in forces deplete their shallow magazines, they may create substantial risks for resupply efforts. Using ships to reload stand-in forces in close proximity to adversaries may be far riskier compared to reloading warships or aircraft that are better able to withdraw beyond an adversary’s weapons engagement zone.

[caption id="attachment_56975" align="aligncenter" width="1440"]

A Navy Marine Expeditionary Ship Interdiction System launcher deploys into position aboard Pacific Missile Range Facility Barking Sands, Hawaii, Aug. 16, 2021. (USMC photo by Maj. Nick Mannweiler)[/caption]

Stand-in forces positioned across island chains could provide timely intelligence that helps the distributed force mass fires against targets. Proximity to island chokepoints will simplify the task of both finding naval targets and massing fires against them. Compared to conventional land-based forces located deeper within a mainland, island-based stand-in forces will be better able to use their organic sensors to cue their own fires. It will be a challenge however for these stand-in forces to achieve broader situational awareness without organic aviation capabilities. High-altitude drones may prove far too vulnerable to last in such close proximity to an adversary, and significant amounts of manned aviation could be too difficult to sustain in advance bases.

While stand-in forces could make major contributions in cueing fires, they will be hard-pressed to mass meaningful volumes of anti-ship firepower on their own and to maintain aviation to secure valuable intelligence. And if stand-in forces struggle to field the larger-scale anti-air missiles that are needed to deny airspace at high altitudes, much of their ability to remain stealthy and manage signatures could be diminished by an adversary's persistent aerial surveillance. The need for small footprints and low signatures is apparent, but it often costs signatures to detect signatures. These stealthy measures may be a critical enabler for a stand-in force, but they could also be a necessary evil when the stand-in force is heavily suppressed by the adversary.

Bombers

Bombers are one of the most advantaged platforms when it comes to contesting sea control, executing distributed operations, and attacking warships. Bombers feature a robust combination of traits, including high maneuver speed, fast reload times, significant on-station endurance, and an offensive magazine capacity that can approach that of surface warships.

While U.S. bombers have an unrefueled range that is similar to large surface warships, their high maneuver speed consumes this range at a much faster rate.[14] While a bomber can travel thousands of miles on a single load of fuel, it will still need to be refueled within the same day, whereas warships can go days without refueling, allowing them to have greater near-term endurance. Yet bombers can rendezvous with aerial tankers in far less time than what it takes warships to meet with their tankers, allowing bombers to provide a substantial proportion of on-station, on-demand fires. The range and endurance of bombers allows them to loiter and be held on call for contributing to aggregated anti-ship fires on a theater-wide scale within hours. Their combination of decent magazine capacity and organic sensing capability can also allow bombers to launch last-ditch fires that approach the volume of warship-based fires but with greater accuracy.

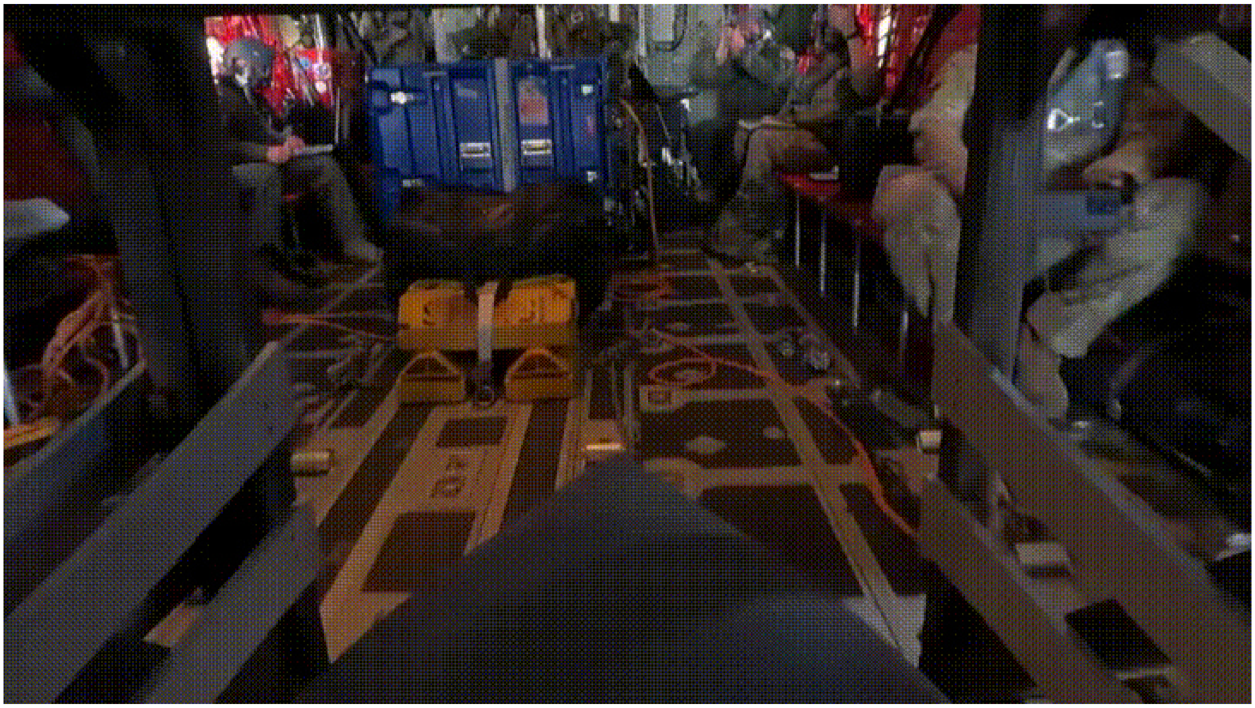
An adversary may develop a sufficient sense of the aggregated firepower available to regional naval forces based on known warship capabilities and dispositions. But they may be less able to account for how airpower and especially bombers could be surged to contribute fires on short notice. Because of their combination of considerable speed and range, adversaries have to assume a wide array of bombers can provide a variety of distributed firing options to the opponent. U.S. warships homeported in the continental United States cannot factor as readily into the latent distribution and firepower posed by a forward U.S. fleet in the same way continentally-based bombers can.

For now U.S. bombers will be confined to firing anti-ship weapons like LRASM, whose early models feature less than half the range of the Maritime Strike Tomahawk.[15] LRASM, like the Harpoon missile, has its capabilities confined by the requirement to be fired from multi-role aircraft that are much smaller than bombers. For the U.S., the ability of bombers to fire much larger missiles than multi-role aircraft will go largely unrealized for the anti-ship mission. Yet bombers test-fired air-launched variants of the Tomahawk decades ago in the Cold War and fielded other air-launched cruise missiles with ranges in excess of a thousand miles.[16] The ability of bombers to contribute to anti-ship massed fires from standoff ranges will be magnified if they can fire cruise missiles that are similar to what can be fired from warship launch cells.

[caption id="attachment_56977" align="aligncenter" width="1600"]

December 6, 1979 – A left side view of a B-52 Stratofortress aircraft carrying AGM-109 Tomahawk air-launched cruise missiles. (Photo via U.S. National Archives)[/caption]

The U.S. Air Force is developing the potentially game-changing Rapid Dragon capability, which allows cruise missiles to be deployed from pallets dropped from airborne platforms.[17] Similar in spirit to the Distributed Lethality concept's mantra of, "if it floats, it fights," this capability would introduce significant cruise missile capacity to hundreds of long-range Air Force transporter aircraft.[18] Rapid Dragon would vastly expand the scope of force structure that can bring long-range missile firepower to bear and offer a major increase in force distribution. If the Air Force procures enough anti-ship missiles, this capability could be a major force multiplier for mass fires.



September 2021 – Over White Sands Missile Range, C-17 and EC-130 aircraft deploy the first Rapid Dragon pallets to release surrogate JASSM-ERs. (Lockheed Martin video)

Conclusion

Massed fires and naval warfighting are greatly enhanced when different platform communities form combined arms relationships. Combined force development and shared platform fluency will strengthen integration between communities. Warfighters will better understand their role in the combined arms team and the operational dynamics that govern the behavior of their cross-community partners. While these relationships will not be without friction or challenging tradeoffs, they will create a force that is far more effective than one that struggles to rise above its silos and parochialism.

Introduction

The aircraft carrier has been the main striking arm of the U.S. Navy for decades, but distributed warfighting demands something new. Anti-ship missile firepower is proliferating across the force structure of both friendly and competitor forces, creating larger demands for the tactical information required to leverage these long-range weapons. Massed fires heavily depend on information to work, and air superiority is a powerful enabler of information superiority. By focusing on a set of critical information functions and fleet air defense, the aircraft carrier can serve as a powerful enabler and force multiplier for distributed fleets and massed fires. These roles foreshadow how nations who engage in naval salvo warfare without naval aviation will be at a sore disadvantage.

Scouting and Cueing Fires

The ocean is vast and busy, presenting a complicated battlespace to make sense of. Sweeps across large ocean areas teeming with commercial shipping can precede anti-ship strikes as targets must be found and quality targeting information developed. As Captain Wayne Hughes emphasized in his classic work *Fleet Tactics*, "At sea better scouting – more than maneuver, as much as weapon range, and oftentimes as much as anything else – has determined who would attack not merely effectively, but who would attack decisively first."[1]

The horizon not only constrains the ability of warships to defend themselves, it makes them almost completely dependent on outside sources of information to target their long-range anti-ship fires. Warships must be well-supported by other forces that can provide the awareness that allows those warships to accurately launch anti-ship fires to long ranges.

Aviation's speed, range, and maneuverability makes it an ideal asset for scouting large swaths of ocean, discriminating targets among maritime traffic, and cueing anti-ship fires. Aviation is also useful for denying this information to an adversary, such as through counter-scouting missions that target aerial scouts well before they could sense and cue fires. By comparison if warships are forced to emit to defeat an aerial scout, then they may have abetted the scout in its mission. By screening a naval force, aviation can serve as both the eyes and the cloak that help naval forces fire effectively first.

One of aviation's most critical advantages in executing these roles is the realm of three-dimensional aerial maneuver. Through speed and maneuver, aircraft can more effectively manage the risks of emitting compared to surface warships. By being able to dip below the radar horizon of target warships when threatened, aircraft can manage their signatures and detectability more dynamically than warships. By shadowing naval contacts at standoff ranges and using maneuver to change the bearing to the contact multiple times over, aircraft can repeatedly stimulate emissions from contacts and use passive sensing to localize and classify targets.[2]

Since warship radar emissions can travel much further than the anti-air weapons these emissions can guide, aviation has an added margin of security when scouting with passive detection and shadowing warships.[3] If aircraft do find themselves within range of naval air defense weapons, their ability to quickly drop thousands of feet of altitude can spoil semi-active targeting and air defense kill chains by diving below radar horizons. The ability of aircraft to use these kinds of maneuvers to preserve survivability while scouting can allow them to earn valuable proximity to warship contacts. This proximity is valuable for stimulating or observing adversary behavior with an eye toward mitigating deception and discovering decoys. By simply scouting or shadowing a warship, an aircraft could stimulate behavior because an aircraft could be interpreted as a harbinger of incoming mass fires.

These attributes allow naval aviation to be at the forefront of finding and classifying targets, cueing anti-ship fires against these targets, and giving prompt notification to friendly forces if those targets have discharged last-ditch fires. Through its superior ability to gain information and mitigate the risks of emitting, naval aviation is uniquely situated to act as quarterback to the broader distributed force.

Retargeting and Reinforcing Mass Fires

Combining missile firepower over a target is an extraordinarily time sensitive tactic. Salvos must cross over the radar horizon of a target within a narrow timeframe to reap the efficiencies of overwhelming fires, rather than have salvos risk defeat in detail. But there will be challenges in coordinating precisely-timed fires across a variety of launch platforms that are hundreds and even thousands of miles apart. Tactics and operations that heavily depend on exquisitely coordinated timing are fragile by nature. This fragility encourages militaries to build redundancy and resilience into their kill chains so they may confidently combine missile firepower from across distributed forces.

A commander could mass fires by precisely positioning distributed launch platforms and then precisely sequencing their fires. However, this is a platform-centric approach to missile aggregation. It limits the flexibility of the individual platforms to adapt to their local tactical circumstances, especially those that would encourage a platform to launch its contributing fires at a different time than what the original firing sequence planned for. The operational availability and behavior of individual force concentrations will be influenced by much more than simply being on call for contributing fires.

Platforms can be afforded more local operational flexibility when their contributing fires can be maneuvered into place after launch, rather than requiring that ideal conditions be met before launch. Firing sequences will be less susceptible to disruption if individual contributors of fires cannot launch on time yet their fires can still be made to fit into an active firing sequence.

This makes in-flight retargeting a fundamental enabler of mass fires, where retargeting adds critical dimensions of resilience and flexibility. As salvos are fired from across distributed forces, retargeting will give commanders the ability to adjust salvo flight paths and maneuvering during an active firing sequence. Rather than depend heavily on establishing highly specific platform positioning and weapon programming before launch, retargeting can give commanders more flexibility to combine and maneuver fires after launch. Retargeting critically preserves the capability to give weapons waypoints after they have been fired, offering commanders greater opportunity to maneuver weapons into combined salvos and leverage waypointing tactics during a firing sequence. Retargeting helps compensate for irregularities and disruptions in the firing sequence, offering individual launch platforms more local flexibility and the overall firing sequence more resilience. Retargeting prevents firing sequences from being locked into place once initiated, preserving a commander's options for real-time adaptation.

The scope of retargeting's ability to combine and maneuver in-flight fires is limited by the same factors that define a weapon's aggregation potential, such as range, maneuverability, and flight times. The amount of opportunity to retarget and maneuver salvos of 1,000-mile range Maritime Strike Tomahawks is far greater than that of missiles with only a few hundred miles of range or a ballistic missile that can hardly deviate from its trajectory.

A longer flight time will also increase the need for retargeting, given how the longer a missile flies, the further its target may have traveled, the more defensive deception capabilities may have been deployed, and the more the overall operational situation may have changed. A subsonic missile launched at very long range, such as an anti-ship Tomahawk, could require more in-flight retargeting to find its target compared to faster or shorter-ranged missiles.

Retargeting can be especially valuable for when targets prove to be decoys, false contacts, or more heavily defended than expected. It can also help salvos remain viable even if they have suffered attrition. If a portion of contributing fires is shot down on the way to the target and it seems the remaining fires can no longer reach overwhelming dimensions, they could be redirected toward a new target that is more feasible to attack. Retargeting can help ensure that valuable missile inventory is not wasted against unfavorable targets and that fresh developments can quickly translate into revised priorities for a firing sequence.

Missiles can certainly have their own onboard retargeting capabilities and employ them together within a salvo.[4] But these capabilities are heavily limited by the relatively short range of their seekers and local networks, as well as the need to maintain sea-skimming flight to maximize surprise. It is also unlikely different missile salvos can effectively communicate when separated by hundreds of miles and when flying at low altitudes. Intra-salvo retargeting is more feasible for the organic capabilities of missiles compared to inter-salvo retargeting across a wider area. The ability to communicate between separate salvos may improve once contributing fires come closer to one another near their terminal approach, but that offers relatively little opportunity to make updates for most of the firing sequence.

Using outside assets for retargeting support broadens the opportunity to make earlier updates and corrections to contributing fires. Instead of having a salvo burn through plenty of fuel only to discover poor target selection at the very end of the engagement, outside retargeting allows corrections to be made much earlier in the firing sequence, preserving range and options. If missiles do not have outside assets to update their targeting information during the firing sequence, the missiles' autonomous programming may encourage them to increase altitude and expose themselves to defensive fires in a bid to gain the information. Outside retargeting can minimize the need for attacking missiles to break from sea-skimming flight profiles, improving their survivability and preserving the element of surprise.

A critical question is who or what can best provide outside retargeting support to salvos. By virtue of speed, maneuverability, and range naval aviation will be especially well-positioned to facilitate the combining of individual salvos into aggregated fires through retargeting. Whether through covering vast ocean areas or by focusing on the airspace around a specific target, naval aviation will be able to work datalinks to combine missile firepower into overwhelming effects.

Assessing the Illusive Offensive-Defensive Balance

As soon as high-end naval conflict breaks out, naval commanders need to prioritize their understanding of the offensive-defensive balance of naval missile exchanges. This remains one of the great unknowns of modern naval warfare that would be uncovered by real combat, of how exactly large volumes of offensive and defensive fires interact and overwhelm one another. Commanders need to know whether their salvos struck the target, how well their missiles withstood countermeasures, and how opposing air defenses performed. As missiles rain down upon warships, collecting data on the effectiveness of a variety of defensive capabilities will constitute an especially critical line of effort for wartime adaptation. Developing a more precise understanding of the offensive-defensive balance is fundamental to optimizing volume of fire, managing munitions inventory, and identifying crucial areas of competitive advantage. In this vein, battle damage assessment and investigating air defense performance are fundamental to securing an edge in modern naval warfighting.

In a form of warfare where dozens of missiles could be needed to break through a warship's defenses, but only a single hit is necessary to earn a kill, the potential for wasteful overkill is tremendous. If the offensive-defensive balance of a naval salvo engagement tilts even slightly toward the offense, it could take the form of numerous missiles wastefully crashing into a warship that was already long gone after the first hit. But commanders that attempt to precisely optimize the volume of fire to minimize overkill are more likely to risk having their salvos be defeated wholesale. Rather, securing information on salvo effectiveness would be more about understanding the margin of overkill and how much overkill can be reasonably afforded and tolerated, rather than attempting to minimize it entirely.

Commanders would clearly want to know if their salvos were shot down. If they are to organize another attack, they would benefit greatly from estimates of what proportion of the attacking missiles were downed by what types of defenses, and how many air defense missiles were expended by the defenders. These factors can help determine how much volume of fire would be needed in follow-on attacks and what types of offensive weapons may perform better. If targets were destroyed, commanders would still benefit greatly from knowing air defense performance for the sake of optimizing future volumes of fire.

But the ability to assess the effectiveness of missile firepower can be severely challenged by the great distances anti-ship missiles must travel and how targets may be fired upon near the limits of scouting capabilities. Commanders may not immediately know whether their targets were destroyed or if their salvos were shot down without landing hits. The uncertainty surrounding the results of long-range missile exchanges can prolong and complicate the decision-cycle and threaten to yield information advantage to the defender, who will often be in a much better position to assess the battle damage, weapons depletion, and defensive performance of their own forces after being attacked.

Naval aviation can earn the valuable proximity to targets to help gather this critical information. By shadowing naval targets, naval aviation can witness hostile air defenses in action and view how missile exchanges play out. Aviation could help commanders understand the offensive and defensive volume of fire being discharged from adversary warships, and the specific composition of that volume of fire. This can enhance a commander's understanding of the adversary's weapons expenditures, how they are assembling massed fires, and their own competing perceptions of the offensive-defensive balance.

This information will be critical for manipulating one of the major levers navies have for adapting the force in the midst of conflict, which is the composition of payloads within platform magazines. By taking a "payloads not platforms" approach, navies can maintain an edge in real-time conflict by flexing missile loadouts in reaction to fresh data on salvo effectiveness and adversary air defense performance. If adversary air defenses prove poor, a navy could afford to bolster its own air defenses by increasing the share of magazine space allocated to such capabilities. Or it could capitalize on the adversary's disadvantage by filling more magazine space with anti-ship weapons, or with the specific types of weapons that are proving to be more effective.

This information will also be vital in knowing what kinds of salvos and volumes of fire do or do not warrant last-ditch salvos. A more precise understanding of the offensive-defensive balance means less inventory will be lost to last-ditch pressures as commanders have a clearer understanding of what warrants a last-ditch salvo. On the flipside, if it does not take much volume of fire to cause the adversary to discharge last-ditch salvos, then that would be critical to know and exploit.

Understanding the offensive-defensive balance is especially critical given the potentially decisive role of defensive systems with limitless magazines. Although they mainly function at close range, capabilities such as electronic warfare, high-power microwaves, laser dazzlers, and other softkill measures could provide an enduring measure of defense. This could prove critical for keeping warships in the fight even if they are running low on hardkill defenses. Softkill capabilities could also substantially change the nature of modern naval combat more generally. As Capt. Tom Shugart (ret.) points out:

"the consequences of the interplay of jammer versus seeker, sensor versus signature, and hacker versus data stream are likely to propagate from the tactical to the operational and perhaps strategic level in ways not seen before. As one specific and obvious example, a conflict where China's [anti-ship ballistic missiles] could be consistently made to miss through the use of jammers *might be a completely different war* than one where that was not the case."[5] [Emphasis added]

This has happened before. The first ever wartime naval missile exchanges highlighted the decisive potential of softkill systems. The naval missile combat of the Arab-Israeli 1973 war took the form of Israeli missile boats successful sinking opposing missile boats despite those adversaries fielding longer-ranged missiles. Israeli electronic warfare was completely successful in jamming every anti-ship missile that was fired at their warships, allowing them to close the distance and destroy their opponents. While these engagements occurred in relatively confined waters between small combatants, Israeli success was likely not possible without extraordinarily successful electronic warfare defenses, and the failure of Arab forces to understand why their missiles kept missing.[6] If aviation can gather data on enemy softkill performance in missile exchanges, it may offer a useful view into some of the more decisive factors shaping the offensive-defensive balance.

Air Defense and Shooting Archers

Aside from critical information functions, there is a vital kinetic role for naval aviation to play. Naval aviation will be sorely needed to preserve the survivability of the broader surface fleet. This dependency is best illustrated through the severe tactical challenges surface warships face in defending themselves against missile salvos.

The immutable obstacle posed by the curvature of the earth severely constricts the amount of space and time in which warships can defeat sea-skimming missiles, despite their dense defenses. Sea-skimming flight takes advantage of the radar horizon limitations of defending warships, leaving them with little choice but to engage incoming missiles at a very short distance away from the ship (typically around 20 nautical miles) and with only tens of seconds before impact.[7]

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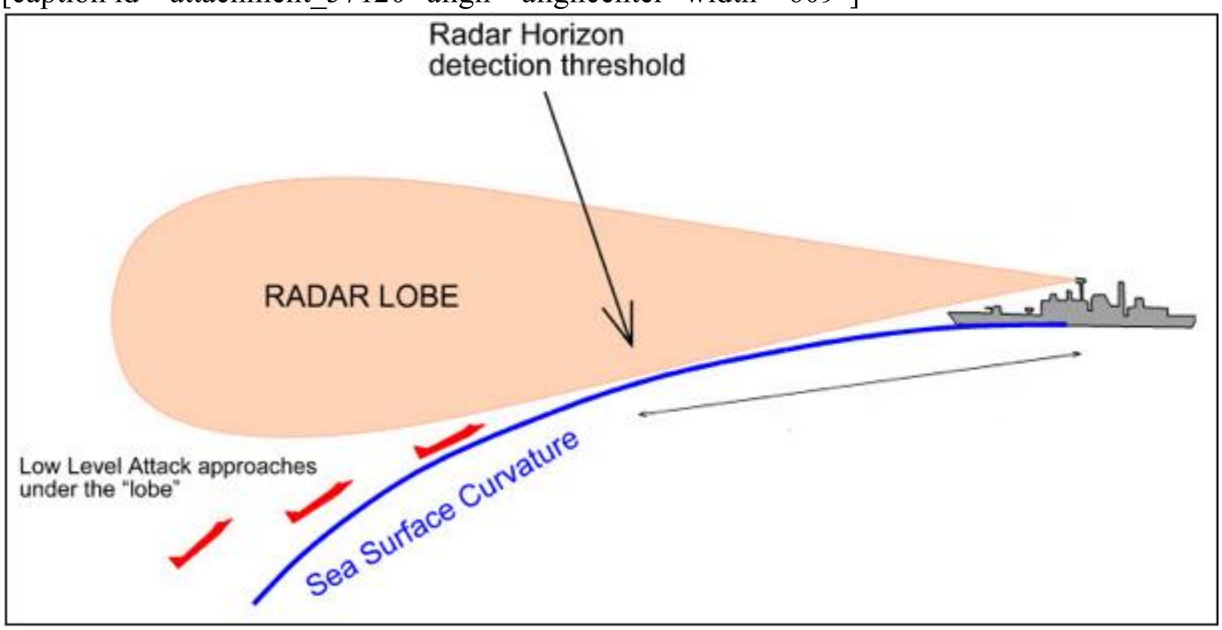
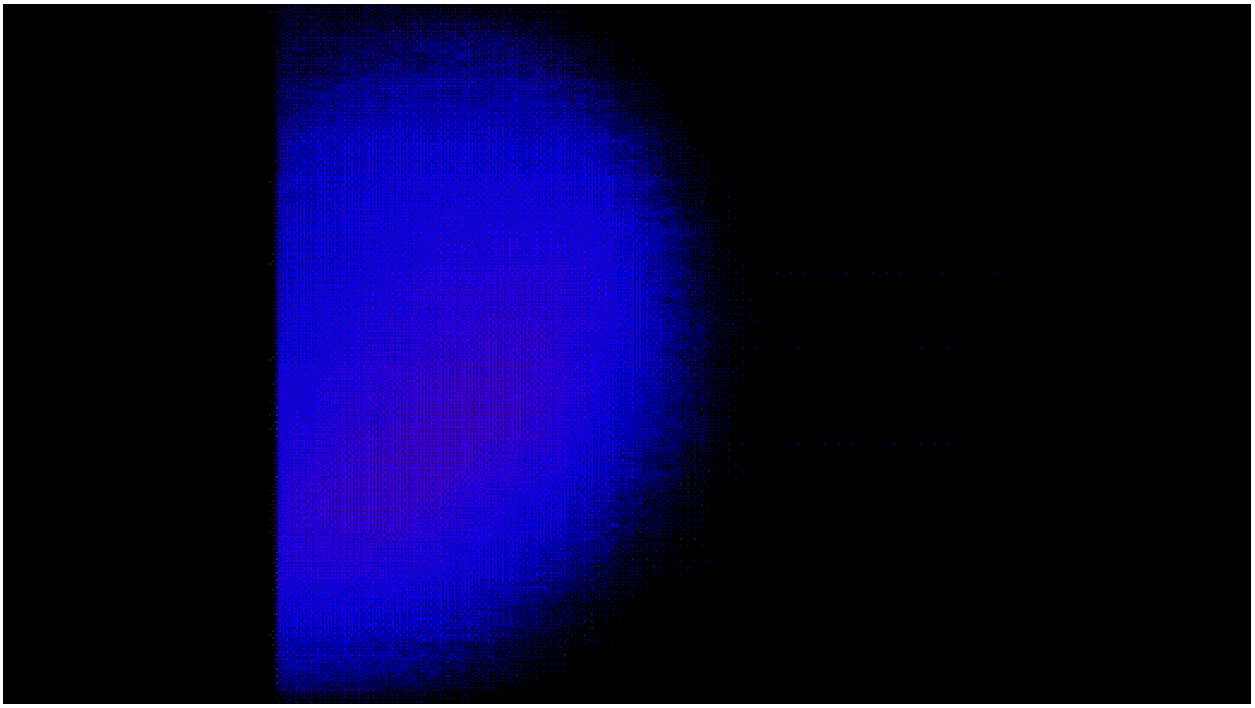


Visualization of the radar horizon limitation. (Source: [Aircraft 101 Radar Fundamentals Part 1](#))[/caption]

In a fierce bid for survival, warships will engage a variety of defensive weapons and systems simultaneously to wipe out incoming salvos bearing down on the ship. But the defending warship will be suffering a major disadvantage given how the totality of the attacking volume of fire is already in flight and closing in, but the defending volume of fire has to be built from scratch and achieve significant mass in a matter of seconds. Not all defending missiles can be fired simultaneously, while the attacking missiles can organize into a saturation pattern where they can all strike simultaneously. Even with a very high rate of fire, the defending missiles will be naturally bottlenecked into a narrow stream salvo pattern which may not achieve sufficient volume of fire. Even firing one defensive missile per second may not be fast enough when an attacking supersonic salvo is roughly only 50 seconds away from impact after it breaks over the horizon.

A supersonic salvo could already be about halfway across the 20 or so miles it is visible to the ship by the time the first intercept occurs.[8] If a warship is employing the U.S. Navy's shoot-shoot-look-shoot doctrine, it may only have enough time to fire off a single salvo per threat from its primary defensive armament before this capability is negated by the incoming missiles getting inside the minimum engagement range of defenses. As inbound salvos close the distance, vertically hot-launched defensive missiles will struggle to rapidly reorient for steep downward intercepts, narrowing the amount of defensive firepower available from the missiles in dozens of launch cells to the relatively few munitions of close-in systems that are able to fire on flatter angles. This challenge will be even more severe when saturation salvos aim to get all missiles inside the defender's minimum engagement range at the same time. In the terminal phase the attacking missiles also enjoy the benefit of traveling at their maximum speed, unlike many of the defending missiles launching from a short distance away. The closer the attacking missiles get to the ship, the less time the defending missiles have to accelerate to higher speeds, further reducing the distance at which they can make intercepts. Because of these factors, even if a warship has a large magazine, a ship may not be able to fully leverage its magazine depth for defense before the first missile strikes the warship.

And missiles may not even need to strike the ship to score a mission kill. As defensive missiles clash with incoming weapons at closer and closer ranges, powerful warheads will be detonating against each other near the ship and at closing velocities of thousands of miles per hour. Exploding missile shrapnel will spray out, easily shredding exposed radar arrays, close-in weapon systems, and electronic warfare suites, systems that are all critical to a warship's last line of defense.

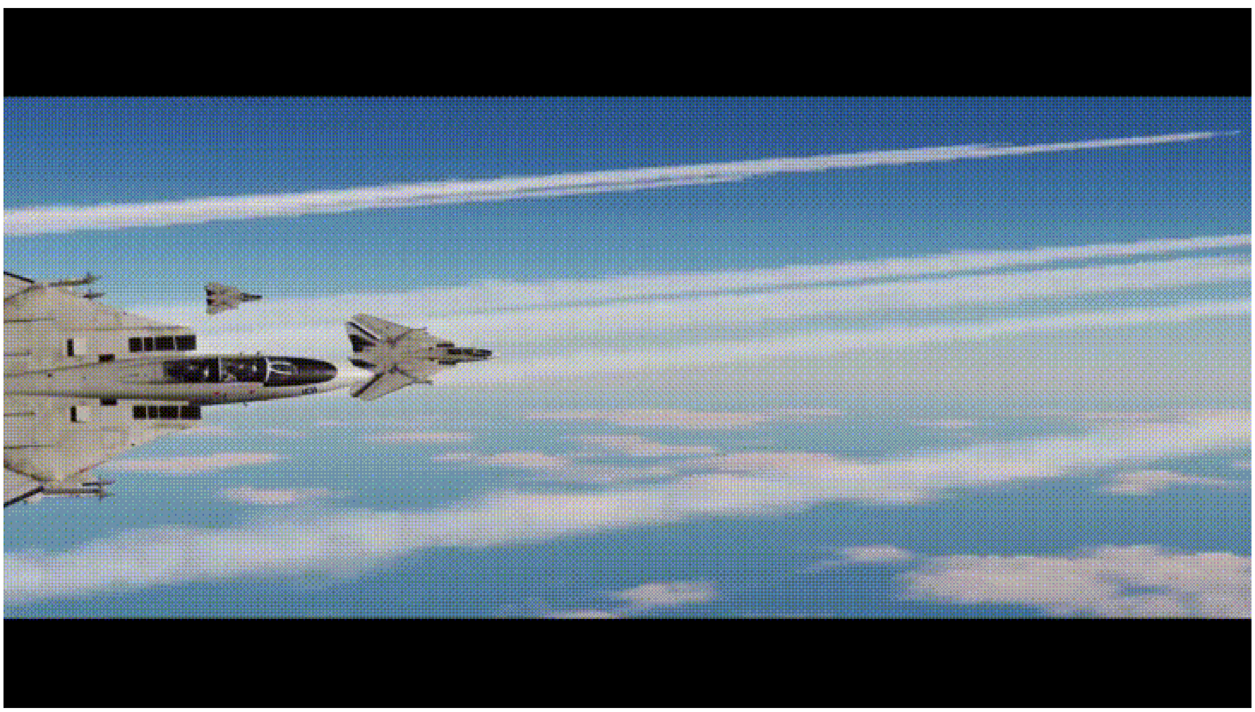


An SM-6 anti-air missile intercepts a relatively small, 600lb AQM-37C test missile. Note the shrapnel. (Source: U.S. Missile Defense Agency Multi-Mission Warfare Flight Test Events)

As automated combat systems and pre-programmed responses come online and take over these complex engagements, Sailors may have little direct control in those final seconds as enormous volumes of automated firepower attack and defend the warship.

Surface warships should be spared the burden of these harrowing missile engagements as much as possible. This will require shooting down archers instead of arrows and being able to destroy missiles that are traveling beneath the radar horizons of their target warships. But shooting down aerial archers will prove especially challenging because the substantial range advantage anti-ship missiles often have over anti-air weapons converts into a greater ability for aerial attackers to fire first. This range advantage also allows attackers to more easily exploit the radar horizon to turn their standoff fires into lethal close-in engagements for defenders.

These factors make airpower indispensable to missile defense because many anti-ship weapons intentionally fly below the radar horizon of warships in spaces only aircraft can see from above. The speed and altitude of aircraft will give them much more opportunity to shoot down sea-skimming missiles compared to warships. Anti-ship missiles also pose no threat to aircraft, allowing for heavily one-sided exchanges. Aircraft can safely and substantially reduce the volume of anti-ship missile firepower bearing down on friendly warships, and potentially even use jamming to attrit incoming salvos with softkill effects. Aircraft can also organize into horizontal formations that launch anti-air weapons in saturation patterns, perhaps making them the only naval platform capable of launching defensive fires in this salvo pattern at scale.



A squadron of F-14 Tomcats arrayed in a horizontal formation launches multiple waves of anti-air missiles in saturation patterns. (Source "Red Storm Rising: Chapter 20 The Dance Of The Vampires (FINAL CUT)" by FIXEDIT via Youtube, generated with Digital Combat Simulator World.)

Aircraft can use speed and maneuver to provide flexible and on-demand air defense support to distributed forces. A commander can dynamically reposition aircraft based on emerging threats and incoming salvos to bolster air defense capability where it may be needed most. While aircraft may be hard-pressed to reposition in time to intercept missiles with a low time-to-target, they can pose a much more serious threat to missile salvos that can take longer to reach their target, especially the Tomahawk.

These anti-air roles are much more favorable to the air wing in a variety of ways, but especially in terms of volume of fire. Because of the limits of hardpoints and airframes, many multirole aircraft can fire a larger number of anti-air missiles than anti-ship missiles. A fully loaded F/A-18 can carry 12 anti-air missiles compared to only four anti-ship missiles, allowing the aircraft to shoot down more anti-ship weapons than it could fire itself.[9] 24 F-18s would be required to match the number of anti-ship missiles fielded by a single American destroyer if its launch cells are fully loaded with anti-ship Tomahawks, but only eight aircraft are needed to match a destroyer fully loaded with anti-air Standard Missiles.[10] A handful of aircraft can therefore be enough to substantially tilt the balance of a naval salvo engagement in favor of the defending warships.

[caption id="attachment_57123" align="aligncenter" width="1913"]

PACIFIC OCEAN (March 6, 2019) An F/A-18 Hornet fully loaded with anti-air weapons prepares for a simulated combat mission off the coast of Southern California. (U.S Marine Corps photo by Sgt. Dominic Romero/Released)[/caption][caption id="attachment_57124" align="aligncenter" width="710"]

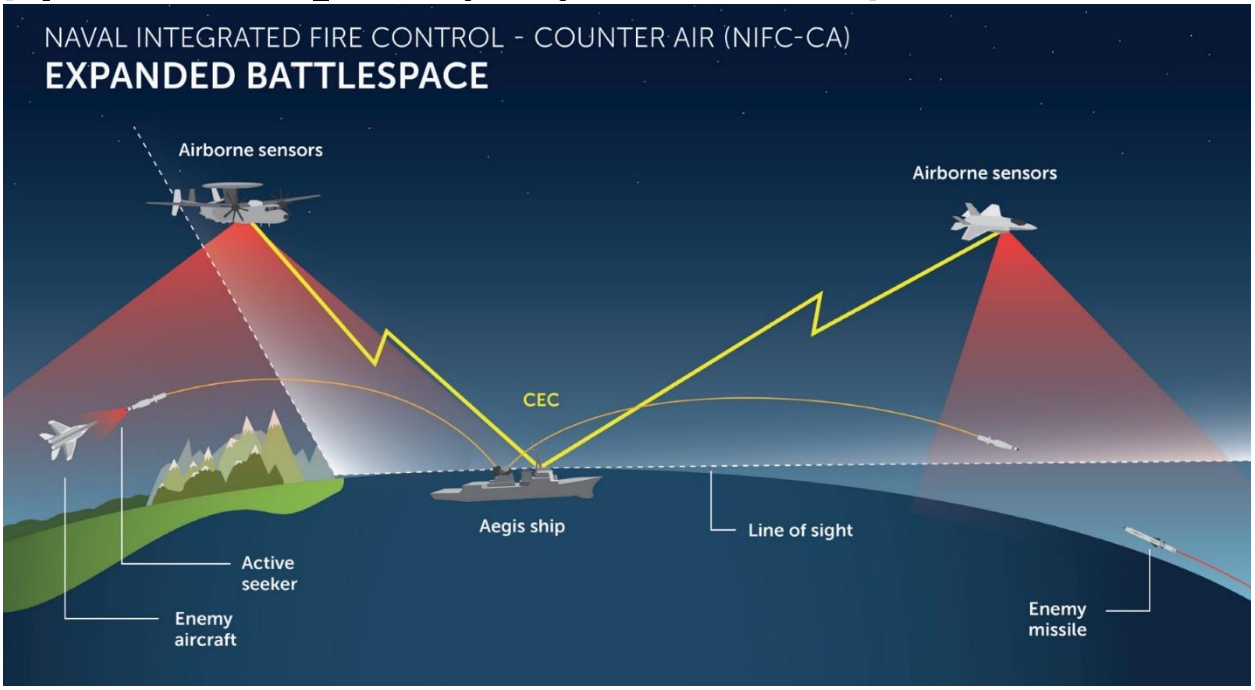
An F/A-18F Super Hornet from U.S. Navy Strike Test VX-23 in flight with four Harpoon anti-ship missiles. (Boeing photo)[/caption]

By virtue of having an overheard view, the anti-air weapons fielded by aircraft can be much more effective at shooting down cruise missiles than the much larger shipboard anti-air weapons. A shipboard anti-air engagement can be spoiled by simply having targets dive below the radar horizon of the illuminating warship, where the radar horizon constraint substantially diminishes the range advantage of the larger anti-air missiles that can be fielded via a ship's launch cells. It is debatable how useful that extra range is for the larger ship-based air defense weapons when so many of these weapons' dependence on semi-active illumination makes their killchains much more easily disrupted by target maneuvering.

Allowing aviation to pick up more of the air defense mission will allow warships to fill more of their launch cells with offensive weapons, where the added missile size and range is much more useful for a warship's offensive fires than defensive ones, save for perhaps defending against aircraft or especially high-end threats like ballistic missiles. Aircraft can also reload their anti-air weapons in a fraction of the time it would take warships to do the same, contributing to a more sustainable warship presence. Aircraft will also be critical for providing warships with early warning of incoming salvos, and helping them determine whether and when those warships should launch last-ditch fires.

Aviation is also needed to work the Navy's NIFC-CA capability (Naval Integrated Fire Control-Counter Air). This allows a warship to fire at targets beneath its radar horizon, if an aerial intermediary can facilitate the engagement.[11] This capability helps extend the anti-air battlespace and adds depth to a warship's ability to defend itself. Extending the anti-air battlespace can also help preserve inventory since the pressure to fire more interceptors per incoming missile increases the closer the salvo gets to striking the warship. But these NIFC-CA capabilities and advantages are dependent on aviation to function.

[caption id="attachment_57129" align="aligncenter" width="1779"]



Click to expand. A depiction of how the NIFC-CA capability allows warships to target air and missile threats traveling beyond their line of sight via a combined arms relationship with aircraft. (Graphic via CSIS Missile Defense Project)[/caption]

A common benefit throughout these various methods of applying airpower to anti-ship missile defense is that they substantially extend and complicate the air defense battlespace. This is critical toward increasing the attacker's challenge in a type of engagement where defending warships suffer significant disadvantage. Regardless of how powerful and capable a warship is, the burden of attacking a warship is substantially lessened by how the radar horizon forces defensive engagements to begin only mere miles away from the ship. Using aviation to extend the air defense battlespace far beyond a warship's horizon will greatly lengthen the gauntlet missiles must run to hit their targets. If attackers suspect that flexible airpower can be brought to bear on their salvos long before those missiles get near their targets, then they may have to consider expending much larger volumes of fire or reconsider the engagement entirely. They may also have to consider more complex tactics in sequencing and waypointing their fires to stretch defensive aviation thin or pull it away in directions that create opportunities for salvos to break through to targets.

This type of air defense coverage can go both ways. An adversary may also deploy aircraft to diminish the volume of fire to help protect their warships. This creates a strong incentive to provide air defense coverage to friendly salvos on their way to the target, since warships can hardly provide such coverage to their own attacking salvos. If a warship wanted to provide air defense coverage to its own offensive salvos, then it would have to substantially close the distance so its air defense firepower can overlap the range its anti-ship firepower has to travel to the target. But this is unrealistic in many contexts, and would sacrifice much of the anti-ship weapons' range. And it would still be of little use against aircraft that can still dip below a ship's radar horizon and engage the ship's attacking salvo without fear of shipboard air defenses. Aircraft will therefore be needed to not only attack incoming salvos below the radar horizon, but to engage opposing aircraft that are looking to do the same on behalf of their own warships.

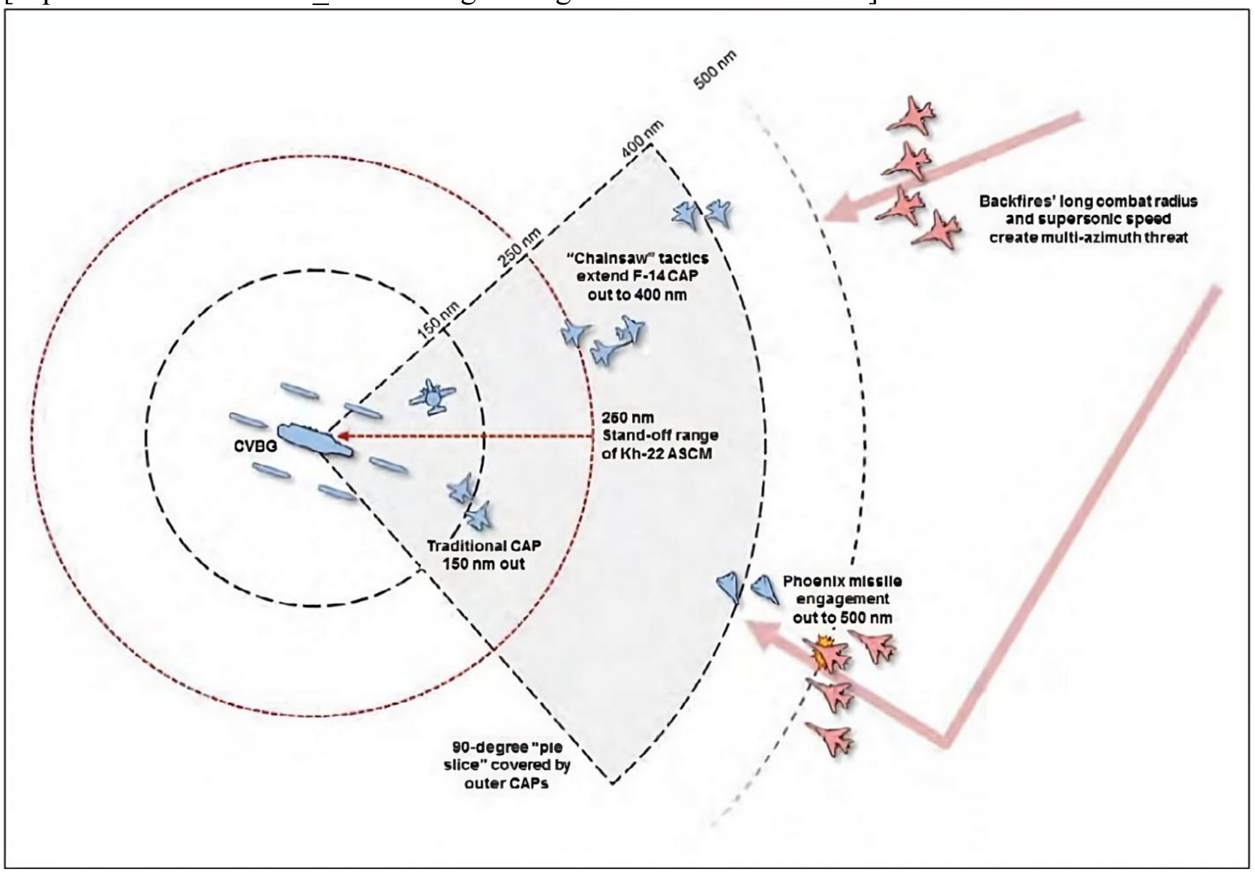
Warships can play a longer-range air defense role in this specific fight, when aircraft are dogfighting near the warship in a bid to protect or attack a salvo that is closing in. Aircraft that look to escort attacking salvos may have to contend with defending aircraft whose tactics can force the escorts to maneuver within view of the target warship's air defense capability. Those maneuvering aircraft could be more targetable at longer ranges for warships than the salvo that is traveling at a more fixed sea-skimming altitude. This can allow a warship to threaten the salvo's escorting aircraft, which then frees friendly aircraft to focus more on attriting the salvo on behalf of the warship. If there are a significant number of aircraft escorting a salvo, then defending aircraft could pull behind the air defense screen of the warship to enhance survivability, while still being in a position to attrit the salvo, although with perhaps less opportunity to do so than a more forward disposition. If substantial opposing aircraft are encountered, friendly aircraft can fall back upon the air defense screens of the surface warships, and leverage combined arms tactics to fight back against the attacking salvos and their escorting aircraft.

Naval aviation is also critical for defending against bombers, which are one of the most flexible and lethal platforms for anti-ship attacks. Because of their long range and the size of their magazines, bombers can launch substantial volume of fire against warships at distances that are well beyond the warship's ability to launch anti-air weapons. These features make it especially difficult to destroy archers before they can fire their arrows when it comes to bombers. Aviation is the main asset that can find and intercept bombers and impose last-ditch firing dilemmas upon them before they are able to fire upon warships.

A key challenge is how to maintain these forms of air defense coverage at a distance from a carrier. These tactics are reminiscent of the "chainsaw" tactics of the Navy's Cold War-era Outer Air Battle concept of the 1980s. A large number of carrier aircraft would maintain a continuously cycling aerial presence well forward of the carrier battle group so they could shoot down Soviet bombers before they could launch anti-ship missiles, and where these engagements would take place between 400-500 nautical miles from the carrier.[12] But this tactic was challenging to sustain in practice and could not cover all approach vectors, even when the baseline capabilities were more favorable to the U.S. Navy than what it has today. Those capabilities included a longer-ranged and specialized interceptor aircraft (the F-14 Tomcat), which fielded a longer-ranged interceptor missile (the AIM-

54 Phoenix), to threaten bombers that were using shorter-ranged anti-ship missiles than what competitors field today. Under the aforementioned concept of operations for supporting distributed forces, multiple carriers would be needed to sustain multiple chainsaw-type air defense screens, and for distributed surface forces and salvos operating at a significant distance away from the carrier, while using shorter-ranged carrier aircraft against bombers that have longer-ranged anti-ship missiles compared to the Cold War. In practice, it may be infeasible to sustain multiple chainsaws out to a range where they could attack archers before they fire arrows. Instead, the air wings may have to limit their reach and allow the hostile firepower to be launched, and then attrit it to a more manageable volume for the surface warships to finish off.

[caption id="attachment_57105" align="aligncenter" width="1844"]



A depiction of the Cold War-era Outer Air Battle and "Chainsaw" fleet air defense concept. (Graphic via Maritime Warfare in a Mature Precision-Strike Regime by Andrew F. Krepinevich, CSBA, 2014) [/caption]

Focusing much of the carrier air wing on providing air defense against bombers and sea-skimming threats will substantially enhance the survivability of both warships and aircraft. Compared to launching distant attacks against warships, defensive anti-air and interdiction roles allow aircraft to remain closer to friendly forces, fly more safely at higher altitudes, and take on anti-air loadouts that are lighter than anti-ship loadouts. Each of these factors contributes to higher endurance, sortie rate, and survivability for aircraft compared to the challenging requirements of massed long-range strikes against heavily defended targets. These missions better play to aviation's strengths and give warships much better margins of survival against potent missile threats.

These trends also signal a clear warning to surface fleets. Surface warships should be especially cautious about traveling beyond the support of aviation, or otherwise risk being alone in facing sea-skimming salvos in harrowing close-range engagements.

Carrier Coverage Limits and Information Roles

The major information requirements of naval conflict and the risky nature of massing carrier aircraft for anti-ship strikes both point to a critical takeaway – in fleet-on-fleet combat the carrier air wing should focus more on enabling the delivery of cruise missile firepower from the broader distributed force rather than delivering it themselves. This is a more complex arrangement than the traditional Carrier Strike Group construct, where the air wing would shoulder most of the anti-ship mission. Now the carrier can be asked to provide critical enabling functions for many warships and salvos, and at substantial ranges across a distributed fleet. But while these functions are more favorable to the air wing and the broader fleet for a variety of reasons, they still have critical constraints that can limit how a distributed force can arrange itself and assemble massed fires.

When it comes to securing information, aircraft can be playing multiple overlapping roles in the contested space between opposing fleets. An aircraft retargeting a friendly anti-ship salvo could end up defending that salvo and itself from opposing aircraft looking to intercept. That aircraft could also be shooting down last-ditch fires launched by the target warship it is guiding the salvo toward, while also gathering data on the warship's air defense performance and the composition of its volume of fire.

These air defense and information functions are highly complementary and integrative. Aircraft will be poised to clash with opposing aircraft that are performing similar information functions as both seek to enable salvos and defend against them. These intertwined functions set the stage for a hotly contested aerial battlespace between fleets as they exchange fire. Securing air superiority in this space, even temporarily, will translate into information superiority that yields significant offensive and defensive advantages.

Many of these critical missions, including scouting, counter-scouting, battle damage assessment, salvo escort, and retargeting support still require proximity to targets and can pull the carrier deeper into the battlespace. This proximity can require that aircraft and aircraft carriers operate from ranges similar to that of launching strikes, except the distances are determined more by sensor and network ranges rather than weapons range. Aircraft that are not E-2s or F-35s may need to get much closer to threats and friendly assets to earn and send this information, and potentially risk themselves against shipboard air defenses. These missions will also require proximity to friendly forces and distributed naval formations to enhance their early warning and air defenses.

The positioning of the carrier and the reach of its air wing will therefore determine the extent of information and air defense coverage it can provide for the broader distributed force and its massed fires. Similar to how weapons range can limit how far forces can distribute from one another and still combine their fires, the limits of air wing coverage can further bind the disposition of a distributed fleet. A fleet will have to limit the extent of its distribution if it is to seize the force-multiplying advantages of these combined arms relationships, while weighing the benefits of those relationships against the risks of greater force concentration.

Consider the need to overlay cruise missile range with aerial retargeting support and air defense coverage to help ensure friendly salvos are well-supported on their way to the target. Combine this with the need to keep surface warships close enough to the carrier that aircraft can interdict opposing bombers before they are within range of firing. Otherwise surface warships could be fired upon and picked off by platforms that are advantaged in firing first against warships. When these multiple combined arms relationships are factored in, the result is a fleet disposition that is considerably more concentrated than simply fielding a variety of widely separated Tomahawk shooters. These relationships and their concentrating effect on fleet disposition are depicted in Figure 1.

[caption id="attachment_57137" align="aligncenter" width="593"]

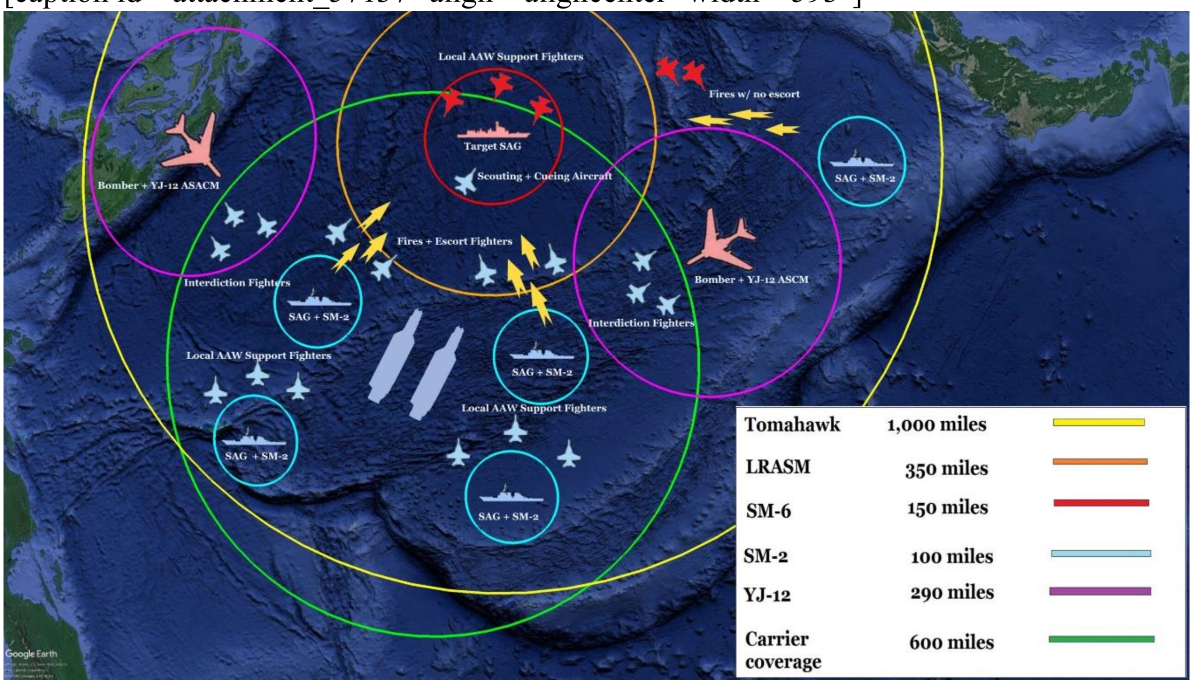


Figure 1. Click to expand. Reverse range rings for Tomahawk, LRASM, and SM-6 are centered on a target SAG, showing how far warships can distribute from one another and still combine fires against a shared target. Regular range rings for all other weapons are centered on their launch platforms. The fleet has to limit its distribution to provide critical aerial support functions to surface warships and to missile salvos. (Author graphic)[/caption]

In particular, the degree of overlap between retargeting coverage and weapons range can limit the area where aggregation can be supported, and how far platforms can distribute from one another. If a carrier wants to support an extreme range Tomahawk salvo, the carrier could have to be hundreds of miles *forward* of the launch platforms since the missile substantially outranges the unrefueled air wing. If a carrier wants to provide similar support for a shorter-ranged Naval Strike Missile attack, the carrier could be hundreds of miles behind the launch platforms and still be available. The missiles that can widen force distribution through their longer range may have to forego critical aerial support across wide ocean areas and especially in the final phases of combining fires, because their long range can also take them well beyond the support of friendly aviation.

The air wing will be severely taxed to cover all these critical information functions across a broad battlespace. This will make it extremely difficult if not outright impossible to mass the air wing, either for concentrated attack or defense. LCDR Sandy Winnefeld noted this challenging dynamic in the Cold War:

"So many fighters are required to support scouting requirements that very few are left on deck to counter the threat once it is discovered…in a superb example of Sun Tzu's maxim, 'He who prepares everywhere will be weak everywhere,' airborne fighters are so spread out that they cannot defend against a concentrated attack…Instead, airborne scouting fighters must be rapidly remarshalled to provide firepower when a [bomber] raid is detected… At realistic power projection ranges, the amount of firepower needed to counter [a mass Soviet naval bomber] raid is currently more than even a multi-carrier battle group force can realistically keep airborne continually during a campaign-length operation…the lion's share of the killing will have to be done by deck-launched interceptors."[13]

Extensive scouting and information functions will need to be performed regardless of whether the air wing is heavily concentrated for offense or defense. Those concentrated aerial formations are themselves heavily dependent on effective scouting, cueing, and in-flight updating to effectively perform at long ranges. The scouting demands of wide-area naval defense are considerable enough, especially when attempting to counter opposing scouts and bomber raids at distances that aim to preempt their firings. Adding the scouting demands of mass air wing attacks on top of baseline defensive requirements will stretch the carrier air wing even more thinly, making this combination of multiple steep requirements likely unworkable.

Even though these roles may not do much to increase the standoff distance of the carrier, an information-centric air wing is more survivable because it allows the air wing to be more distributed. Even one scouting aircraft can be enough to conduct the aforementioned information functions, from scouting a target warship at standoff ranges, cueing fires against it, retargeting those fires into an aggregated salvo, and assessing defensive performance and the result of the attack. This is far more preferable than sending masses of concentrated air wings to the limits of their range to launch risky attacks against only several warships at a time. The amount of aviation needed to sense a target and network fires against it could likely be met by far fewer aircraft compared to the numbers needed to mass the volume of fire organically through the air wing itself.

[caption id="attachment_57132" align="aligncenter" width="623"]

BAY OF BENGAL (Oct. 17, 2021) An F-35C Lightning II assigned to the "Argonauts" of Strike Fighter Squadron (VFA) 147 flies over the Bay of Bengal as part of Maritime Partnership Exercise (MPX) 2021 (U.S. Navy photo by Mass Communication Specialist 2nd Class Haydn N. Smith)[/caption]

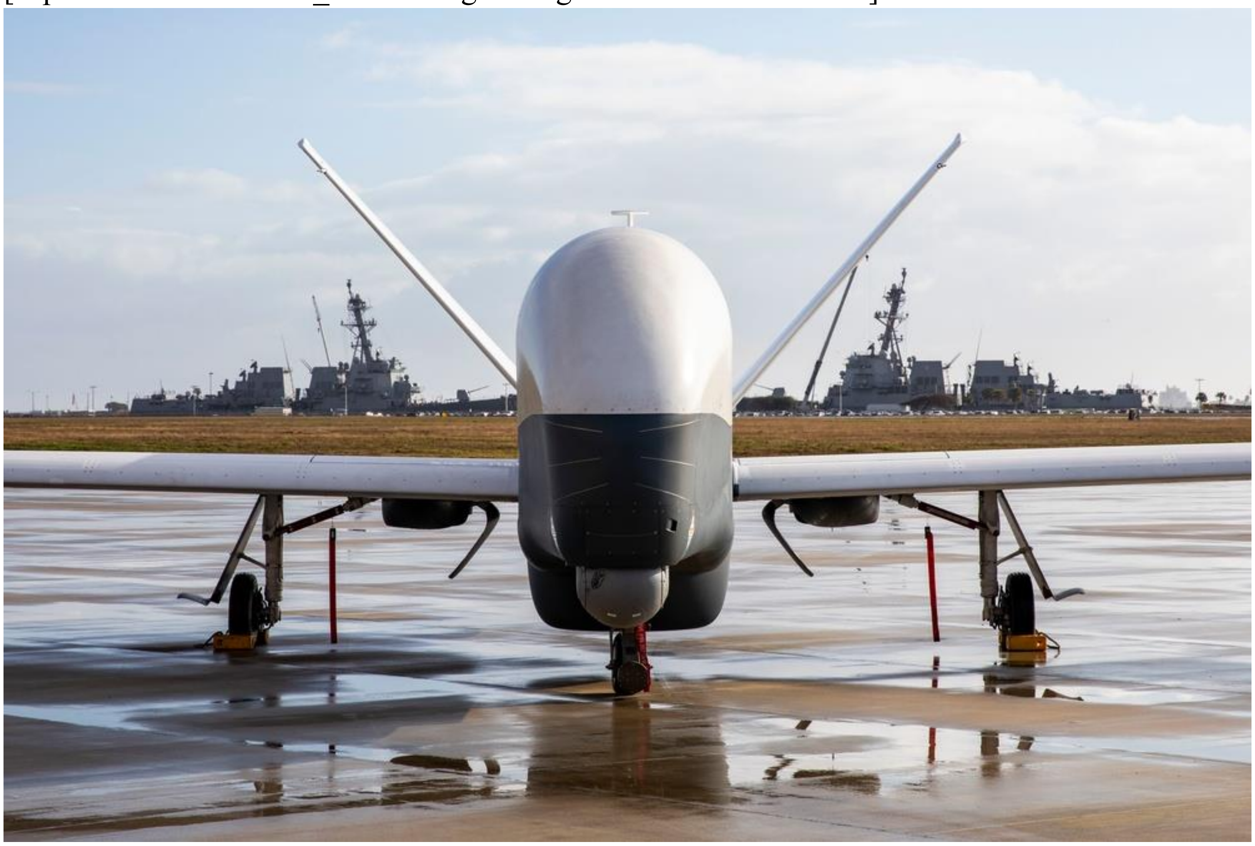
Removing much of the demand for carrier-centric strike operations will improve the survivability of the carrier. Adversaries may not choose to fire weapons near the limits of their range to engage carriers, especially long-range assets such as bombers and ballistic missiles. Instead, they may wait until the carrier is within range of its own offensive capability, knowing that the air wing may then be split between offensive and defensive missions, which lowers the volume of fire required to achieve overwhelming effect. If an anti-carrier strike was launched at ranges that exceed the offensive capability of the target carrier, then the strike is more likely to have to contend with a purely defensive air wing composition. As LCDR Winnefeld noted:

"If the Soviets cooperate by attacking at extremely long ranges, U.S. battle forces will be able to fight the [bomber raids] on their own terms. Carriers will be able to enhance their survivability by orienting their flight deck configurations exclusively to [defense]… Unfortunately, the Soviets may wait…tacticians counting on defeating the [bomber forces] at long ranges may be disappointed by an adversary who is unwilling to come out and fight on the [carrier group's] terms. Carrier battle forces will probably be required to defend themselves and project power simultaneously."[14]

These information-centric missions improve carrier survivability by allowing for more aircraft and hardpoints to be devoted to early warning and defensive capability. But even with their advantages, these information-centric missions may improve the carrier's survivability only marginally because of the enduring need to earn proximity to targets and friendly forces.

The carrier air wing does not have to be alone in executing these roles. The Maritime Patrol Aircraft community can make major contributions to battlespace awareness and communications, especially through new high-endurance drones like Triton. The land-based aircraft of the MPA community can substantially alleviate the burdens these information missions place on the air wing. However, these aircraft do not equip much in the way of anti-air weapons and are not as maneuverable as carrier multirole aircraft. Their ability to kill scouts and missiles will be extremely limited.

[caption id="attachment_57133" align="aligncenter" width="1000"]



Naval Station Mayport, Fla. (December 16, 2021) - An MQ-4C Triton Unmanned Aircraft System (UAS), assigned to Unmanned Patrol Squadron 19 (VUP-19), sits on the flight line. (U.S. Navy photo by Mass Communication Specialist 2nd Class Nathan T. Beard/ Released)[/caption]

Information can of course come from other assets. The Air Force can play a major role in developing awareness of the maritime battlespace, as well as space-based assets and allied forces. What is less clear is whether the degree of network interoperability and integration is enough to supplant many of naval aviation's information functions, rather than only supplement them.

The suggested information-centric missions are limited by what resides within the modern carrier air wing. It is unclear whether the mainstay aircraft of the Navy's carrier air wings – the F/A-18 – has powerful enough sensors and networking ability to conduct these information operations to a highly capable degree. These aircraft often depend on information from the E-2 airborne early warning aircraft, which features long-range sensing, considerable networking capability, and extensive battle management systems. But only a handful of these aircraft are fielded in an air wing, and only recently have they begun fielding variants that are capable of in-flight refueling.[15] These limitations greatly constrict the availability of the aircraft and therefore the scope of ocean space that can benefit from their information functions. The F-35, with its modern sensing and networking capabilities, may prove especially useful in executing these information-centric air wing operations. But until the F-35 is widely fielded, the Navy's ability to reap the benefits of these information functions and harness the broader firepower of the distributed fleet will be constrained.

Conclusion

General platform attributes or mission areas are not a sufficient basis to determine the continued relevance of a platform. Ultimately in combat, a platform lives or dies by the viability of its tactics, of how its specific concepts of employment interact with a contested battlespace, and of the precise details of how it would actually be applied in warfighting. For distributed warfighting at sea, there is a clear argument to be made for the vital role of naval aviation, whether it must come from aircraft carriers or somewhere else. Some of these arguments are couched in the fact that many of the premier weapons of modern naval warfare are themselves fast airborne payloads, that warships are mostly blind to spaces of enormous tactical consequence, and that air superiority is a powerful enabler of information superiority. Navies should carefully consider these factors as they debate the future of their force structure and naval warfare.

Introduction

China's arsenal of anti-ship weapons is truly a force to be reckoned with, and is superior to that of the United States in many respects. These weapons and the tactics that make use of them can be at the forefront of China's ability to deny U.S. forces access to the Western Pacific. As both great powers build up and evolve their anti-ship firepower, it is critical to assess their respective schemes of massing fires, and how these schemes may compete and interact in a specific operational context, such as a war sparked by a Taiwan contingency. Whichever side wields the superior combination of tools and methods for massing fires may earn a major advantage in deterrence and in conflict.

China's Anti-Ship Missile Firepower

China has assembled a wide array of anti-ship missiles and naval force structure for generating massed fires. These weapons and the way they have been distributed across platform types come together to form an outline for how China can mass fires against warships. These weapons should be assessed through a framework of the specific traits that highlight their mass firing potential, including launch cell compatibility, platform compatibility, range, maximum flight time, numbers of weapons procured, and numbers of weapons fielded per platform.

China's main anti-ship missiles are the YJ-12, YJ-18, YJ-83, DF-21, and DF-26. The YJ-12 serves as a primary weapon for bombers and coastal launchers; the YJ-18 is a primary weapon for submarines and large surface warships; the YJ-83 is fielded by multirole aircraft and surface warships smaller than destroyers; and the DF-21 and DF-26 ballistic missiles are China's most long-ranged land-based anti-ship weapons.[1] While there are other anti-ship missiles in China's inventory, those appear relatively uncommon compared to these five weapons.

[caption id="attachment_57274" align="aligncenter" width="566"]

Weapon	Estimated Range (miles)	VLS Capable	Platform Compatibility	Speed	Estimated Max Flight Time
YJ-83	110	No	Multirole aircraft Surface warships	Subsonic	12 minutes
YJ-12	290	No	Bombers Land-based launchers Surface warships	Subsonic (w/supersonic terminal sprint)	30 minutes
YJ-18	330	Yes	Surface warships Submarines	Subsonic (w/supersonic terminal sprint)	35 minutes
DF-21	930	No	Land-based launchers	Hypersonic cruise phase, supersonic terminal descent	15 minutes
DF-26	1,850	No	Land-based launchers	Hypersonic cruise phase, supersonic terminal descent	20 minutes

Click to expand. Key traits of mainstay PLA anti-ship missiles. (Author graphic)[/caption]

Each of these weapons, save for perhaps the YJ-83, is relatively modern and introduced into China's anti-ship arsenal within the past 10-15 years.[2] While the recency of introduction suggests the inventory may not be deep enough for a major conflict, China's precise weapon procurement rates are not as publicly discernible compared to U.S. forces. However, the U.S. Department of Defense has stated that China conducted more than 135 ballistic missile live firings for testing and training in 2021, which "was more than the rest of the world combined," excluding conflict zones. The DoD made the same remark about 2020, with China firing 250 ballistic missiles that year, and earlier again for 2019, but with no accompanying figure.[3] These firing rates suggest that China has invested in a robust missile production industrial base and recognizes the value of building out deep inventories of precision weapons.

The YJ-83 is a relatively common Chinese anti-ship missile that is widely fielded across its surface and air forces. It is similar to the Harpoon in being a smaller, shorter-ranged weapon that is not compatible with vertical launch cells. For warships, it is primarily fielded in box launchers aboard Chinese frigates, corvettes, and small missile boats. Multirole aircraft can field this weapon as well, making it the primary anti-ship missile for non-bomber PLA aircraft, such as land- and carrier-based aviation.[4]

The lack of launch cell compatibility makes it fielded in relatively low numbers aboard the compatible platforms. The short range and low magazine depth forces the extensive concentration of platforms to mass large enough volumes of fire. The range of the weapon is short enough that aviation can be forced to concentrate in large numbers within or near the limits of modern shipboard air defenses, although attacking aircraft may still have enough space to fire and then dive to spoil semi-active illumination. Like Harpoon, the greater the proportion of YJ-83s in a mass firing sequence, the greater the risk the force will incur.

[caption id="attachment_57275" align="aligncenter" width="564"]

YJ-83 box launchers mounted aboard a Chinese frigate. (Photo via Wikimedia commons)[/caption]

The YJ-18 strongly stands out in the PLA arsenal for being its only widely fielded anti-ship missile that is compatible with vertical launch cells.[5] It is fielded aboard China's large surface combatants, the Type 52D destroyer and Type 55 cruiser, and a torpedo tube-compatible version of the weapon is fielded aboard PLA submarines.[6] By combining a long range of more than 300 miles with launch-cell compatibility, the YJ-18 offers a strong capability for the Chinese surface fleet to distribute across wider areas and still combine large volumes of fire. Primarily because of the YJ-18, it is starkly clear that large U.S. surface warships are heavily outgunned by their Chinese equivalents, and must compensate for the disparity in offensive firepower with superior tactics, defenses, and combined arms methods.

The YJ-12 has similar range to the YJ-18 and is compatible with a larger variety of launch platforms, including coastal launchers and bombers, but crucially it lacks launch cell compatibility.[7] The range of China's bombers and the roughly 300-mile range of the weapon could allow bombers to reach out at long distances, concentrate aircraft well beyond the range of warship air defenses, and fire effectively first. By being compatible with bombers, this weapon can be at the forefront of China's ability to fire on warships at extreme ranges from the mainland.

The YJ-12 and YJ-18 feature terminal sprint capability, a major force multiplier that is absent from U.S. anti-ship missiles. By accelerating to around Mach 2.5-3.0 after breaking over the horizon view of a warship, these missiles can offer less than half the reaction time for the target warship to react compared to subsonic weapons.[8] This allows the missile to cross much more distance from the horizon before the warship can make its first intercept, and reduces the time it takes the missile to get inside the minimum engagement range of major warship defenses. By substantially reducing reaction time, terminal sprint allows lethal effect to be achieved with less volume of fire compared to a slower weapon. These weapons still fly at subsonic speed for most of their flight to maximize range, especially when traveling at sea-skimming altitude. This strengthens the imperative to intercept sea-skimming missiles with aviation well before they can activate their deadly terminal sprint capability against warships.

China's DF-21D and DF-26 anti-ship ballistic missiles offer critical asymmetric advantages by offering a combination of especially high speed and long range, allowing them to be at the forefront of China's ability to mass fires against warships. This combination of traits also allows these weapons to combine fires with a large variety of other platforms and payloads on a theater-wide scale. If a Chinese platform is firing anti-ship missiles at a naval formation within the second island chain, the defenders cannot discount the possibility that the salvo could be bolstered by high-end ballistic fires launched from the Chinese mainland. However, if the concentrations of these land-based launch platforms are maintained at their widely separated bases across the mainland, then this will lessen the overlap between their fields of fire and dilute their delivery density. [9]

[caption id="attachment_57272" align="aligncenter" width="2204"]


Ballistic missile bases and brigades of the PLA Rocket Force. (Photo via CSIS China Power Project)[/caption]

With the anti-ship Tomahawk, the U.S. may soon finally have anti-ship firepower that is more widespread and long-range than what resides within China's arsenal. But it is a major assumption to think China's anti-ship capability will remain static in the next 10-15 years as the U.S. builds up its anti-ship Tomahawk inventory. The state of advantage could change if China fields anti-ship weapons similar in design to the Tomahawk, or fields more of its novel missile types, such as the YJ-21 anti-ship missile that was reportedly test fired from a Type 55 cruiser in 2022.[10] The YJ-21 could stand to be the first hypersonic, launch-cell compatible, anti-ship missile for Chinese surface forces. While forthcoming variants of the SM-6 could stand to offer similar capability to U.S. forces, it will likely be subject to multiple factors that dilute its anti-ship potential as described in Part 2.[11] China has clearly demonstrated a strong interest in developing advanced anti-ship missile capability, and will be motivated to maintain its edge.

Key Elements of China's Naval Force Structure

China's force structure features much more variety than the U.S. military in terms of the platform types that can field long-range anti-ship firepower. Select elements and traits of this growing force structure deserve to be highlighted in light of their ability to contribute to mass fires.

Within the past decade China's surface fleet has emerged as a major force in its own right. After producing multiple short-run variants, several modern warship designs entered serial production, dramatically increasing numbers and capability. Today China's surface fleet is mainly composed of about eight cruisers, 30 destroyers, 30 frigates, 50 corvettes, and 60 fast-attack missile boats.[12] Most of the PLA surface fleet's capability to fire large volumes of long-range anti-ship missile firepower is concentrated in its large surface combatants, a force of nearly 40 warships that was built within the past ten years. If current production trends hold, this force of large surface combatants could double to around 80 warships within the next decade.[13]

[caption id="attachment_57270" align="aligncenter" width="586"]

The Type 55 guided-missile destroyer Nanchang (Hull 101) attached to a naval vessel training center under the PLA Northern Theater Command steams in tactical formation to occupy attack positions in an undisclosed sea area during a 10-day maritime training exercise. (eng.chinamil.com.cn/Photo by Zou Xiangmin)[/caption]

The asymmetry of certain scenarios and force structure can allow PLA surface warships to take on more favorable missile loadouts compared to the U.S. Navy. Given its expeditionary nature, the U.S. surface fleet faces greater pressures to split its magazine depth across multiple missions, including anti-ship, anti-air, anti-submarine, and land-attack missions. If the Chinese surface fleet is operating within the second island chain, much of the demand for land-attack capability could be offloaded to forces on the Chinese mainland, such as by having bombers, multirole aircraft, and ballistic missiles filling the demand for land-attack strikes. While Chinese frigates and corvettes have virtually no long-range anti-ship or land-attack capability, their anti-submarine capability could alleviate further demand on the larger surface combatants. The U.S. Navy by comparison does not feature frigates or corvettes, which concentrates its surface fleet's division of labor in its large surface combatants.

By being spared of the need to devote considerable magazine space to land-attack and anti-submarine weapons, China's large surface combatants could allocate a larger proportion of their magazines to anti-air and anti-ship weapons than equivalent U.S. warships. This advantage could give China's surface fleet more capability and staying power on a ship-for-ship basis when it comes to fleet-on-fleet salvo combat.

China's surface forces can be significantly bolstered by non-military elements. China's coast guard and maritime militia feature numerous vessels, and its commercial shipping fleet is massive. While these ships feature little in the way of firepower, they can considerably enhance the distribution of Chinese forces and complicate targeting by allowing the Chinese surface fleet to mask its presence among these more numerous vessels. China could also reap considerable gains in the ability to mass fires and pose a far more distributed threat if it opts to extensively field containerized launchers that could fire weapons and decoys from commercial ships.[14] Missile seekers that are programmed to avoid striking contacts that look like civilian vessels may struggle to differentiate these threats. The threat of hidden arsenal ships residing within China's massive shipping fleet could pose an especially distributed challenge.

China's naval service fields bombers within its force structure, unlike the U.S. military. The H-6J variant is optimized for maritime strike and can carry up to six YJ-12 missiles, an increase from the four missiles the H-6G can carry.[15] This increased carrying capacity translates into fewer platforms needing to concentrate around a target to mass enough fires.

These bombers are relatively limited compared to their American counterparts with regard to magazine depth. An American B-1B bomber can launch 24 LRASM missiles, a volume of fire that is four times greater than what an H-6J can muster, and with similar weapons range.[16] The U.S. can launch a greater volume of fire from its bombers by fielding cruise missiles that are small enough to be compatible with internal rotary launchers, substantially increasing the magazine depth per bomber. By comparison, YJ-12s are large enough weapons that they can only be carried via external hardpoints, limiting the magazine depth of the platform.

[caption id="attachment_57276" align="aligncenter" width="2560"]

Sept. 19, 2014 – An internal rotary launcher is seen outside a B-52 bomber. (U.S. Air Force photo/Senior Airman Jannelle Dickey) [/caption][caption id="attachment_57277" align="aligncenter" width="637"]

A PLA H-6 bomber equipped with two YJ-12 anti-ship missiles mounted on external hardpoints. (Photo by Japanese Ministry of Defense)[/caption]

However, as mentioned in Part 2, the U.S. Air Force is procuring so few LRASM weapons that long-range anti-ship capability is almost non-existent for the air service.[17] The fact that China has dedicated maritime strike bombers within its naval service suggests it is less likely to grossly under-resource their inventory of anti-ship weapons.

The PLAN operates about 50 attack submarines, where all but a few are diesel-electric, which limits their range and endurance compared to nuclear-powered submarines.[18] A critical shortfall is the lack of vertical launch cells in all PLAN diesel-electric submarines. They are confined to firing anti-ship missiles from their handful of torpedo tubes, which severely restricts their volume of fire.[19] But the ability of these submarines to field anti-ship missiles with terminal sprint capability may allow them to compensate for low volume of fire by launching close-range, high-speed missile attacks against warships.

[caption id="attachment_57279" align="aligncenter" width="738"]

A PLA submarine attached to a submarine flotilla under the PLA Northern Theater Command steams during a maritime combat training exercise in early August 2022. (eng.chinamil.com.cn/Photo by Shi Jialong)[/caption]

China fields hundreds of land-based multirole aircraft that could be critical in a naval conflict, including for growing or attriting volumes of fire and securing information advantage.[20] Land-based aircraft tend to have longer range than carrier-based aircraft, but most of China's land-based aircraft are fielded by the PLA Air Force, which will naturally have less familiarity and practice operating over maritime spaces than PLA naval aviation.[21] But these aircraft will still likely operate over or near maritime spaces in a Taiwan contingency, making them a considerable factor in naval operations.

Among the many trends of China's evolving naval force structure, its growing inventory of aircraft carriers stands to substantially tilt the naval balance in critical ways. The U.S. ability to overwhelm China's naval forces will be enhanced by its expanding arsenal of new anti-ship weapons, but maybe not as much as hoped for because of China's carriers. A world in which the U.S. military has finally built up enough anti-ship Tomahawks and LRASMs to mass fires against warships is also likely to be a world where China has built around six aircraft carriers, if current production trends hold.[22] China is poised to substantially change the balance of naval aviation in the Pacific during the same timeframe it will take the U.S. Navy to field enough weapons to mass anti-ship fires. China’s newfound carrier capability will then be poised to heavily attrit America’s newfound anti-ship capability, which will further drive up the volume of fire the U.S. will have to muster.

[caption id="attachment_57280" align="aligncenter" width="625"]

China's Type 003 carrier, Fujian. (Photo via South China Morning Post)[/caption]

But while China may be on track to field more carriers in the Pacific than the U.S. Navy, the U.S. may maintain a critical edge by fielding increasing numbers of the F-35 aboard carriers. It is unclear if China’s carriers will field as many 5th generation aircraft, potentially giving the U.S. major advantages in sensing, networking, and battle management functions that are powerful force multipliers for massing fires.

Nonetheless, the following dueling concepts of operation for mass fires take place in a hypothetical future 10-15 years from now, with both sides fielding considerable carrier aviation capability, and with China able to project a substantial amount of multirole naval aviation over the Philippine Sea.

China versus the U.S. and Competing Schemes of Mass Fires

The U.S. and China have developed forces that assemble massed fires in different ways. In looking at how a potential conflict may play out, it is critical to conceptualize how these different schemes would interact and oppose one another. A comparison of mass firing schemes highlights each nation's advantages and disadvantages in the context of the other's capabilities, and forms an outline for how kinetic exchanges could transpire.

What all of China's mainstay anti-ship weapons have in common is that they can travel to the limits of their range in roughly 30 minutes. The firing sequences of Chinese massed fires will typically be much shorter and concentrated than that of U.S. forces, such as those that rely heavily on Tomahawks (Figure 1). There will be comparatively less opportunity to counter PLA massed fires after they begin, where a shorter mass firing sequence reduces the defender's opportunity to reposition defensive airpower to attrit inbound salvos, launch interruptive strikes against waiting archers, and organize last-ditch salvos and their contributing fires. The PLA will benefit from a faster decision cycle compared to forces using much longer firing sequences, where multiple rounds of PLA massed fires could fit into the time it takes to mount a single firing sequence using Tomahawks that are launched near the limits of their range. The emphasis will instead be more about complicating the PLA decision to fire through distribution and other means, carefully pre-positioning airpower to attrit salvos soon after they are launched, and striking PLA archers early enough that they cannot initiate massed fires.

[caption id="attachment_57375" align="aligncenter" width="1279"]

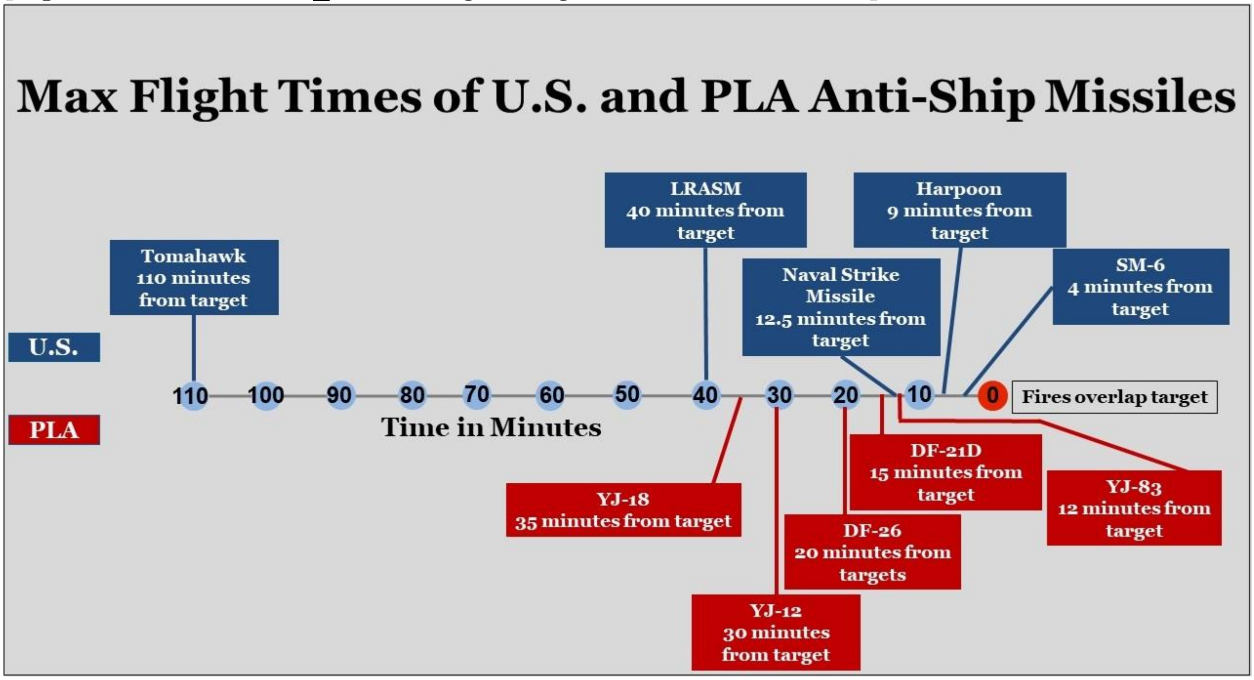


Figure 1. Click to expand. A timeline chart of the max flight times of U.S. and PLA anti-ship missiles, highlighting how PLA firing mass firing sequences can be more concentrated than those of U.S. forces. (Author graphic)[/caption]

U.S. forces may typically have longer firing sequences by virtue of the Tomahawk's long range and subsonic speed. However, the longer flight time of the mainstay U.S. anti-ship weapon will give it more opportunity to grow the volume of fire and more ability to leverage waypointing tactics, especially to increase the complexity of threat presentation and to feint attacks in a bid to trigger last-ditch fires. This long range and flight time also translates into more opportunity to maneuver across different salvo patterns, and more ability to recover from deception in pursuit of new contacts. China will be hard pressed to match these advantages, especially when its anti-ship weapons that rival the range of Tomahawk are ballistic missiles that are much more constrained in their ability to maneuver and reorient along their fixed ballistic trajectories.

However, the long range and flight time of Tomahawk gives the defender more opportunity to bring airpower to bear against salvos, and where the range of Tomahawk could outstrip the range of friendly escorting aircraft. Mass firing sequences that heavily depend on Tomahawk will have to strongly emphasize salvo patterns and waypointing tactics to compensate for the weapon’s survivability challenges and to preserve as much volume of fire as possible. These specific challenges and tactics also make Tomahawk especially dependent on naval aviation to provide critical information and air defense support to Tomahawk salvos. If PLA warships manage to get within range of Tomahawk-equipped warships, then many of the advantages that come with Tomahawk's longer range and flight time will be minimized.

China may hold a critical advantage with respect to interruptive strikes, which are used to disrupt an active firing sequence as it is unfolding. China’s anti-ship ballistic missiles can offer plenty of options for interruptive strikes by virtue of their high speed and long range. Warships that are suspected of being waiting archers in a lengthy firing sequence can be attractive targets for ballistic missile strikes, encouraging those warships to launch earlier and leverage waypointing to artificially increase their time to target. But this comes at the expense of frontloading the firing sequence and reducing the distribution of fires across time. China’s potentially superior ability to launch interruptive strikes could then shift the overall interaction between competing schemes of mass fires. China’s superior interruptive ability can lead to the opponent frontloading their firing sequences, which subsequently affords China more time and opportunity to bring defensive airpower to bear against the incoming salvos, while also giving China more time to organize last-ditch salvos and their contributing fires.

Anti-ship ballistic missiles can cast a shadow over the air defense doctrines of numerous forces operating within the weapons engagement zone, where warships may be forced to split their attention between sea-skimming and ballistic threats simultaneously. Warships deeper in the battlespace may be forced to radiate active sensors for the sake of defending more distant friendly forces from incoming ballistic threats, since being deeper in the battlespace can translate into more opportunity to make midcourse intercepts of those ballistic threats. By being forced to radiate and launch against ballistic threats, these warships could be highlighting their positions to the adversary. But the ability to shoot down ballistic threats will be a critical form of insurance against China's ability to leverage its potential superiority in interruptive strikes. In this sense, effective ballistic missile defense can interrupt China's interruptive strikes, and shift the balance of advantage in the ensuing interactions between competing schemes of massed fires.

China's Multiple Layers of Massed Fires

China's ability to mass anti-ship fires can be understood in terms of multiple layers. These layers are a function of the range of the weapons and the platforms that field them. Each layer of land-based anti-ship capability adds a new combination of platform types for growing the volume of fire and increasing the complexity of threat presentation. Within these more fixed layers of land-based capability, naval forces can be maneuvered to augment the density of the overlapping fields of fire. While weapons range and platform range are not enough on their own to extrapolate precise concepts of operation, they are an important point of departure for outlining options and limits.

The longest-ranged layer of how China can start to combine anti-ship fires from across land-based platform types is a mix of DF-26 ballistic missiles and bombers. These two delivery systems are China's most far-reaching options for delivering anti-ship missile firepower, and could come together to threaten naval targets starting at around 1,800 miles from the mainland.[23]

Massing fires from this limited combination of platforms poses its own set of challenges, especially by having only two main sources of firepower to draw upon. If bombers are destroyed before they can fire, PLA commanders would be forced to compensate by increasing the expenditure of their most high-end anti-ship weapons. Alternatively, if the kill chains enabling the ballistic missiles are undermined or uncertain, the transiting bombers would have virtually no options to increase their volume of fire while in flight, and may be forced to close with targets to secure targeting information for platforms other than themselves.

Bomber sorties could feature large numbers of aircraft to build a greater margin of overmatch to ensure the volume of fire can remain overwhelming in the face of unforeseen challenges and attrition. This was essentially Soviet naval aviation's doctrine for distant anti-carrier group strikes, where upwards of 70-100 bombers would fly more than a thousand miles from their bases and then heavily concentrate within 250 miles of a carrier battle group to mass fires.[24] The need to mass fires at extremely long range confined the Soviet Navy's options to gambling a major amount of its bomber force structure in each individual carrier attack, while being limited to homogenous force packages to produce mass fires instead of leveraging combined arms tactics. PLA naval aviation is perhaps in the more favorable position of being able to combine bomber fires with ballistic fires at extreme ranges, allowing fewer bombers to be risked per strike, and being able to compensate for bomber attrition in a timely manner with high-speed ballistic weapons.

Even so, China may not want to risk sending unescorted bombers into distant oceans and risk losing these valuable platforms to opposing carrier air wings, where air wings can better optimize themselves for early warning and air defense when reacting to especially long-range attacks.[25] Even with the possibility of combining fires with ballistic missiles, the bombers still have to concentrate their platforms inside a 300-mile radius of the target to launch fires. This could present a lucrative and concentrated target for U.S. carrier aircraft, where only a handful of fighters would be enough to credibly threaten a concentration of unescorted bombers. And the fighters can preserve the anti-air threat to bombers even if the bombers drop below the radar horizons of their target warships. Extensive aerial refueling would be required to ensure the bombers have enough aerial escorts that can accompany them on long-range strikes and contend against carrier air. The limitations imposed by refueling copious amounts of smaller escorting aircraft to extreme range could constrain the range of the larger bomber platforms, despite the extensive reach of those aircraft.

While China certainly has some ability to combine fires at the initial 1,800-mile layer, it remains a highly unfavorable scheme for massing fires, especially due to the challenge of providing extreme range aerial escort to bomber forces and a potentially heavy reliance on its most high-end anti-ship weapons.

With the twin overlapping threats of bombers and DF-26s starting at around 1,800 miles from the Chinese mainland, U.S. naval forces can travel another thousand miles closer to China before encountering the next major layer that adds another combination of land-based air and missile forces. These forces include a mix of hundreds of multirole aircraft such as the JH-7, J-10, and J-16 platforms that can field the YJ-83 anti-ship missile.[26] The DF-21D anti-ship ballistic missile also comes into range at around 900 miles from the Chinese mainland, assuming the launchers are near the coastline.[27]

This distance is still beyond the range of unrefueled U.S. carrier air strikes, allowing air wings to focus mainly on defense. But this distance is also roughly where U.S. warships and bombers would first be able to fire on Taiwan and the Chinese mainland with land-attack cruise missiles, creating a strong incentive for the PLA to mount a strong naval and air defense at this distance.

Attacking Chinese multirole aircraft would need to heavily concentrate in large numbers within 100 miles of their targets to mass overwhelming fires with the short-ranged YJ-83. But these aircraft are much better able to defend themselves against carrier aircraft compared to bombers and can diversify their loadouts to include a mix of anti-air and anti-ship weapons. If U.S. aircraft are unable to prevent these PLA aircraft from firing their anti-ship weapons, then the number of aerial targets will drastically multiply after they launch their volume of fire. U.S. aircraft will be forced to divide their attention and anti-air weapons between firing on enemy aircraft and firing on enemy missiles that are roughly ten minutes away from impacting friendly warships. And once PLA aircraft fire their anti-ship missiles, they could be well-positioned to attack the U.S. aircraft attempting to attrit the salvos.

[caption id="attachment_57281" align="aligncenter" width="2560"]

Fighter jets attached to a naval aviation brigade under the PLA Eastern Theater Command sit in their aircraft shelters prior to a night flight training exercise on April 17, 2020. (eng.chinamil.com.cn/Photo by Zhao Ningning and Tian Jianmin)[/caption]

U.S. carrier aircraft can certainly be in a position to inflict similar dilemmas on an adversary with their own anti-ship strikes. But a critical difference is that the aforementioned PLA land-based multirole aircraft have longer range than the U.S. Navy's F/A-18 aircraft, and airfields can have a higher sortie generation rate than carriers.[28] These advantages can give them more opportunity to inflict these dilemmas and with potentially greater numbers on their side.

However, projecting substantial airpower to nearly 800 miles beyond China's mainland will still create major demands for aerial tanking capability. To make the most of tankers to extend range, this in-flight refueling would have to take place near potentially contested areas, such as the airspace near Taiwan, the Ryukus, and the Batanes island chain. If the airspace around these locales can be effectively contested, China may be severely limited in its ability to project land-based aircraft in large numbers over the Philippine Sea, forcing China's carriers to be alone in providing multirole airpower beyond the first island chain.

The next major layer of PLA anti-ship firepower begins roughly 300 miles from the mainland. In this layer, coastal YJ-12 batteries and YJ-83s fired from short-range Type 22 missile boats pose an especially distributed form of massing anti-ship fires. These assets can help the

PLA project sea denial over much of the East China Sea, the northern areas of the South China Sea, and over the maritime approaches to Taiwan. The fleet of 60 missile boats in particular could be valuable in contesting sections of the Batanes and Ryukyu island chains and the maritime approaches leading toward expeditionary advance bases posted on those islands.[29]

[caption id="attachment_57282" align="aligncenter" width="631"]

Type 22 fast attack missile boats under the PLA Eastern Theater Command steam in formation during a maritime attack and defense training exercise in waters of the East China Sea in late March 2018. (eng.chinamil.com.cn/Photo by Chen Jian)[/caption]

These three main layers of combined anti-ship capability have more limited dispositions due to being fielded by land-based forces and small surface warships. On top of these more static land-based layers, China's surface and submarine forces are able to dynamically extend the scope and concentration of China's ability to mass fires against warships, and provide a maneuvering base of offensive fire. But these forces have their own limits to survivability and their ability to generate large volumes of fire.

Chinese submarines could arguably pose some of the earliest missile threats U.S. forces face by deploying far and away from the Chinese mainland, but their volume of fire is especially constrained due to the lack of vertical launch cells. Chinese submarines could still stalk certain areas such as Yokosuka, where they could fire on depleted warships returning from the fight, divert frontline assets to local submarine hunting patrols, and generate uncertainty around the maritime approaches to critical naval bases. Chinese submarines could also make major contributions to preserving the broader PLA anti-ship missile inventory by making a priority of torpedoing U.S. large surface combatants, which boast large missile magazines and considerable air defense capability.

China's fleet of large surface combatants, primarily the Type 52D destroyers and Type 55 cruisers, could add significant volume to a mass firing scheme. However, it is debatable how far forward China is willing to employ these ships from the mainland in a high-end conflict. The need for airpower to be on hand to improve survivability for these ships and their salvos, and to provide critical airborne information functions, limits how far these ships can be confidently deployed. If China extends a surface force from beyond the umbrella of airpower's critical enablers, those surface forces may be alone in contending with hostile salvos and airpower, especially from U.S. carrier air wings. Sending surface warships beyond the range of supporting aviation and into the weapons range of opposing aviation is a recipe for defeat in detail.

The struggle to maintain a substantial amount of multirole aviation out to a thousand miles from the mainland imposes significant liabilities on any mass firing scheme China can assemble at this distance. But until China can confidently field a significant number of its own carrier air wings, the bulk of naval-enabling airpower will have to come from land-based aviation that may be hard-pressed to fight in distant waters. For now, the U.S. may be heavily advantaged in being able to maintain robust combined arms relationships between its surface and carrier air forces regardless of the distance between those forces and land-based airfields. In the near-term, China's ability to make the most of its surface fleet's contributions to massed fires will be heavily constrained by the range and sustainability of land-based airpower, and its limited ability to overlay airpower's critical enablers over distant maritime spaces.

In designing the overall scheme of massed fires with these limitations in mind, China's surface fleet fits well within the second main layer of

China's anti-ship firepower. By leveraging a combination of YJ-18s launched by ships and YJ-83s launched by multirole aircraft, China can substantially lessen the burden on its bombers and land-based ballistic missiles to mass fires. Instead, it can focus on using much more common platforms and missiles to generate massed fires while posing a more distributed threat.

The similar range of the YJ-12 and the YJ-18 means China's surface and bomber forces need to concentrate within a similar ring around a target to combine fires. Through combined arms methods, warships could provide critical air defense and sensing support to friendly aircraft and provide a protective screen from which their airpower can leverage. Carrier air wings that pursue bombers and multirole aircraft could be led into Chinese warship air defenses.

The range differential between the the YJ-12, YJ-18, and YJ-83 is small enough to create a disposition where PLA aircraft and warships can readily provide critical enablers to one another, rather than the more divided nature of having U.S. airpower travel far forward to support Tomahawk salvos fired from upwards of a thousand miles away. While the similar ranges of China's primary anti-ship cruise missiles can certainly increase force concentration, their similar ranges also create a foundation for force-multiplying combined arms relationships and closely integrated force packages.

The second main layer of anti-ship firepower at around 800-1,000 miles from the mainland appears the most preferable to China. But maintaining a robust scheme for massing fires at this distance will not just be a function of the available combinations of capability. For China, it is a critical operational imperative.

Buffering the Pacific: Competing Mass Fires in Operational Context

China's potential schemes of massed fires have to be assessed in a specific operational context. While there are many dimensions to future contingencies, a core operational challenge for China in a Taiwan contingency is to maintain a maritime buffer zone out to around a thousand miles from the mainland. If U.S. and allied forces can get within this range, they can launch large volumes of land-attack cruise missile fires against China and Taiwan that can considerably complicate PLA operations. If China cannot effectively contest a maritime buffer out to this distance, it would have to devote considerable airpower toward cruise missile defense over oceanic spaces, when that airpower may be sorely needed for operations elsewhere. Preempting the looming threat of hundreds of land-attack cruise missiles launching from U.S. warships and bombers is therefore a critical operational imperative for China. As opposing forces contest sea control, the success of the anti-ship effort will unlock or deny options for follow-on power projection that could have decisive effects on a campaign.

A key question then is what sorts of combined arms relationships can China maintain out to this critical distance from the mainland, what schemes of massed fires those relationships would yield, and how those schemes of massed fires would interact with those of opposing expeditionary forces. The previous section highlighted how at about 800-1,000 miles from the mainland, China's combined arms relationships for massed fires can consist of bombers, anti-ship ballistic missiles, and land-based aviation. China's surface and submarine forces can be maneuvered to add to this mix, which considerably increases the potential volume of fire and complexity of threat presentation.

China would be in the challenging position of having to maintain a maritime defense that is forward enough to hold U.S. surface forces at risk before they can launch land-attack fires, but not so far forward that it outstrips the PLA's ability to add more platform types to its combined arms scheme of massing fires. It also cannot be so far forward that surface forces outstrip their ability to be well-supported by aviation in the critical air defense mission, or else those surface forces could be alone in facing withering anti-ship fires. The need to maintain substantial PLA surface warships near the outer edge of a buffer zone would also limit their maneuver space compared to the opposing expeditionary forces that can leverage the broader expanse of the Philippine Sea and adjacent waters. This asymmetry in maneuver space would simplify the scouting and targeting challenges for expeditionary forces facing warships that are tasked with reinforcing a buffer zone. But these surface warships are critical for providing a major base of fire that can persist at the outer edge of the buffer zone, or otherwise a disproportionately large volume of the available firepower would have to come from more transient platforms such as aircraft.

U.S. forces can impose some of these buffering dilemmas today because the land-attack Tomahawk missile is widely fielded across its surface warships. Those warships would still have to lean very heavily on U.S. submarines and carrier aviation to destroy opposing surface and air forces in advance, where those forces could prevent U.S. warships from reaching firing areas that are within Tomahawk range of Taiwan or China.

The dynamic significantly changes if China's anti-ship capability remains constant enough that the U.S. can secure a major range advantage with the anti-ship Tomahawk. This range advantage would threaten to split apart the combined arms relationships the PLA is able to maintain in a distant maritime buffer. The anti-ship Tomahawk would force the PLA to depend more on the platforms that are better able to reach out and threaten U.S. warships while circumventing Tomahawk firepower by attacking from different domains. These platforms include aviation, submarines, and ballistic missiles, but each of these has significant disadvantages, such with respect to sustainability, volume of fire, and survivability. This scheme may be the only combined arms mix that could have a chance of attacking distant surface forces before they could fire first against an outranged surface fleet.

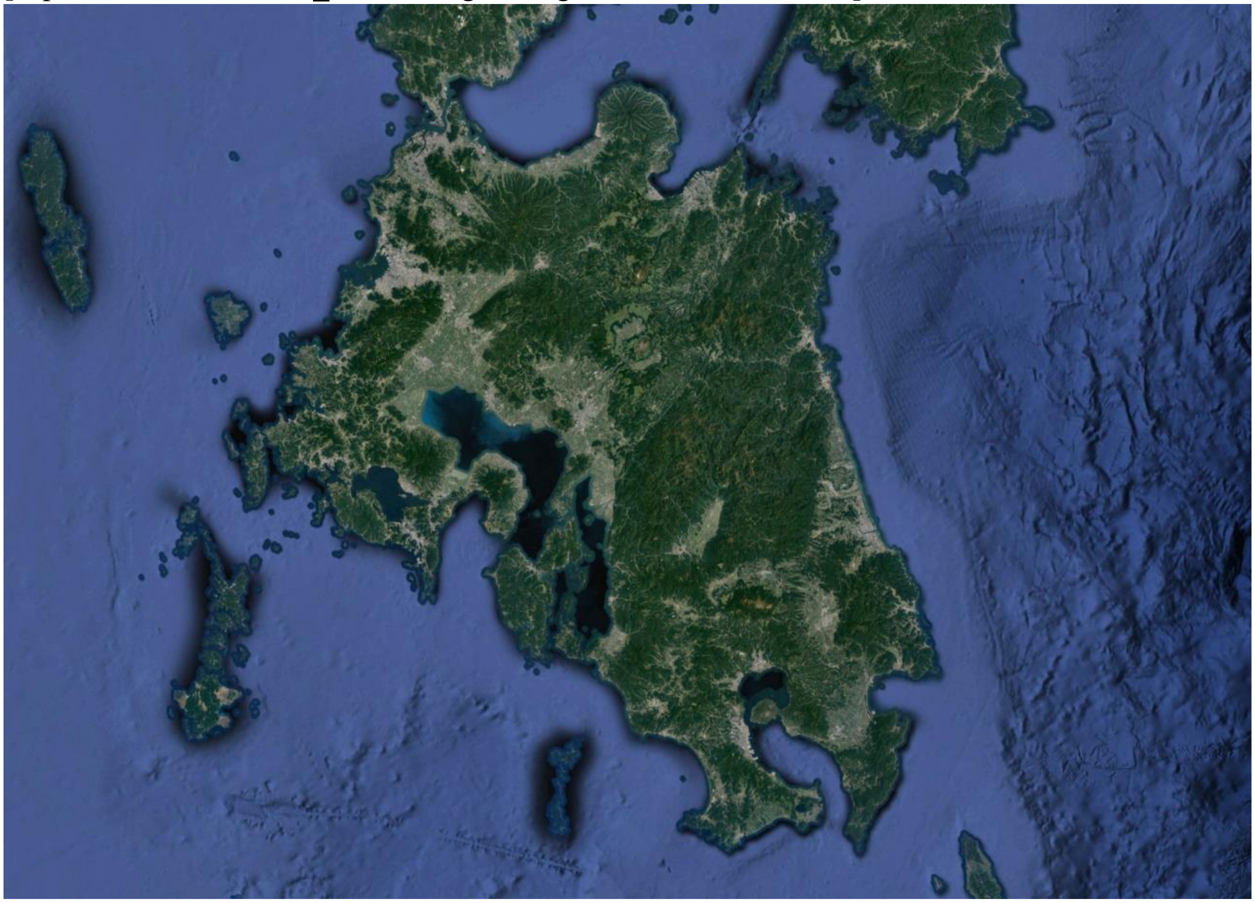
A key challenge then is how to maintain a robust mass firing scheme within a forward maritime defense when the defender's anti-ship capability is heavily outranged. If the defender's surface force can be more easily fired upon first, then it can threaten to remove a major base of fire that is undergirding the combined arms scheme for much of the maritime buffer.

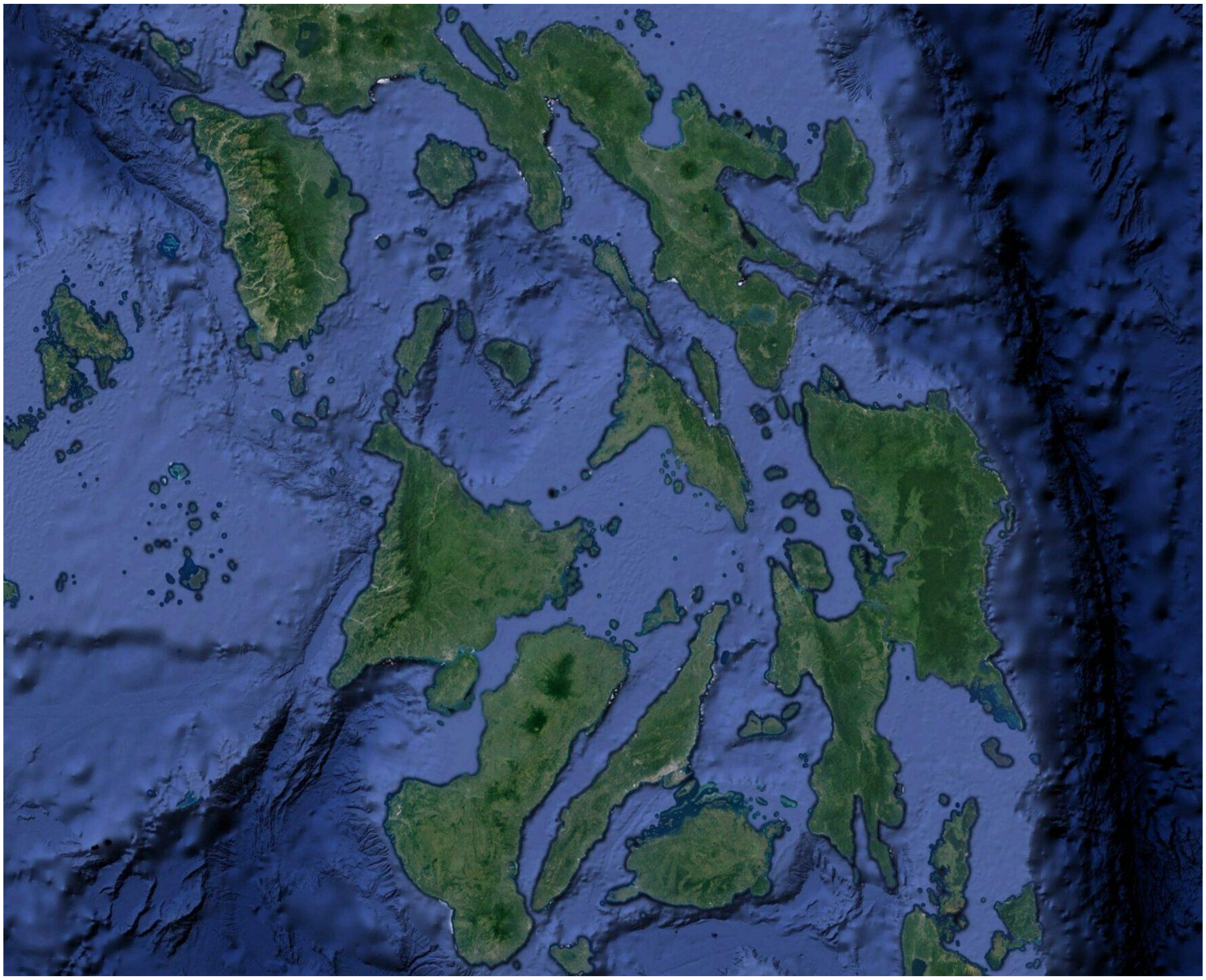
A surface force that is outranged or at risk of aerial attack must rely on more creative and combined arms tactics to compensate for the inferior ability to fire effectively first. This disadvantage especially requires a force to place heavier emphasis on scouting, counter-scouting, deception, and stealth. By securing distinct advantage in these specific areas, a force can earn vital proximity to an adversary with longer-ranged weapons, or induce them to launch wasteful fires, or complicate their decision to fire at all. Airpower is valuable for executing these specific tactics that help warships compensate for a disadvantage in the ability to fire first, but a distant buffer zone increases these challenges by diluting aviation's availability while limiting the surface maneuver space.

A force that is more likely to be fired on first may be forced to focus much of its initial strategy on optimizing for defense, so it can absorb enough volume of fire in the hopes of then transitioning to a more offensive posture that has better options against a depleted adversary. But if the adversary is firing with weapons of much longer range, then they can more effectively withdraw from the battlespace without coming under fire themselves. The buffering defenders may have to content themselves with inflicting weapons depletion more so than platform attrition, and maintaining sea denial rather than seizing sea control.

China has unique options for reinforcing a maritime buffer even if its surface forces could one day face major disadvantages in their ability to fire first. By filling the forward edge of the buffer zone with copious amounts of state-owned commercial shipping, China could vastly complicate the sensory picture of the battlespace. China's surface warships could then lurk among these large commercial vessels, and work with aviation to challenge scouts that attempt to probe and make sense of the morass of maritime contacts. Submarines may struggle to use sonar to isolate warship contacts amidst the heavy churning of many commercial ships. Anti-ship missiles may need to rise above sea-skimming altitudes to dodge commercial ships and discover warship contacts, potentially exposing themselves to more defensive fires and offering more early warning to an adversary. China's uniquely asymmetric ability to leverage large fleets of state-owned commercial shipping in naval warfare deserves careful consideration, especially within the context of maritime active defense.

While China's commercial fleets can vastly increase the complexity of its naval threat presentation, the U.S. has its own unique advantages that can provide similar effects. The long reach of the Tomahawk broadens the geography of firing areas enough to where the U.S. can capitalize on alliance advantages. The Tomahawk has long enough range to where it can be fired from within the complex littoral geography of the Japanese and Philippine home islands and into a variety of Indo-Pacific maritime spaces. This could allow U.S. forces to circumvent maritime buffers or fire upon them from their littoral margins, which are mostly allied territories. This concept is somewhat similar to the Cold War-era concept of hiding carriers within Norwegian Fjords to launch strikes against the Soviets.[30] Warships traditionally rely on broad oceanic maneuver to be a major enabler, but operating from labyrinthine littoral terrain can also complicate detectability and enhance the complexity of threat presentation even if it comes at the expense of maneuver space.

[caption id="attachment_57283" align="aligncenter" width="664"]

The littoral geography of the Japanese home island of Kyushu. (Photo via Google Earth Pro)[/caption][caption id="attachment_57284" align="aligncenter" width="627"]



The littoral geography of the central Philippines. (Photo via Google Earth Pro)[/caption]

While operating within fixed geography can certainly help adversaries localize naval forces, it may be more difficult to mass fires against warships residing within these littorals. Operating from these areas substantially increases the opportunity for warships to leverage friendly land-based air defense and aviation for support, increasing the volume of fire required to overwhelm warships. The challenges of navigating over littoral terrain can also force missile salvos to engage in tactically unfavorable behavior. Anti-ship missiles may have to depart from sea-skimming altitudes when flying over land, or burn more range to maintain themselves over water at low altitudes while taking more circuitous routes toward littoral contacts. Although it may increase warship findability in some respects, littoral firing areas could improve defensibility enough to compensate. The U.S. can carefully consider how the Maritime Strike Tomahawk opens up vast opportunity for launching massed fires against opposing fleets from friendly littorals.

Figure 2 highlights how these competing fields of fire overlap, and how firing areas located within these island littorals offer key advantages. These littorals can help U.S. forces circumvent a PLA buffer zone and bring those forces within Tomahawk range of Taiwan and the mainland coast. These separate areas also offer a substantial degree of overlap for combining fires over key geography. Tomahawk-equipped forces lurking within the complex littorals of Kyushu and the central Philippines will be able to combine and mass fires with one another over Taiwan and a substantial area of the Philippine Sea.

[caption id="attachment_57351" align="aligncenter" width="647"]

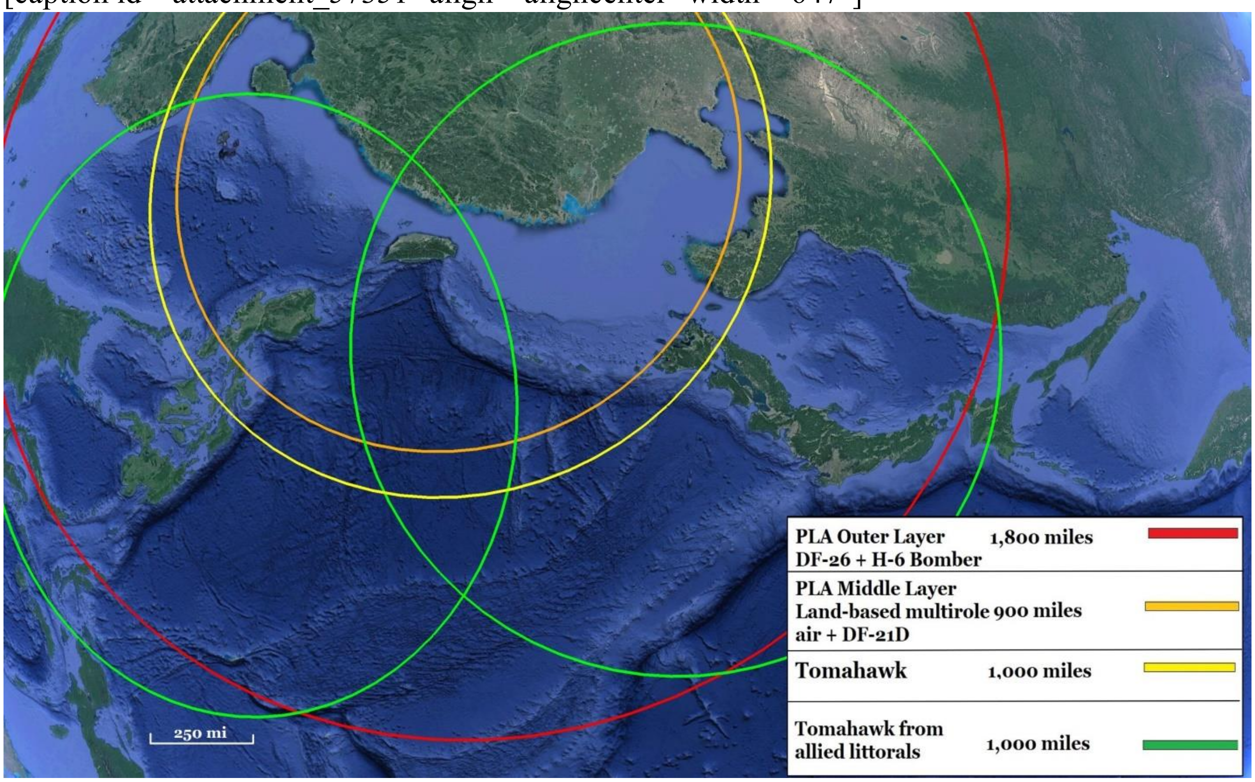


Figure 2. Click to expand. The yellow reverse range ring, centered on a location 100 miles inland on the Chinese mainland, shows the area from where U.S. forces enter Tomahawk range of Taiwan and much of the mainland coastline. All other markers are conventional range rings, depicting the range of capabilities placed at the center of their respective rings. (Author graphic)[/caption]

These dueling schemes of massed fires therefore look to increase their complexity of threat presentation with unconventional means. China's navy could aim to preserve its maritime buffer by lurking within a vast array of commercial vessels, and the U.S. Navy may seek to circumvent or damage the buffer from within a web of allied island geography. While this hardly makes for a traditional view of maneuvering battle fleets exchanging heavy fire, modern navies may be driven toward such methods by the unforgiving ferocity of naval salvo combat and its overriding insistence on firing effectively first.

Conclusion

China’s ability to mass fires against warships is a product of a truly historic evolution. China was a third-rate maritime power only two decades ago, but it has transformed into a force that heavily outguns the U.S. Navy in major respects. China has clearly stolen a march on the U.S. when it comes to developing advanced anti-ship firepower, and now the U.S. is racing to close the gap. But it will still be many years before the U.S. has the tools in place to have decent options for massing fires. By then, the Chinese naval arsenal may have become something even more fearsome.

Introduction

Militaries are left with little choice but to design their forces regardless of how well they understand the details of future warfighting. Force design is an exercise in placing educated bets on the future relevance of current and emerging capability. Many of these bets are far-reaching and irreversible, setting in stone much of what will be a service's capability for decades. But the services must be prepared to make radical changes if the future of warfare heralds decisive new methods.

Distributed naval warfighting and massed fires offer a practical operational context for valuing the combat power of force structure. The broad fundamentals of these warfighting dynamics could provide an enduring basis for force design. By establishing criteria and frameworks based on lasting operational considerations, navies can preserve their relevance.

Critical Traits for Valuing Distributed Naval Force Structure

The factors that make forces concentrated, distributed, or stretched thin are closely tied to how those forces are packaged and postured. In physical terms, these different aspects can describe the density of capability in individual platforms, the way density is spread across a fleet, and how forces are spread across a battlespace. The concepts of force structure, force posture, and force packaging are intrinsically linked and come together to define an overall state of distribution. Consider how force density manifests differently across the following fleet configurations:

- Concentrated force structure in concentrated formations, such as the main battlefleets of WWII, with large battleships and fleet carriers often massed together.
- Concentrated force structure in distributed formations, such as spread-out surface action groups, with each consisting of a few large surface combatants.

- Distributed force structure in concentrated formations, such as dense clusters of small surface combatants.
- Distributed force structure in distributed formations, such as widely separated small surface combatants.

These configurations provide a frame of reference for the different shapes of fleets and how they could interact and compete. The distribution of one's force structure should threaten to make the adversary's force structure more concentrated or stretched thin by comparison. These disparities then allow the better distributed force to capitalize on its advantage by inflicting steep sudden losses against the more concentrated opponent, or inflicting cumulative defeat in detail against one who is stretched thin.

The fundamentals of mass fires and distributed naval operations translate into a set of traits for valuing the combat power of naval force structure. The fleet that exhibits a superior combination of these traits will offer better options for force employment and operational design.

Information and Decision Advantage. The informational and decision-making implications of force structure are more difficult to perceive and measure than physical manifestations of capability. But a distributed force's ability to mass fires and strike effectively first is dependent on securing information advantage.

The physical structure of forces has a major influence over their methods of command-and-control, and how they challenge the command-and-control of the adversary. Force design should be mindful of the limits of command-and-control and the potential of force structure to overwhelm its own commanders. A distributed force structure may be of little use if the added complexity of wielding a wider distribution overwhelms commanders and corrodes the intended operational design.

Much of the decision-making challenge of attempting to mass fires stems from the burdens of sourcing firepower from across one's own forces, and deciding how to apply that firepower across the forces of the adversary. A distributed force structure should strive to provide superior options for sourcing firepower, while making it more challenging for the adversary to apply their own fires across the breadth of one's forces. Ideally distributed force structure sets the stage for mass fires to come together more quickly, with greater volume, and at longer ranges than the adversary.

It is not enough for a distributed force to field longer-range firepower, it must be able to out-scout and counter-scout the opposition. Much of a force structure's ability to offer information and decision advantage will derive from its ability to field platforms with superior sensing, networking, and battle management functions. Each of these functions is critical in being able to find targets, cue fires against them, and maneuver those fires through retargeting functions and other methods. Aircraft in particular, such as high-endurance drones and 5th generation airframes, can do much to enhance to enhance these functions.

Having a superior ability to collect information is not the same as having a superior ability to decide on it. Ultimately much of the information and decision-making advantage will derive from the human element, and how warfighting procedure has been structured to support human choice. One of the more difficult challenges of force design is in perceiving how it will influence the human aspect.

Complexity of Threat Presentation. Distribution is meant to directly challenge the adversary's ability to secure information and decision advantage, especially by complicating their ability to prioritize fires and interpret the battlespace. Complex threat presentation helps inflict paralysis by analysis, where an adversary's decision-making is heavily consumed by making sense of the situation, and how the ensuing doubt slows their decision-making. It is a momentous operational decision to launch a large volume of fire and be willing to suffer the resulting weapons depletion. Complex threat presentation makes it more difficult to firmly commit to such irreversible choices.

Each type of platform and payload offers a specific form of threat presentation through its signatures, behaviors, and attributes that create demands for information and interpretation. The state of advantage can change depending on how assets come across on an adversary's sensors and how easily they can be understood. Aircraft can employ fast maneuver, highly variable loadouts, and quick reload speeds to raise complexity. The steep magazine depth of surface warships can obscure a wide variety of potential weapon loadouts that may only be well-understood well after they launch fires. Submarines are aloof and hard to detect, forcing an adversary to scour for undersea contacts across wide ocean areas. Missiles with robust multimodal seekers and autonomous targeting logic can make it challenging to grasp their behaviors and devise real-time countermeasures. These many capabilities can integrate and overlap, creating interactions that are more difficult to understand than their standalone elements.

The complexity of one's own force can also be self-defeating. There can be an assumption that a commander will have a better grasp of the complexity of their own forces in the battlespace compared to the adversary. But distribution and a fluid battlespace can challenge a commander's ability to stay on top of how the complexity is evolving. Force complexity can also challenge units if a lack of familiarity with dissimilar forces hampers their ability to form combined arms relationships. There can also be an assumption that one's understanding of the opposition's complexity must be highly sophisticated to devise effective counters, but strong capability and effective tactics can compensate for lack of precise understanding.

There is a fundamental tension between presenting complex threats to the adversary and posing a simpler command-and-control challenge to one's own forces, and force design must be mindful of striking a deliberate balance.

Longevity of Distribution. A distributed force should ideally maintain a high degree of distribution throughout the duration of the fight and ensure the distributed posture is enduring. It does not suffer from episodic fluctuations that sharply concentrate or stretch thin the force. Longevity of distribution is promoted by effective defensive firepower, deep inventories of weapons, higher numbers of long-endurance platforms, and robust logistical sustainment. It is also a factor of sustainable force generation practices and readiness cycles.

Longevity of distribution in a high-end battlespace will function differently than peacetime naval operations, where forces are continuously rotated to maintain a specific level of presence in the forward environment. The history of fleet-on-fleet combat strongly suggests there is little use for tactical reserves, unlike in land warfare.[1] Rather, the fleet that can more quickly surge and concentrate greater forces and then deliver superior firepower first will be far more likely to succeed.

The longevity of distribution for an engaged fleet will be less a matter of devising a sustainable tempo of rotating forces through the battlespace, although that will still be an important function. Rather, longevity of distribution can be achieved by surging large numbers of forces and being able to maintain them for longer in the battlespace. Larger numbers increases the collective magazine depth of the distributed force, which allows the individual platforms to launch smaller increments of contributing fires, allowing them to persist for longer and contribute to a more enduring distributed posture on a force-wide level.

Inventory Breadth and Depth. A distributed force garners significant advantage by having a broader and deeper weapons inventory than its opponents. Inventory breadth is achieved by having a wide variety of numerous platforms that are compatible with long-range weapons. Inventory depth is achieved by having large numbers of weapons, both in the magazines within platforms and in weapons stocks that can be readily accessed for reloading. Deeper magazines allow commanders to diminish uncertainty by erring on the side of firing larger volumes of fire. Deeper weapon stocks reduce the major doubts and constraints that stem from concerns over depleting limited weapons inventory.

Firepower and Payloads. Information and decision advantage may count for little if they cannot be capitalized on with firepower. A distributed force aims to have superior options for massing fires by fielding missiles that have an edge in critical capabilities. These capabilities include long range, low time-to-strike, robust seekers, and waypointing and retargeting capability. Advanced networking and autonomous targeting logic is especially important for enabling missiles to optimize their own searches, defeat softkill measures, and leverage complex attack patterns during their terminal approach. These specific capabilities enhance the ability of weapons to combine into larger volumes of fire, preserve their lethality, and reduce the length of a firing sequence, even if they are fired from widely separated forces.

Much of force structure's combat value is derived from its ability to deliver and withstand highly lethal payloads, making it vital to understand how different combinations of force structure result in different options for handling massed fires.

Scalable and Proportionate Combined Arms. Force structure must preserve the viability of combined arms relationships across the scope of its distribution. The force structure of a navy's individual components should all ideally evolve in tandem and in proportion to one another to preserve their combined arms relations. If one dimension of a fleet's force structure becomes more distributed while another remains relatively concentrated, combined arms relationships may not be as forthcoming.

As one example, the U.S. Navy would already be very hard-pressed to sustainably overlay carrier aviation's critical enablers over multiple surface action groups that are widely distributed at a distance away from the carrier. If the force structure of the surface fleet becomes more distributed, but the carrier force does not, then many of those more distributed and smaller combatants may be well beyond the reach of naval aviation's critical enablers. This then puts them and their salvos at greater risk of defeat in detail.

Uneven distribution across force structure can also increase risk to a force's critical logistical enablers. Smaller ships typically have shorter range than larger ships, which makes them more dependent on logistical support vessels for regular refueling when operating over large oceanic expanses.[2] The need to support small warships in a forward operating environment could drive critical support ships deeper into the contested battlespace and put them at higher risk. Or smaller ships would have to remove themselves far and away from the battlespace to meet up with support ships, which comes at the cost of diminishing force distribution.

A force design that plans on introducing large numbers of smaller combatants also demands a commensurate fleet of smaller support ships. Otherwise, the mismatch between the risk-worthiness of the small combatant and the large support ship could substantially increase the risk to critical enablers and force distribution.

Resilient degradation. The attributes that create advantage for a distributed force on a force-wide level should be able to gracefully scale downward if the distributed force fractures into isolated units, rather than allow an adversary to secure outsized leverage by severing links. If the cohesion of a distributed force fractures into standalone units and force concentrations, those isolated elements should still be able to muster substantial volume of fire independently, or be able to form enough proximate connections with nearby forces to mass enough volume on a local basis. Vital combined arms relationships should also be able to withstand force fracturing, or be quickly regenerated by isolated forces seeking each other out.

Last-Ditch Resilience and Effectiveness. Ideally the various elements of a distributed force cannot be easily manipulated into launching wasteful last-ditch fires that needlessly deplete inventory. This instability is minimized by information advantage and by having superior defensive capability at the local level. If elements of a distributed force must fire last-ditch salvos, those salvos are accurate, within reach of viable targets, and can be bolstered by well-controlled contributing fires. Units do not feel compelled to impulsively launch contributing fires to bolster a last-ditch salvo, either because the last-ditch salvo features considerable volume on its own, or due to adequate doctrine and command-and-control.

Critical Tactics and Methods. Aside from more general attributes and traits, specific tactics can create enduring requirements for dedicated force structure. Because sea-skimming salvos should be attrited well before they break over the horizon view of defending warships, the major tactical blindspot imposed by the horizon creates a strong force structure requirement for naval aviation. The desirability of using torpedo attacks to sink warships at far less cost compared to large missile salvos creates a strong requirement for submarines. Certain tactics offer outsized leverage in the battlespace and are deserving of specific force structure. Force structure ultimately exists to manifest the preeminent tactics of the day.

Debating Force Structure Through Small versus Large Surface Combatants

While force design encompasses the whole of the naval enterprise, offering a comprehensive rundown of specific force levels and platform requirements is not the intent of the analysis here. Part 6 assessed the various strengths and weaknesses of major naval platform types, and Part 7 examined the vital enabling roles of naval aviation. Major force structure implications can derive from those factors.

A more focused look at the variability of surface forces can yield broad takeaways for naval force structure. A critical aspect of considering naval force design is in debating the tradeoffs between small and large surface warships in the tactical context of distributed warfighting and massed fires. The comparisons offered here are mainly centered on the magazine depth of surface warships, which is perhaps the core factor in their ability for generating and withstanding mass fires. The average magazine depth of the individual surface force package can have outsized influence over the larger dynamics of mass fires and have cascading effects across combined arms relations.

Small surface warships can be understood as corvettes, fast attack missile boats, and surface warships with a magazine depth of 20 or less vertical launch cells. Large surface warships can be defined as warships with 60 or more vertical launch cells. Useful conclusions about force structure and force packaging can be drawn from how the tactical dynamics of mass fires shift in relation to these two widely separate degrees of magazine depth. A fleet that is more distributed and fields a lower average launch cell count per force package could face very different options and risks when massing fires.

Offense, Defense, and the Unstable Firing Sequence

Small combatants have tended to field smaller missiles with shorter ranges, such as 100 miles or less, and with relatively few missiles per platform.[3] This stems from how many of these warships are too small to fit vertical launch cells into their hulls and accommodate the larger and longer-range missiles that would accompany these deeper launchers. Small combatants have instead often had box launchers mounted topside, which imposes major limits on magazine capacity and missile capability. This combination of low magazine depth and shorter-range weapons forces smaller combatants to closely concentrate around a target in larger numbers to achieve enough volume of fire to defeat warship defenses.

The shorter range of box-launched weapons makes it more likely small warships will have to withstand waves of fires if they are to eventually find themselves in a position to launch their own offensive firepower. But when it comes to defensive capability, many small warships that are confined to box launchers also tend to lack the magazine depth and hull space to mount the larger sensors and weapons that facilitate long-range air defense and early warning. Whatever organic air defense capability they field tends to be especially limited, potentially driving small warships toward concentration by the need for denser air defenses. And more warships firing defensive weapons at the same time within the same formation can mean more inefficient weapons depletion, unless those forces are tightly networked and integrated.

[caption id="attachment_57396" align="aligncenter" width="1200"]

PACIFIC OCEAN (Sept. 13, 2019) The Independence-variant littoral combat ship USS Gabrielle Giffords (LCS 10) transits the Pacific Ocean. The warship's anti-ship missile box launchers are visible aft of the main gun mount. (U.S. Navy photo by Mass Communication Specialist 3rd Class Josiah Kunkle/Released)[/caption]

If small surface warships are to feature in massed fires, their force structure ideally should equip vertical launch cells at a minimum. Otherwise, a force will incur severe risks by attempting to mass firepower from short-range platforms carrying only a handful of short-range weapons. And even if those platforms do feature vertical launch cells, lower average magazine depth across force packages can have a major effect on the overall character of a mass firing sequence, especially with regard to susceptibility to last-ditch firing pressures, the distribution of timing across a firing sequence, and defensibility. Many of the same disadvantages that derive from box-launched weapons can also be incurred by the increased risk-worthiness of small combatants, where more risk-worthiness implies a capacity for more aggressive posturing in the battlespace.

Small combatants may be heavily dependent on larger warships to provide an enduring measure of air defense coverage. But the isolating effect of the horizon on naval defense tightly compresses the amount of space a warship of any size can defend. A destroyer protecting smaller combatants would only be able to offer meaningful defensive coverage to a relative handful of warships that are very proximate to the destroyer. If a larger number of small combatants want air defense coverage, the more tightly they will have to concentrate around larger combatants, and to perhaps very extreme degrees of concentration. This can create a denser and more distinct mass of signatures an opponent could exploit.

Having aviation provide air defense coverage could allow a wider distribution of small combatants compared to larger warships that are tightly confined by the horizon limit. But aerial assets tend to have more episodic presence compared to warships unless commanders are willing to pay the logistical price of maintaining constant aerial presence. A distributed formation of small combatants may have to hedge against the uncertain persistence of friendly air cover by remaining near larger friendly warships, which comes at the cost of more concentrated force packages.

While steady aviation support can offer more distribution space for small combatants, those warships can still constrain aviation's maneuver space. In the combined arms relationship between aviation and surface warships, there is a dynamic where the range of the warship's anti-ship firepower shapes the amount of maneuver space the supporting aviation can leverage in defending the warship and escorting its salvos toward targets. The typically short range of box launcher weapons considerably tightens the amount of space a friendly aircraft can maneuver within between two opposing naval formations. If aviation is to interpose itself in the small space between a formation of friendly small combatants and an opposing large surface warship, then the ranges involved are more likely to put the friendly aircraft within range of the large warship's air defenses. The range is tight enough to where the aircraft will likely have to worry about its own survivability while also protecting the survivability of the small surface ships and their salvos. And if that target warship launches a last-ditch salvo against the small combatants, the aircraft will be sorely needed to reduce the volume of fire as it is only minutes away from threatening the small warships.

By comparison, vertical launch cells afford supporting aircraft much more maneuver space by virtue of fielding offensive weapons of much longer range. Aircraft that are helping secure warships that are firing on one another hundreds of miles apart will have to worry far less about encountering warship air defenses while shooting down warship-launched anti-ship missiles. The limits of box-launched anti-ship weapons considerably increase the risk to supporting aircraft in this respect.

Shifting toward a more distributed force structure tends to mean a lower average launch cell count per force package, but more force packages overall. Yet this supposed promise of small combatants – fielding more forces across wider distributions – can be in tension with the limits of combined arms relationships. Vertical launch cells can offer small warships more space to distribute and still combine fires, but this increase in spacing and risk-worthiness may take them well beyond the range of friendly aviation support.

It is unclear how willingly small warships would want to venture beyond the umbrella of friendly air coverage, which would already be highly risky for even large warships. Their relatively little long-range air defense capability and the risk of being deprived of friendly aviation support makes widely distributed small warships more susceptible to being stalked, surveilled, and jammed by opposing aircraft. This can put these warships at critical informational disadvantages and make it much easier for the adversary to fire effectively first. If a force is unwilling to risk sending numerous small warships beyond the reach of supporting aviation, then the resulting force posture of those force packages may become more concentrated than what the force design had intended.

Distribution does not only describe the physical aspect of force density, but also the timing aspect of how launches are spread across a firing sequence. It is important to consider where small combatants may fit into a mass firing sequence and how this affects the risk posed to the platform and the firing sequence.

The short range of box-launched missiles typically gives them relatively low time-to-strike, which will likely place their launch platforms far later in a firing sequence, especially one that also includes plenty of Tomahawks. But a small combatant that plans to fire much later in a firing sequence may very well be the first warship to be destroyed by the enemy's reaction. The longer a warship has to wait to launch during an active firing sequence, the more opportunity the adversary has to launch interruptive strikes against waiting archers. In the case of a small combatant waiting to fire Harpoons or Naval Strike Missiles, it could be forced to wait tens of minutes and even an hour or more while waiting a relatively short distance from the threatened adversary.

Small payloads typically translate into low time-to-strike, which can translate into launching later in a firing sequence, which then converts into more opportunity for a threatened adversary to launch interruptive strikes against the waiting archer. Even if they field longer-range weapons, these effects can also be suffered if the added risk-worthiness of small combatants translates into them being sent deeper into the battlespace and closer to the adversary.

Shortening the firing sequence for the sake of lowering the risk of interruptive strikes against small combatants would come at a steep price. A shorter firing sequence could be obtained by massing enough small combatants so their concentrated formation can launch a standalone salvo of sufficient volume of fire. A shorter firing sequence could also be achieved by combining fires from other domains and platform types, such as aviation, submarines, or stand-in forces that can earn enough proximity to the adversary. But it is debatable how much risk these platforms should assume to help the contributing fires of small combatants become more viable.

Small combatants that do not feature vertical launch cells that can accommodate larger weapons may struggle to put themselves into a more survivable place, both spatially within the battlespace, and temporally within the timeline of a firing sequence. Many of the risks of employing small combatants in mass fires will be mitigated by fielding vertical launch cells that allow them to hold the same long-range weapons that large surface warships can carry, even if their cell count is lower. However, fielding a lower launch cell count per force package still invites some risks with respect to salvo instability.

The relatively weak nature of small combatant defenses makes them highly unstable in a naval missile exchange. A major contributor to this instability is their higher susceptibility to last-ditch firing pressures, which adds instability to the broader mass firing scheme. A warship that can only shoot down a few anti-ship missiles before it is overwhelmed and destroyed may very well be operating on a hair trigger in a major war at sea. If it takes a very low volume of fire for a small warship to feel existentially threatened, then it may take relatively little to provoke these warships into wasting their weapons in last-ditch fires.

And a small volume of fire may not even be needed to be sufficiently threatening. A small warship may have so little defensive capability that methods of active sensing, jamming, posturing, and other actions that could be interpreted as a prelude to an attack could trigger a last-ditch salvo. These methods would allow an adversary to potentially trigger wasteful fires without having to expend any volume of fire of their own. By comparison, larger warships can hold their offensive firepower in reserve while being sensed or even while under active attack, because the incoming fires can have little chance of overwhelming their defenses without enough volume.

A small combatant's higher susceptibility to last-ditch firing pressures could unravel the effectiveness of a force and its mass firing schemes more rapidly than that of a more concentrated force structure or force posture. In many circumstances a last-ditch salvo will struggle to achieve enough volume of fire, which puts pressure on other platforms to add fires. Because small combatants have smaller magazines, their last-ditch salvos are far less likely to reach meaningful volume without outside support. If small combatants are pressured to discharge last-ditch salvos, then other platforms may also feel strongly pressured to launch contributing fires to give those smaller last-ditch salvos enough volume. If the small warships are close to an adversary or are firing box launcher weapons, then the low time-to-strike would minimize the ability of outside forces to offer contributing fires. This adds further pressure on nearby small warships to launch contributing fires in support of the last-ditch salvos, and makes the firing scheme more unstable. These susceptibility and instability challenges are further exacerbated by the aforementioned difficulties in providing persistent air defense coverage to small combatants.

Larger platforms are less susceptible to last-ditch firing dilemmas by virtue of having denser defenses. It takes more firepower for them to feel existentially threatened, where larger warships are better able to defeat volumes of fire without having their decision-making forced into making irreversible actions. If they must fire a last-ditch salvo, their magazines are deep enough to where they may be able to launch a large enough volume of fire on their own, reducing the pressure on other platforms to contribute fires on short notice, and offering more stability to a mass firing scheme.

When it comes to preserving the longevity of distribution, small combatants can make a force more concentrated through inventory depletion dynamics. Small combatants typically field so few offensive missiles they may have to function like aircraft by firing most if not all of their entire offensive loadout in a single salvo to offer contributing fires. In this sense they combine the disadvantages of both air and surface platforms – the quick depletion of firepower of a small aircraft with the long reload time of a warship.

This can cause small combatants to have a profound influence on the longevity of force distribution in a battlespace. Small combatants could use their numbers to help maximize distribution in the early stages of a fight, but may sharply reduce a force's distribution shortly after the initial salvos. The shallow nature of small combatant magazines can make their contribution to force distribution more episodic and transient.

After the first few rounds of massed fires, a force may become much more concentrated as its small combatants leave the fight to reload. The ensuing reduction in force distribution makes the remaining warships more vulnerable, and the small combatants may have fewer surviving forces to come back to when they reenter the fight. If a force is counting on a short, sharp war of intense salvo exchanges, small combatants may help frontload the distribution of the force, but then substantially diminish and fluctuate distribution later on.

With respect to complexity of threat presentation, the smaller the magazine, the easier it is for an adversary to ascertain a platform's missile loadout and tell when it is out of firepower. Many small missile combatants only field one type of offensive missile at a time in their box launchers, simplifying the adversary's challenge of tracking expenditures and reducing the complexity of threat presentation. Longer-ranged weapons that are fired and waypointed from standoff distances make it more challenging for an adversary to associate specific weapon expenditures with specific force packages. But the typically shorter weapons range and more risk-worthy nature of small combatants can draw them deeper into the battlespace and within easier view of the adversary. If a small combatant depletes itself and then remains in a forward area to maintain a degree of force distribution, it will be easier for the adversary to call the bluff.

Much of the comparison between large and small warships is contingent on specific tactical context. While large combatants have certain advantages over small combatants, it is a broader question of whether a certain force posture or operational design draws more enemy attention toward the larger or smaller combatants of a fleet. Many of the disadvantages of smaller combatants may not be incurred if an enemy believes the larger combatants are more deserving of their massed fires. Much of the drive toward distribution is also fueled by a concern that great power competitors will not struggle to muster overwhelming volumes of fire no matter how dense the naval target. But what is critical to understand is that smaller warships have certain drawbacks that can encourage them to concentrate among themselves and also form force packages with larger warships. And a large group of small ships is still a concentrated formation that can become a priority target for an adversary.

Force packages of large warships can certainly invite catastrophic levels destruction if even a handful of salvos land their blows. Each successful enemy salvo would result in especially steep losses in capability, and where it could easily take 20 or more years of shipbuilding to regenerate major losses. Given the already tightly stretched nature of the U.S. Navy in meeting its existing peacetime commitments, if a single large naval formation falls prey to a salvo, then it could radically reshape the global force posture of the U.S. Navy for the foreseeable future.

A more distributed force structure may be perceived as being able to degrade more gracefully under fire than a more concentrated force structure. But a force that takes distribution to an extreme will be stretched thin, and it may be difficult to perceive the overextension until it is too late. Being stretched thin, whether as a matter of force structure or force posture, invites defeat in detail while making it more difficult for a force to combine its fires. Rather than suffer catastrophic destruction in one fell swoop like a more concentrated force, a force that is stretched thin could suffer rapid cumulative destruction as distributed elements are picked off through defeat in detail.

It is important to be mindful of how small combatants may figure into fleet-on-fleet massed fires, and consider what risks may come with mass firing options whose dependencies could often stem from small combatant disadvantages.

Network Degradation and Fracturing Distributed Forces

Network reliability has a tremendous effect on the extent to which forces and capabilities can be distributed and concentrated in combat. But the distribution and concentration of capability is also what force structure seeks to optimize. A fleet that is built on a vision of a well-functioning network could have a vastly different composition compared to a fleet that expects to mostly fight in the dark.[4]

Concepts of force employment and force design are heavily influenced by perceptions about the offensive-defensive balance and the hider-finder competition. These beliefs have trended in the direction that the finders and the attackers have been gaining the advantage as sensors and offensive weapons have grown more capable in relation to their counters. It is easier to be found, and once found, it is easier to be destroyed.

Regardless of the overall trends, these balances and competitions are still dependent on specific operational context. The state of advantage is markedly different when a fight is characterized by low emissions, probing scouts, and massed fires held at the ready, versus when the fight has erupted into a cacophony of signatures, networks are degraded or overwhelmed, and widely distributed forces are consumed with their local battles. The ability of a force to mass fires will degrade in combat, especially when command-and-control struggles to keep pace with the rapidly evolving situation.

Force design and force employment must account for how operations may take on a widely different character in these contexts, and how the state of advantage may change. It is especially critical to envision how a collection of widely distributed forces that were meant to combine fires can instead fracture into individual force concentrations that attempt standalone attacks, and what this could imply for designing resilient force structure.

When a network degrades and a distributed force fractures into smaller concentrations, defensive capability rises in relative strength against offensive capability. This is because the act of massing fires across forces is inherently more dependent on networks compared to warship self-defense. While degraded networks could challenge the ability of ships to leverage aviation for missile defense, the radar horizon has an isolating effect on warship defense regardless of the health of the network. An attacking volume of fire can be drawn from a variety of widely separated forces, but the defending volume of fire can be mainly limited to what the targeted warships can muster through their organic capability. A degraded network makes it harder for a ship to make use of its offensive firepower, but the ship's organic defensive capacity is left relatively untouched. Because of this, the offensive requirement for massing enough volume of fire remains intact, but the ability to meet that requirement becomes much more difficult.

This can shift the character of naval salvo combat when the ability to mass fires is degraded. Standalone force concentrations that are isolated from the broader network may be compelled to seek out other isolated forces in a bid to pool enough capability so they can muster enough volume of fire. But the act of having to seek out and combine with other forces can cause isolated units to release emissions, travel beyond the familiar local battlespace, form denser force concentrations, and engage in other behaviors that increase their targetability.

Because their ability to muster enough volume of fire is more doubtful, isolated forces would also be more pressured to deplete much larger shares of their magazine depth per salvo. Their uncertainty would be especially worsened if they are unable to assess the effectiveness of their attacks against distant targets or track adversary weapons expenditure. This knowledge is valuable for calibrating weapons expenditure, and uncertainty would encourage a force to expend larger volumes of fire to err on the side of risking more overkill to ensure lethal effect. These isolated forces would then suffer quicker depletion than if they could combine their fires in smaller increments with broader forces. As isolated forces form ad-hoc force packages and improvise standalone fires, the distributed posture of the overall force would degrade as isolated units quickly deplete themselves in piecemeal fashion.

Isolated forces that retain a significant amount of capacity, such as larger warships or force concentrations, will be less likely to face these pressures. Larger warships will have deeper magazines, more robust sensors, and organic aviation detachments, where each helps preserve a warship's ability to gather information and muster enough volume of fire when isolated.

[caption id="attachment_57387" align="aligncenter" width="542"]

Zumwalt-class guided-missile destroyer USS Michael Monsoor (DDG-1001) leads a formation during U.S. Pacific Fleet's Unmanned Systems Integrated Battle Problem (UxS IBP) on April 21, 2021. (U.S. Navy Photo)[/caption]

Isolated small combatants that are severed from the network will be less likely to launch enough volume of fire on their own. They will be more dependent on seeking out other forces to pool enough magazine capacity, and where the search for other isolated forces could invite more risk. And even if coherence is preserved, the dependence on outside forces and functioning networks is still greater overall for small combatants. A force that primarily fights as a collection of broadly distributed small combatants is a force that is fundamentally more dependent on network resilience.

Distribution of Fire Across Force Structure

Distribution is often described as a force multiplier through challenging command-and-control, especially by making targeting priorities less clear.[5] But steep command-and-control burdens can also come with sourcing firepower from one's own forces, organizing that firepower into a timely mass firing sequence, committing to seeing it through, and assessing the effects. The density of the opponent's defenses can increase these command-and-control burdens. While a denser concentration of capability can add clarity to target prioritization, it can also add ambiguity by creating doubts about whether many different kill chains can be effectively harmonized into generating the necessary volume of fire on time. This allows dense defensive capability to also impose challenges on adversary decision-making, but through different mechanisms than force distribution.

When assembling massed fires, commanders have to make decisions about distribution in two key respects. Commanders have to decide how they will source firepower from across their force structure, and decide how to distribute that firepower across the force structure of the adversary. Different force designs will affect the distribution of how firepower is sourced and applied.

A commander who is assembling massed fires will have two primary options for growing the volume of fire. One option is to pull deeper from larger magazines, and another is to add more platforms to the firing sequence. With respect to the command-and-control burden, it should generally be easier to pull deeper from a larger platform's magazine then it will be to add more platforms to the firing sequence. If a commander decides they need to quickly add more volume of fire to an imminent firing sequence, it may be easier to ask a large warship to fire 30 more missiles than originally planned, rather than source the same firepower by adding multiple new platforms and force packages to the firing sequence on short notice.

Each new platform and force package that is added to a firing sequence will make that sequence subject to more sources of friction, such as by hoping each unit's local operational circumstances are favorable enough for it to launch fires on time. The more distributed platforms that are added, the more the firing sequence may incur interruptions, delays, and other challenges. A firing sequence that features many small and widely separated combatants and force packages will have more variability. A force that is mainly composed of small combatants is more likely to grow a volume of fire by adding more platforms to the firing sequence rather than taking deeper pulls on magazines.

By comparison, there is less command-and-control friction and less variability when asking a large surface warship, or a denser concentration of forces, to simply fire a larger volume of fire. This is not to suggest that one method of adding fires will always tend to be superior, but it demonstrates how the concentration of capability can simplify command-and-control in valuable respects, especially in a form of warfighting where a speedier ability to marshal volume of fire can be decisive in firing effectively first.

Choosing to organize and launch a large volume of fire against a naval formation is a momentous operational decision and inflection point. But the weight of decision may shift depending on the scale of the target formation and the volume of fire required to overwhelm it. The prospect of incurring substantial weapons depletion in a single firing sequence, while operating with an imprecise grasp of the offensive-defensive balance of naval salvo combat, may weigh more heavily on the minds of commanders when tasked with destroying denser naval formations compared to smaller, more distributed elements.

Conclusion

Decades of naval capability trends have encouraged high-end fleet design to focus on being able to generate and withstand massive volumes of missile firepower. While great power rivalry has set the stage for this incredibly resource-intensive form of combat to escalate, it has also set the stage for asymmetric counters and offsets that could radically reshape naval force structure. A squadron of small quadcopters could render a destroyer impotent where an anti-ship missile salvo could not, or microwave weapons could one day negate salvos that could not be stopped by advanced defensive missiles. Asymmetric counters are appearing on the horizon, but their long-term consequences for naval force structure are difficult to perceive.

The truth of what ultimately makes for superior naval force structure and weapon interactions is a moving target, something that is evolving rapidly and imperceptibly as technology changes and humanity's ability to grasp the implications ebbs and flows. Much of this truth will remain unseen until it is violently unmasked by high-end warfare.

Introduction

Force development is the process of investigating the future of warfighting and aligning the preparations of a military along the lines of that investigation's findings. If knowing how to fight could be described as knowing how to execute tactics, then force development is about how to get better at fighting.[1] Yet force development is not just about creating viable tactics or proper crucibles for forging warfighting skill. It is about ensuring there is a high level of force-wide fluency on warfighting and a broad understanding of how to get better at fighting.

Force development serves a vital role in safeguarding a military from its own atrophy. A major symptom of institutional decay in militaries is when warfighters, especially those in the combat arms and unrestricted line communities, struggle to realize that their fundamental job is to be tacticians. If not consciously kept in check, creeping bureaucratic forces will gradually turn warfighters into administrators, maintainers, engineers, and other things that eventually eclipse their fundamental role of being tacticians, of being professionals that learn how to fight.

A prime imperative of force development is to preserve the fundamental principle that tactics are at the core of what any navy is and does, that tactics are the "soul of our profession," as once described by Vice Admiral Art Cebrowski.[2] Chief of Naval Operations Admiral Tom Hayward argued the same point in the introduction to the first edition of the seminal work *Fleet Tactics* by Captain Wayne Hughes, where he argued, "What is the naval profession about if not tactics, tactics, and more tactics?" A military service that loses sight of this fundamental principle of existence will have dysfunction radiate throughout its institutions. This is because tactics are not just mere details or minor actions, they are the ultimate logic that governs how fleets are destroyed in combat. Regardless of whether warfighters are aware of it, tactics are a central animating force behind much of what a navy does, whether it be strategy, force design, human resources, and many other efforts. So much of military policymaking is critically degraded when the warfighters do not have a good idea of what the fighting is going to look like, or of how to get better at fighting.

The force employment of a military will largely be a function of how good its force development can make it. A military's ability to fully manifest a new warfighting concept will depend on how well its force development can take the abstract notions of the concept and convert them into genuine force-wide improvement in warfighting skill. As the U.S. Navy explores the future of distributed warfighting and naval salvo combat, it must be prepared to make major changes to how its force development institutions cultivate warfighting skill so the fleet can effectively evolve alongside the intensifying threat environment.

Force Development and the Major Engines of Change

Overarching warfighting concepts are often developed by specific groups such as fleet staffs, warfighting development centers, wargamers, and others. Compared to the broader fleet and the multitudes of deckplate warfighters, these groups are extremely niche staffs. Just because a warfighting concept has been developed by specialized groups and approved of by senior authorities is no guarantee that it will actually result in force-wide change. Major efforts have to be made to deliberately introduce the warfighting concept into the service's primary engines of force development, and bridge the wide gap between the niche insight of the concept developer and the force-wide reality of the deckplate sailor.

The major engines of force development in a service are the primary mechanisms through which warfighting skill is developed on a force-wide level. These engines mainly include the exercise and certification regimes, training and readiness matrices and syllabi, schoolhouses, graduate education programs, and the tactical instructor programs of warfighting development centers. Tens of thousands of servicemembers are rotating through these mechanisms to learn about warfighting. If a warfighting concept generated by a niche staff is to stimulate genuine force-wide improvement, then the concept must be broken down into specific operational skills and challenges that are then administered through these major engines of force development. Syllabi must be revised, new certifications must replace older ones, and new scenarios should keep warfighting crucibles fresh and challenging.

The content of the warfighting concept must inform and align with the content of force development. Otherwise, the force will incur major risks in conflict when the content of its warfighting concepts and war plans are vastly different than what the force as a whole has actually been prepared to do.

This process of change has to be deliberate and measured. The aftereffects of introducing more tactics, doctrine, and capabilities into the major engines of force development are often not well appreciated, but these effects threaten to strangle progress. The downstream effects of introducing new things to force development are often more requirements, more administration, more maintenance, and myriad other burdens added to already stretched warfighters. The imperative to effectively master something new can be suffocated by the overflowing system of requirements and certifications, and where many of these requirements are a product of undisciplined bureaucratic accumulation.[3] Failing to make deliberate tradeoffs will risk losing critical new warfighting imperatives amidst the crammed labyrinth that characterizes much of the U.S. Navy's requirements and certification system. This overflowing system has forced combat training schedules to take the form of serialized one-off events, rather than focused series of multiple rounds that allow warfighters to flesh out specific skills and conduct extensive trial and error. The Navy needs to consolidate its overstretched focus so it can afford to go deeper in priority areas.

If the Navy is to seriously introduce the new force development efforts that are vital to making DMO and massed fires a reality, it will need to vigorously protect and guarantee time and focus for these efforts amidst the ocean of other demands that threaten to stifle these initiatives. Careful and deliberate tradeoffs must be made in defining what tactical skills and scenarios sailors should be prioritizing their time on, rather than simply adding to the system's congestion.

One specific example of how force development tradeoffs can be made is in adjusting the amount of focus spent on building damage control skillsets versus air defense. Since it only takes one hit to kill a warship, if the offensive-defensive balance tilts even slightly in the attacker's favor, then the result will be extreme overkill. This happens because naval salvo combat can consist of forces launching dozens of missiles at warships, so if a warship is going to take a hit, it is very unlikely to take only one. Damage control at that point will often be an exercise in futility. While sailors can certainly learn much about their systems through damage control practice, the force development implication of this brutal tactical reality is that much more preparation should be spent on preventing the ship from getting hit than learning how to save it.

That is one aspect of naval salvo combat that readily translates into deckplate-level force development implications. But the act of massing fires from across a distributed force is something that can happen on a theater-wide scale, which is a larger-scale scenario that can strain unit-level training methods, resources, and perspectives. While new studies and curricula are useful for teaching the broader picture, tactics are actions. The cultivation of tactical skill demands extensive hands-on application and learning-by-doing.

If mass fires are to become a mainstay tactic and skillset, then wargaming and Live, Virtual, and Constructive (LVC) events need to become a much more mainstream and higher fidelity experience for unit-level warfighters. Wargaming and LVC are key simulation tools that can help deckplate servicemembers experience warfighting on a much larger scale and understand how their piece of the fight contributes to broader success. Unit-level sailors can strive to understand how their long-range salvos will combine into a larger volume of fire against a distant target, and how the broader distribution or concentration of the force can be affected by their unit-level actions. They can learn to craft custom firing sequences and assemble massed fires against serious opposition in a variety of contexts. They can become more proficient in interpreting the situation presented in the broader common operating picture that goes beyond the scope of their organic sensors, which can also help them contemplate effective targets for last-ditch or standalone fires. They can develop a deeper understanding of how higher-echelon commanders think about naval salvo combat and assembling massed fires, which helps build a common doctrinal framework across the chain of command. By leveraging these tools, unit-level servicemembers can improve their fluency with these inherently large-scale warfighting methods.

Despite the fierce character of naval salvo combat and the high stakes involved, a warfighting imperative is often not strong enough on its own to compel change when the imperative must be operationalized by a bureaucracy. The major engines of force development need to be infused with clear professional incentives for warfighters to develop specific tactical skills and distinguish themselves as above average tacticians. The incentives for competitive promotion and assessment are arguably some of the strongest levers for fomenting change in any organization, and this holds true for militaries as well.

The introduction of new tactics and methods requires commensurate new criteria for assessing proficiency and rewarding tactical skill. But the specific nature of launching anti-ship fires challenges the ability to craft stirring professional incentives for the tactical actions that are at the heart of massing fires.

There may be relatively few distinguishing factors when a unit is simply one platform out of many that is launching anti-ship missiles at distant targets. The act of launching fires at forces that are far beyond the limits of one's organic sensors can substantially reduce the scope of decision-making and tactical skill to be exhibited and assessed at the unit level. Launching anti-ship fires may be far less tactically distinguishing or exciting than the scope of tactical skill a lone fighter pilot can display in a dogfight, or a submarine officer can exhibit in setting up a torpedo strike. Serving as a missile magazine to be cued by someone else's firing decisions may hardly make for provocative debriefs or in-depth assessments of tactical skill at the unit level. These types of challenges can cause warfighting establishments to undervalue critical tactical tasks because they offer little opportunity for warfighters to distinguish themselves from their peers and challenge professional assessment mechanisms. As a result, military bureaucracy can limit the amount of time training and exercising these skills.[4]

Here is where wargaming and simulation can come together with assessment criteria and professional incentives. Because wargaming and LVC can allow deckplate-level warfighters to practice the large-scale tactics of massing fires, it can also provide a venue where warfighters can distinguish themselves professionally, and be assessed on more complex matters of tactical skill compared to simply launching contributing fires. Wargaming and LVC can also offer settings where Sailors can operate their individual platforms in simulated network-contested environments, where they can demonstrate how they would take the initiative, such as by assembling massed fires on a local basis or launching standalone attacks as an isolated unit.

The U.S. Navy will have to make major changes to its force development to promote more opportunity for warfighters to tactically distinguish themselves from their peers and spark their competitive spirit. But a system of certification that aims to train warfighters to the same baseline standard will struggle to provide this opportunity. The U.S. Navy's ability to offer meaningful crucibles for warfighters to distinguish themselves is also severely challenged by its deeply ingrained habit of artificially guaranteeing victory in combat exercises and deliberately handicapping opposition forces.[5] These fundamental and far-reaching flaws will strongly constrain the Navy's ability to discover and cultivate its best tacticians, as well as impair its ability to have a rigorous process of investigation undergirding its force development. These self-inflicted flaws have already rendered many prior Navy warfighting concepts into unrealized and underdeveloped aspirations. These flaws will continue to challenge the Navy's ability to manifest any warfighting concept that can be durable enough to withstand the chaos of war.

Ultimately DMO should provide the impetus to reform not just the content of the Navy's force development, but also its character.

New Force Packages for DMO

The U.S. Navy is attempting to manifest DMO with a relatively concentrated force structure of high-tonnage warships. It will need to revise its current force employment and force packaging to be more distributed in the near term. As the Navy transitions toward DMO, it needs to consider how it may reorganize its existing force structure to better manifest the concept.

The relationship between force structure and force employment is closely related to the standard force packages of a service and the warfighting concepts that animate them. In the case of the U.S. Navy, the Composite Warfare Commander (CWC) concept has animated its carrier strike groups and naval formations for years.[6] Regardless of the many concepts that have been developed over time, the CWC concept is what the Navy has actually been putting into practice on a force-wide level, and it forms a major point of departure for naval force employment. Countless strike group staffs and wardrooms have had their visions of warfighting heavily shaped by this concept. Consistent application of CWC over the years has molded a critical form of operational muscle memory that pervades the U.S. Navy as an institution.

The introduction of DMO should warrant a deep examination of new formations, force packages, and tables of organization that will embody the new concept. Historically, militaries will modify these aspects of their organization in relation to changing perceptions of the future of warfare and force employment. When reforming for great power war, these changes have heavily focused on defining the proper echelon for integrating combined arms capability.[7] This has often resulted in pushing the integration of multi-mission, combined arms capability down to lower-level units, while also being mindful of not overwhelming lower-level commanders with too much span of control. As they push combined arms integration downward, militaries have also gone upward in designating a larger-scale formation as the primary standard unit of control when emphasizing focus on great power war. For example, where artillery and anti-air fires may have been held at the brigade commander level, now the company commander can direct these fires; where the brigade was once the primary operational unit, now the division is the primary unit.

The Navy can consider similar changes to its organization. New force packages can encourage an accompanying revision of the command relationships and operating concepts that animate the formations. New force packages provide a valuable impetus and point of departure for initiating fresh force development efforts.

At first sight, DMO may encourage an amorphous vision of force packages, where units can flexibly plug-and-play at will across a dynamic battlespace. A distributed force will gain a significant amount of resilience if its lone units can seek one another out and dynamically come together to apply effects on a local basis, rather than be wholly dependent on higher-echelon commanders to organize them. But while this hypothetical flexibility is desirable, in reality it can lead to an undisciplined and unstructured vision for how a distributed force may actually be wielded. It may leave far too much to chance and assume too much about the ability of individual units to meaningfully integrate on the fly. Instead of a flexible and resilient force, the risk is the spontaneous creation of disorganized pickup teams that will have little time to build common understanding in the midst of a fight. That common understanding may prove crucial to success, especially for methods that require careful harmonization, including emissions control, air defense doctrines, and last-ditch firing protocols. One of the hard WWII lessons the U.S. Navy paid abundantly for in blood is that combined units need time to develop into genuinely integrated force packages before being sent into battle.[8]

As a potential new DMO force package, consider a force of two destroyers supported by a squadron of carrier aircraft. Half of the squadron remains in the local vicinity of the destroyers to defeat sea-skimming threats well before they break over the warships' horizon, and to provide early warning such as for air defense and last-ditch fires. The other half of the squadron is far forward of the two destroyers, and conducts scouting, counter-scouting, and bomber interdiction. The forward element also helps cue warship salvos toward targets, inputs retargeting support to the salvos, defends the salvos from aviation threats, and assesses salvo effectiveness against the target. This forward aviation element is the primary actor in contesting aerial and information superiority in the critical space between opposing fleets. If those forward aviation units are under heavy threat by opposing aircraft, they can pull behind the surface warships and leverage their air defense capability. The roles conducted by the aircraft kept closer to the destroyers can be assigned to F/A-18s and an E-2D. The forward roles are ideally conducted by F-35s, with their longer range and robust sensor fusion capabilities.

This force package of two destroyers and a squadron could be termed a surface strike group (SSG) and be a standard unit of a distributed naval force (Figure 1). It represents the lowest level at which carrier aviation and surface warships could be fully integrated for combined arms naval warfighting. Through its warships, this force could conceivably field up to 80 anti-ship missiles in its launch cells. This makes for a considerable amount of magazine depth that could allow the force to steadily persist and preserve force distribution as it fires small but meaningful increments of contributing fires. If network links degrade or some other circumstance isolates the surface strike group from the broader force, it will have a decent amount of organic capability to fall back upon, it will have preserved vital combined arms relations, and it will retain significant magazine depth as a standalone unit.

[caption id="attachment_57464" align="aligncenter" width="816"]

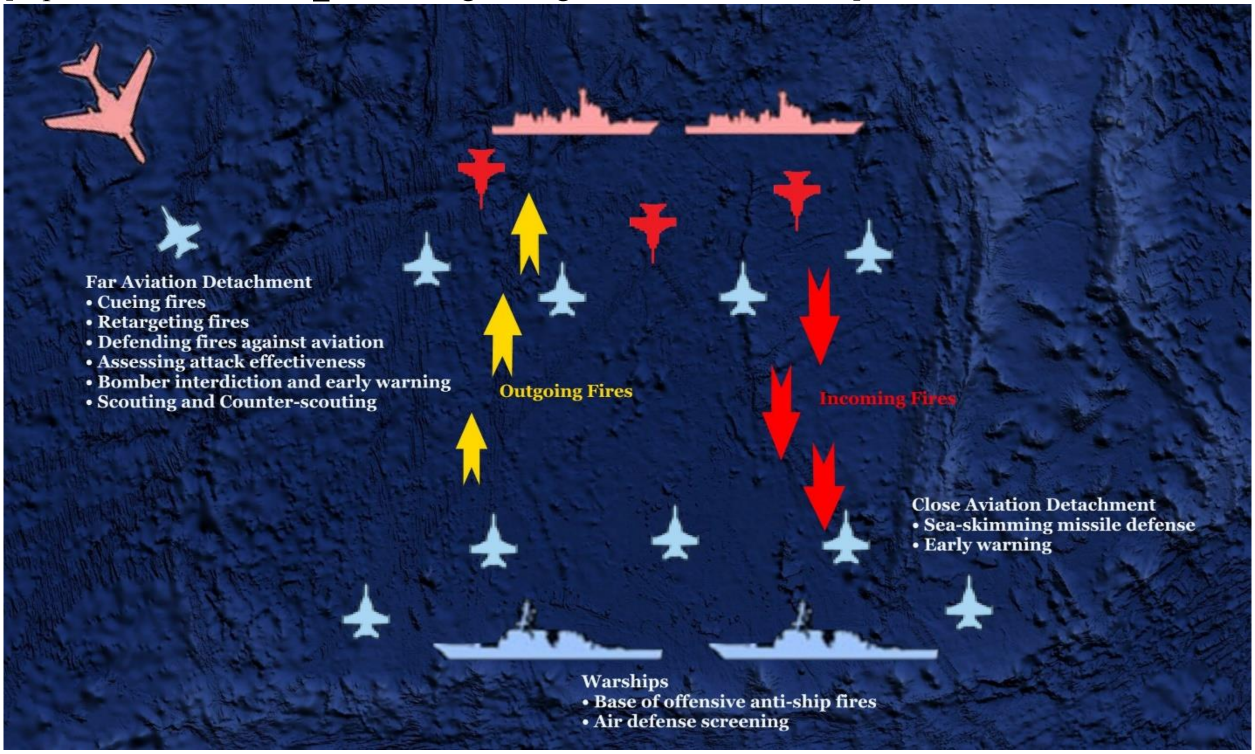


Figure 1. Click to expand. A notional Surface Strike Group (SSG) force package. Two destroyers operate with a squadron of aircraft that is divided into close and far aviation detachments. Dispositions and ranges are not to scale. (Author graphic)[/caption]

Multiple CNOs have now called for a renewed emphasis on fleet-level warfare.[9] A renewed emphasis on fleet-level warfare requires a fleet-level force package. The parent force package of the Surface Strike Group could be the principal fleet-scale maneuver element, a hypothetical Fleet Strike Group (FSG) that would be larger than a carrier strike group. It could consist of the combined forces of about two carrier strike groups, divided into four surface strike groups with two destroyers each, and four destroyers assigned to escort the two carriers (Figure 2). The carriers are protected by roughly four squadrons of aircraft, with the other four squadrons assigned to the surface strike groups, which are the primary striking arms of the Fleet Strike Group for generating massed fires.

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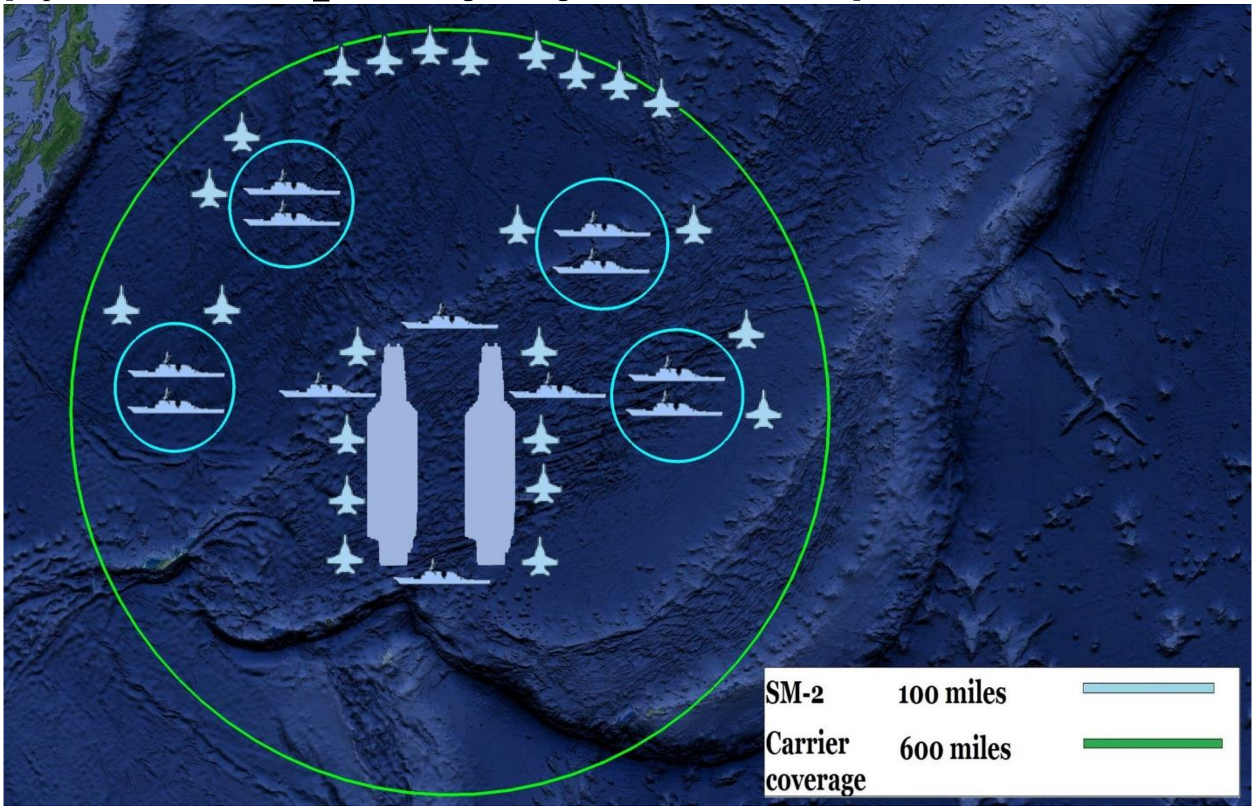

Figure 2. Click to expand. A notional Fleet Strike Group (FSG) force package. Two carriers operate with four nearby destroyers and four squadrons providing close- to mid-range air defense. Four surface strike groups operate at a wider distribution from the carriers, but well within range of aerial support. Half of the squadrons assigned to the surface strike groups provide close-in air defense and early warning for the destroyers, and the other half contests the forward battlespace between opposing fleets. Each aircraft icon represent two aircraft. No offensive capability ranges are marked. (Author graphic)[/caption]

The surface strike groups may be oriented in various dispositions relative to the carriers, but must not exceed the ranges required to have confident aviation support, and not exceed ranges that would stretch them too thin to combine their fires against a shared target. A force package does not always imply a specific disposition, but it provides a clear point of departure for multiple arrangements of forces while maintaining a coherent command structure and concept of operations.

These force package concepts illustrate the critical constraints of organizing a distributed fleet. Warships can only disperse so far from one another before they are spread too thin to effectively combine fires. Surface warships will substantially increase their risk if they venture beyond the range of aviation support, and they would have more flexibility of maritime maneuver if that aviation support came from carriers instead of airfields. But carrier aviation can only travel so far and remain on station for so long. Carrier aviation must also maintain enough reach and capacity to strongly contest the aerial battlespace between opposing fleets, and secure the critical scouting and informational advantages that come with earning air superiority in this area. Yet carriers cannot be pulled too deep into the battlespace themselves, or else suffer increased risk.

These critical factors of mutual support bind the extent of distribution and help define the divide between what is usefully distributable versus what is unfavorably stretched thin. Standardized force packages capture these critical relationships and constraints, and provide a framework to work within them.

These force packages formalize other essentials of DMO. They formalize a closer tactical relationship between aviation and surface platforms, who will need a tight-knit doctrinal relationship at a level below the traditional strike group. It establishes a new fleet-scale unit that is larger than a carrier strike group, both in terms of the number of platforms and in the scope of its applications. It also establishes a subordinate lower-echelon unit that is credible enough to pose a threat on its own even if the force fractures or disaggregates. These fundamentals can provide an enduring basis for designing force packages regardless of their specific composition.

Standard force packages provide a valuable frame of reference for what forces can coalesce or disaggregate into, which is a vital part of DMO. If a distributed force fractures into individual units and force concentrations, many units may naturally seek each other out to pool their capability and broaden their awareness in a bid for local overmatch. But as standalone units gather themselves, they may unwittingly create a force that is overly concentrated. Standard force packages can provide a valuable frame of reference by defining a ceiling of tolerable concentration or dispersal. Forces may use this frame of reference to independently distribute or converge if they believe they have overly concentrated or stretched themselves. It is critical that effective concentration and distribution is not just something imposed on a force by higher-echelon command, but something that lower-echelon units can effectively self-organize into through shared doctrinal understanding.

The frame of reference offered by a force package can also encourage isolated units to prioritize the regeneration of combined arms capability. In the case of distributed warfighting, isolated aircraft would know to seek out warships to leverage their magazine depth, and warships would seek out aircraft to leverage their greater situational awareness. As isolated forces seek out one another and combine into force packages, they can not only have a sense for judging appropriate concentration, but also a sense of judging proportion between the combined arms.

This frame of reference also makes hard tradeoffs more doctrinally acceptable. A core defensive goal of distribution is to minimize losses when they are taken. A core offensive goal is to manipulate this concern to compel opposing forces to stretch themselves thin. The threat of accurate firepower can force units to sacrifice their ability to provide mutual support as they widen their distribution to try to minimize potential losses. If a force package is judged too concentrated and must distribute, the diminishing availability of combined support will be better understood as a deliberate tradeoff rather than a reckless omission.

As much as an assortment of smaller units attempting to integrate across a battlespace can confuse an adversary, it can also confuse a force's own commanders. The desire for open-ended flexibility must be balanced against the need for coherence, and standardized force packages are a critical mechanism for creating coherence of forces. But the organizational coherence that force packages offer can certainly be a liability. The predictability of organization for oneself also makes it more predictable to the adversary. This predictability can lend itself toward the speedier massing of fires, both from a force and against it. There can be a direct connection between using organization to reduce the command-and-control challenge of wielding a distributed force, and reducing the challenge to the enemy's decision-making. Commanders must weigh the benefit of coherence along these lines.

New force packages can serve a critical organizational function in moving force development forward and strongly emphasize a service's commitment to transformation. In the case of the U.S. Marine Corps, the new Marine Littoral Regiments are a major embodiment of that service's concrete commitment to new operating concepts.[10] By creating this new force package, certain combinations of capability and cross-community relations were formalized and obligated. These relationships were then cultivated through shared force development and put into practice in exercises and elsewhere.[11]

[caption id="attachment_57466" align="aligncenter" width="597"]

U.S. Marines with 3d Marine Littoral Regiment, 3d Marine Division establish a combat operations center during exercise Bougainville II at Puuola Range, Hawaii, Oct. 28, 2022. (U.S. Marine Corps photo by Lance Cpl. Cody Purcell)[/caption]

If the U.S. Navy wants to make DMO a reality, one of the most powerful steps it can take is to commit to new force packages. This can send an especially strong signal to its competitors and its own organization that real transformation is coming.

Developing Doctrine for DMO and Massed Fires

At first glance, the tactics of massing fires could easily lend themselves to heavily scripted methods, preset responses, and automated decision aids. Algorithms and playbooks will surely serve an important role in speeding the coordination of available firepower into salvos against shared targets. But the fundamental importance of subjective human judgement cannot be eclipsed by these factors. Naval force development on DMO must focus heavily on cultivating the human skills and decision-making that undergird mass fires. Developing a common doctrinal understanding will be vital toward employing this form of warfighting that depends so much upon shared awareness and coordination.

Doctrine does not only consist of official publications or standard responses. Doctrine is best understood as the implicit and subjective visions of how to fight that warfighters subscribe to.[12] Doctrinal development should principally focus on creating shared expectations in the minds of warfighters of how massed fires function and why.

The doctrine of massed fires will need to carefully govern how release authorities control the employment of various weapons. These mainly concern the circumstances under which offensive and defensive weapons are to be retained, delegated, or seized by various authorities. For massed fires to work, the release authority for anti-ship weapons cannot often be in the hands of the unit-level commanders of individual platforms except in highly specific and threatening situations. A higher-echelon commander or a commander with a higher degree of situational awareness will need to have the authority to reach into the magazines of various assets to assemble a volume of fire from the available options.

Because of this, there are few concepts that have as much potential to undermine massed fires than that of mission command and the initiative of the subordinate. Mission command has been defined as "the conduct of military operations through decentralized execution based upon mission-type orders…Successful mission command demands that subordinate leaders at all echelons exercise disciplined initiative and act aggressively and independently…"[13] If each individual platform decides to launch its fires independently, then the force will often fail to muster enough volume of fire to overwhelm targets and it will suffer disproportionate weapons depletion across its units. The evolving distribution and concentration of the broader force will pitch and roll without much consideration for larger consequences, and many higher-order designs and intentions will be at the mercy of spontaneous, local-level developments. It is unclear if a distributed force that grants wide-ranging independence to its many individual units can be meaningfully wielded as a coherent "fleet."

The principles of mission command and the initiative of the subordinate are often couched in terms of seizing fleeting targets of opportunity.[14] But the ability to fire quickly on independent initiative should be tempered by the challenging requirement of assembling enough volume of fire. Totally delegated release authority can lead to premature and ineffective attacks, where it may be of little use to have an individual unit fire on a target of opportunity if it ends up wasting missiles because it cannot muster enough volume of fire. The requirement to achieve enough volume of fire to hit a densely defended naval formation changes the definition of what actually makes for a viable target of opportunity.

Relying on individual initiative and mission command can certainly result in a higher tempo of decisions and unit-level actions, but this is not an inherent advantage if those decisions and actions are not operationally effective. Having a higher tempo of decision-making does not always guarantee a higher quality of decision-making. A force that patiently musters its missile firepower for a single strong blow against a naval formation may often prove to be much more effective than a force launching numerous individual blows that are too weak on their own to overwhelm the adversary. Initiative of the subordinate can enable self-defeating impulses in a form of warfare that demands a significant measure of coordination to muster a minimally viable amount of striking power. Given the requirement to build enough volume of fire, many unit-level leaders will have to exercise tense patience rather than sharp initiative, even if they have all the targeting information they need to take their personal shot at the target.

The concept of delegating authority for the sake of taking advantage of fleeting opportunity in the battlespace cannot be blindly advocated as an enduring theoretical good. The successful application of this principle depends on specific tactical context, and it can clearly be self-defeating in many situations. Having a wide variety of distributed units prosecuting their local engagements with great independence assumes a theory of success where broader victory is the product of accumulating many smaller wins. But it is unclear how well this construct applies to the unique nature of high-end naval warfare, which has historically tended toward highly centralized tactical decision-making, large-scale pulses of fleet-destroying firepower, and extremely dense concentrations of capability. To unconsciously apply these principles without operational context is to strip away many of the potential benefits of massed fires.

Therefore higher-echelon commanders will naturally need to maintain some sort of doctrinal grip on the offensive anti-ship loadouts of many units if they are to harness their potential for massed fires. The same can hardly be true for defensive doctrine. The sudden nature of defending against anti-ship salvos or submarine attacks involves highly time-sensitive decisions. Doctrine statements that are pre-programmed into combat systems need to be able to automatically engage defenses to give warships a fighting chance of survival against incoming salvos. Therefore the release authority for defensive capability will have to naturally reside at a much lower level of command.

But unit-level commanders will still need some authority to independently launch their offensive missiles in certain situations. The potential of last-ditch fires means commanders need to exercise subjective judgement about their tactical situation and know when it warrants them firing off their weapons without higher-level approval. Commanders who perceive they are on the verge of detection or destruction will need to be afforded the discretion to do what they can under extreme circumstances. A similar logic applies to operating within degraded network environments. If adversaries have effectively damaged trust in networks and communications, then commanders may hesitate to believe what the networks are telling them. If commanders are unsure if their higher-echelon leadership can reach them to issue firing orders, they may feel compelled to take the initiative in launching fires themselves.

The doctrinal implications of who exactly organizes massed fires in what operational context deserve serious emphasis in force development. Joint commands, fleet staffs, and warfighting development centers need to design doctrinal schemes of release authorities for massed fires on both force-wide and unit-level scales. Commanders at all levels need to understand the distribution of these release authorities for various weapons and how the scope of these authorities can change with specific circumstances, such as heavily degraded networks or low-emission postures. Certain circumstances that make it challenging to mass fires from widely distributed assets can trigger fallback schemes that delegate release authorities to individual units and force concentrations.

But massed fires may be unworkable if the joint fires targeting process is too bureaucratic and rigid to be applied in a chaotic warfighting environment.[15] While there are certainly many considerations that deserve to be factored into mass fires, the joint fires process should be prepared to expedite procedure for the sake of speeding decision. In a combat environment that is being heavily shaped by naval salvo warfare, custom firing sequences will need to be quickly designed to meet emerging needs. This is especially critical for the time-sensitive methods that help a force preserve its capability while under heavy fire, methods such as interruptive strikes against the adversary's active firing sequences, or adding fires to the last-ditch salvos of dying units. Speed of decision is vital to winning in naval salvo combat, but an overly bureaucratic joint fires targeting process could easily confer major decision-making advantage to the adversary.

Lone units may not care much for official procedure when they are facing imminent destruction at the hands of incoming salvos. Unit-level commanders need to know how to craft an effective last-ditch firing protocol and have the subjective judgement to know when to trigger it. Commanders need to know how to assess the signature of an inbound volume of fire, judge the offensive-defensive balance, and decide if they are unlikely to survive. They must also have the skill and nerve to know when not to launch last-ditch salvos, or otherwise risk being provoked into wasteful fires.

Effectively practicing last-ditch fires will be less a matter of preventing unit destruction and more about having commanders smartly deploy a custom last-ditch firing protocol in the context of what information they had at the time. Scripted solutions and automated decision aids will not be enough to forge the prudence needed in this crucial battle of nerves. The U.S. Surface Warfare community in particular must cultivate this judgement in its warfighters through exercises and simulations that impose the last-ditch firing dilemma, but where warfighters do not know in advance whether they are expected to survive.

Developing doctrine for last-ditch fires is critical for ensuring archers are not destroyed before they can discharge their offensive firepower, and ensuring that valuable weapons inventory is not lost before it can make some contribution to the fight. Otherwise a force under fire will lose its weapons as it loses its platforms, and crews will be deprived of their chance to offer a final parting shot to the adversary. The extreme circumstances that surround last-ditch choices create a demand for extensive doctrinal development so that warfighters can be ready to make the most of what may be their final moments.

The Joint Element and the Role of Fleet Commanders

The act of massing fires is an inherently large-scale, combined arms, cross-service function. The joint contours of this capability are already becoming apparent, with all of the services now procuring anti-ship missiles and getting into the mission of sinking warships.[16] While it will take at least another decade for them to procure enough weapons to be able to truly mass fires, all of the services must focus more force development on the anti-ship mission. The extent to which service kill chains can be effectively linked in a contested battlespace can determine the true extent to which massed fires can be brought together from across the joint force. Otherwise operational methods may default to standalone fires from service-specific forces. The force development of massed fires must occur through critical joint and service command structures, and the nature of these structures puts fleet commanders in a prime position to refine these concepts.

While war plans are meant to be executable today with current capability, service warfighting concepts tend to have a longer time horizon to guide the development of capability in a purposeful direction. But ideally at some point the timeframes overlap, and the content of the warfighting concept should begin to inform the content of war plans. The DMO concept as it stands today is more of a service-specific concept for the Navy rather than an overarching concept for the joint force, although DMO could serve as the Navy's pillar to the Joint Warfighting Concept (JWC).[17] But it remains unclear if there is a deliberately structured relationship for how the warfighting concept of a service informs the war plan (OPLAN) of a combatant command. A warfighting concept can represent how a service would like to fight and how it believes it could make its best contribution to the broader joint force. But ultimately the employment of forces falls under the authority of the combatant commands, who may have different force employment concepts than a service.

Therefore a critical role of service-specific force development is not only generating improved operational methods, but also socializing these methods with the combatant commands and joint organizations that would ultimately be charged with employing these methods. The more the content of a service's warfighting concept is reflected in the content of the war plans, the more successful the concept may have been in earning joint buy-in. Given how all the services are now procuring anti-ship weapons and the sea control mission is growing in importance, the Navy can take a leading role in shaping how the joint force envisions massing fires against warships.

The act of massing fires is not only a joint endeavor, it is an expression of combined arms warfighting. The Navy itself is a joint force with its separate communities. But most of the Navy's force development is heavily siloed within the type commands who manage the force development for their respective communities. This siloed character is reinforced by how most of the Navy's workup cycle focuses on unit- and squadron-specific force development, with only a few weeks of truly integrated, cross-community exercising toward the end.[18] This relative lack of deep cross-community integration has also been reinforced by the disaggregated operations of recent decades.[19] The Navy does not appear to have a singular overarching mechanism or higher-echelon command that purposefully integrates the force development agendas of the type commands around a common framework, whether it be a war plan, DMO, or other concepts. The heavily siloed nature of the Navy's force development strongly impairs its ability to deepen vital combined arms relations and manifest new warfighting concepts, especially ones as cross-cutting as DMO and massed fires.

Fleet commanders are needed to fill these gaps and serve these two vital functions – deepening the force development integration between the navy's communities, and socializing service-specific warfighting concepts with joint commands.

The purview of fleet commanders sits a step higher than that of the type commands and allows them to integrate the multiple communities in operational context. As Vice Admiral Hank Mustin once noted, the type commanders "stayed within their own little pookas until somebody mixed them all. That's the role of the fleet commander."[20] Fleet commanders could ensure that each community-specific force development agenda is organized around common frameworks. This could take the form of ensuring the content of the war plans is reflected in the training certifications and syllabi of the various communities, or that warfighting development centers are collaborating on combined arms doctrine. The fleet commander's position as the lead naval component commander within a combatant command also allows them to more readily access their fellow component commanders from the other services. They are in a prime position to socialize DMO and naval massed fires into joint partners and command structures.

Aside from influencing the force development of lower echelons and joint partners, fleet commands will need to be heavily subjected to force development themselves. A renewed emphasis on fleet-level operations demands more warfighting practice for fleet-level staffs. As CNO Gilday has emphasized, "If we're going to fight as a fleet – and we moved away from fighting just as singular ARGs, as singular strike groups, to fighting as a fleet under a fleet commander as the lead – *we have to be able to train that way"*[21] [Emphasis added]. Fleet-level staffs should engage in frequent wargaming to exercise the command of naval massed fires and fleet-scale force packages.

Because fleet commanders reside within the operational chain of command, their primary focus is operations, not force development. Historical experience has often shown that when significant force development and operational responsibilities are combined under one administrative structure, the latter tends to eclipse the former.[22] Guarding against this tendency is the Department of Defense's bifurcation into the distinct spheres of operations, and train/man/equip. But unlike the Navy, the other services have vital mechanisms that ensure service-retained control of large ready units for the purposes of force development, where combined arms relations can be consistently exercised and evolved without being constrained by an imminent need to deploy. But to its severe detriment, the structure of the Navy has caused most of its opportunity for live cross-community force development to fall under the operational command structure.

The Navy's integration between its own communities is not nearly as well developed as it needs to be to make DMO and massed fires a reality. The fleet commands must take an active role in deepening cross-community integration and force development, as well as refining joint methods for massing fires against warships. But their operational responsibilities will hardly abate, and decades of habit will make it challenging to introduce major new force development imperatives to what are fundamentally operational commands. Even if they can take on these efforts, the variety of multiple fleet commands may not translate into a coherent set of enduring requirements for integrating the force development agendas of the type commands around a common framework like DMO.

If the fleet commands cannot take sufficient ownership of coordinating these force development functions, then these functions may have to be centralized on the OPNAV staff. This responsibility would fit best within the OPNAV N7 Warfighting Development Directorate, but N7 seems to lack the critical authorities that would allow it to issue firm directives to the type commands and integrate their force development agendas in any major way.[23] OPNAV also has very little in the way of service-retained ready forces under its control, challenging its ability to manage much of the vital force development that would need to happen through the active operating forces.

The Navy's organizational structures and operating patterns already heavily impair its ability to implement major force development reform. The needs of DMO and massed fires demand more than just changing the content of existing practices or agendas, these warfighting methods demand significant changes to how the Navy organizes its force development in general. Hopefully DMO can provide the impetus for much-needed reform.

Series Conclusion

"Peacetime commanders are the professional anscestors of men who fight...Peacetime leaders forget that their first responsibility is to keep doctrine current and train to it. Working machinery, full supply bins, and reenlistments matter, too, but since they are more tangible than combat readiness they tend to divert attention from it....peace should be a time for renewing tactics and doctrine." –Captain Wayne P. Hughes, Jr.[24]

The Navy must not become so invested in the concepts of DMO or massed fires that it artificially guarantees their success, whether that be in its warfighting crucibles and experiments, or in its internal politics and programming. These are not concepts to be haphazardly “validated,” they are concepts to be ruthlessly interrogated.

The first and foremost principle is preserving a rigorous standard of warfighting resilience. Whatever the methods, they must be able to withstand the chaos of war. It is the duty of force development to uphold this standard, and to ensure that visions are grounded in practical reality, rather than be entranced by grandiose concepts. While something may seem conceptually elegant on paper or in models, this may obscure the fact that the deckplate-level warfighter will have to do the painstaking work of ironing out myriad critical details of implementation to manifest these things in a meaningful way. And during that process, the deckplate warfighter may unearth flaws and liabilities that could render a warfighting concept unworkable. No service should ignore the possibility that it can be better served by ruling out a warfighting concept than by moving forward with it. If the Navy must reject the idea of massed fires or DMO after rigorous trial and error suggests these elaborate methods cannot withstand the chaos of war, then the Navy will have been all the better for it.

Ultimately this series has been an exercise in exploring what DMO can be, not what it actually is in the eyes of the U.S. Navy. By investigating the critical leverage points of naval salvo warfare, it hoped to carve more definition into this concept, and illuminate what modern naval warfare may encompass. Whether this adequately aligns with the U.S. Navy’s own vision of DMO is an open question. But concepts and visions aside, many of the discussed fundamentals of naval salvo warfare will remain enduring regardless of whatever vision of future war is under consideration. And despite the heavily kinetic focus on massed fires and salvo combat, there are many non-kinetic factors and theories of victory that deserve deeper investigation.

The future of naval warfare has never been more uncertain. The destructive potential of high-end battle fleets is growing ever more ghastly and awe-inspiring. While the precise nature of modern naval warfare and all its many interactions remains deeply uncertain, its potential to change the course of history in an afternoon is not. As the world's oceans become a major arena for great power competition, navies have little choice but to set course for the hazy horizon.

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Part Three

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Maksim Y. Tokarov, "Kamikazes: The Soviet Legacy," U.S. Naval War College Review, Volume 1, 67, 2014, pg. 17, https://digital-commons.usnwc.edu/cgi/viewcontent.cgi?article=1247&context=nwc-review.

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4. For weapon range, see:

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7. For comparisons of times to plan and launch Tomahawk versus carrier air wing strikes, see:

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Newer Tomahawk variants than those discussed above have considerably shorter launch preparation times. See:

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Seth Jones, "Empty Bins in a Wartime Environment: The Challenge to the U.S. Defense Industrial Base," Center for International and Strategic Studies, pg. 14, January 2023, https://csis-website-prod.s3.amazonaws.com/s3fs-public/2023-01/230119_Jones_Empty_Bins.pdf?VersionId=mW3OOngwul8V2nR2EHKBYxkpiOzMiS88.

2. For one example, a warship on a one-way trip and traveling at 20 knots would take nearly two weeks to reach the Philippine Sea from U.S. naval infrastructure in San Diego. This assumes a straight line path, which may be less realistic under wartime conditions.

3. For JASSM range, see:

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For MK 48 MOD 7 torpedo cost, see:

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Part Five

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"JSM: Joint Strike Missile," Kongsberg, https://www.aerocontact.com/public/img/aviaexpo/produits/catalogues/92/Brochure-Joint-Strike-Missile.pdf.

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Massed Fires – A Core Tactic of Distributed Warfighting

A core tactic that operationalizes the concept of concentrating effects without concentrating platforms is combining the missile firepower of widely distributed forces. As various platforms launch weapons, their contributing fires combine to grow an overall aggregate salvo that is directed against a shared target. As commanders look to defeat and defend fleets, their decision-making will be strongly influenced by shaping the potential of these massed fires. These methods of massing missile firepower can form a centerpiece of fleet combat tactics in the modern era.

Because even one missile hit can be enough to put a ship out of action, modern high-end warships tend to emphasize powerful air defenses, which can include anti-air weapons, point defenses, electronic warfare, decoys, and other means. These many defenses significantly drive up the volume of fire needed to overwhelm warships and score hits. This makes the ability to mass anti-ship fires from distributed forces a valuable method for mustering enough volume of fire to threaten naval formations.

The adage of "firing effectively first" has sometimes been based in winning the scouting competition that precedes the launching of fires.[1] But one can certainly find the adversary first while not having enough available firepower to overwhelm their defenses. It is possible for opposing naval formations to effectively target one another, but are forced to hold fire until more additional launch platforms are made available to add enough contributing fires. A critical component of firing effectively first is being the first to launch *enough* volume of fire to overwhelm warship defenses.

The current inventory of only eight Harpoons or Naval Strike Missiles on many U.S. surface combatants is hardly enough to be a credible threat to many modern warships. However, if warships carrying only a few missiles apiece can be credibly augmented by more anti-ship fires delivered by bombers, submarines, and other platforms, then the individual warship presents a much larger and amorphous threat. The individual warship features as part of the greater whole that is the distributed force, because a small salvo launched by one platform could very well mean that more salvos from more platforms are on the way. Warships fielding small loads of missiles cannot be discounted or viewed in isolation from the larger force, which magnifies the threat posed by even lightly-armed combatants. Therefore the ability to mass fires considerably broadens the extent of force distribution in the eyes of the adversary.

Contributing Fires and Aggregation Potential

Massed fires can combine multiple different types of missiles, which can be done for the sake of presenting more distributed threats, preserving certain types of weapon inventory, or making due with whatever firepower is available. However, combining fires from a variety of platforms fielding a variety of weapons will pose challenges. Commanders must understand what characteristics dictate the options for how massed fires can take shape, and how these options affect the distribution and risk profile of their forces.

Each individual act of contributing fires to an aggregating salvo can have a narrow window of opportunity measured in only the tens of seconds.[2] Launching too late or too early will amount to launching an entirely separate salvo, and risk having missiles suffer defeat in detail while forsaking the advantages of combining fires. To effectively overwhelm multiple layers of air defenses, the missiles of an aggregated salvo have to tightly overlap the target within a similar timeframe, such as within the critical two-minute timeframe that subsonic sea-skimming missiles are visible to a target warship after they break over the horizon. Coordinated timing is central to concentrating firepower.

Regardless of the range or speed of the types of missiles, they will combine over a target if their time to reach the target is similar. One salvo does not need to physically merge with another salvo on the way to the target so long as their time to reach the target overlaps. However, the firing sequence will be affected by how different missiles have different ranges, and how quickly their speed allows them to travel those ranges. The desired timing of strikes affects the sequencing and availability of distributed launches.

Although contributing fires must overlap the target at a similar time, the fires may not all be launched at a similar time. If the U.S. Navy wanted to fire each type of its anti-ship weapons at the same time and have them strike at the same time, then all launch platforms would have to be roughly within the small 80-mile range of the Harpoon missile. The SM-6 launch platform would be a few dozen miles further out because of the weapon's greater speed. More realistically, taking advantage of a variety of weapon ranges means distributed forces will be at different distances from the same target, and will have to sequence their launches to combine fires. A core task of assembling massed fires is organizing these firing sequences, and understanding the tactical implications of their design.

A critical factor is how long it takes a type of missile to fly to the limit of its range. Assuming the missile can be targeted out to this distance, the maximum flight time creates thresholds and ceilings for how much opportunity the missile has to combine with other fires. Missiles with longer flight times or longer ranges have more aggregation potential and offer more opportunity to combine with other fires. But if missiles have to be fired from a variety of ranges, then missiles with shorter times-to-target will have to wait on missiles with longer times to combine with them.

The maximum flight time of LRASM is estimated here at slightly less than 40 minutes.[3] If LRASM fires are to combine with a separate salvo, then that salvo must also be 40 minutes away or less from striking the target. Once these two factors come close to overlapping – the time-to-target of the waiting contributing fires and the time-to-target of the traveling aggregated salvo – those contributing fires will then have tens of seconds of opportunity to launch and effectively combine with the salvo. The figures below show roughly how long it takes U.S. anti-ship missiles to travel their maximum ranges at their maximum speeds, highlighting a critical factor of aggregation potential (Figures 1 and 2).

[caption id="attachment_56425" align="aligncenter" width="596"]

Weapon	Range (miles)	Speed	Est. Max Flight Time
Harpoon	80	Subsonic (est. 550mph)	9 minutes
LRASM	350	Subsonic	38 minutes
Maritime Strike Tomahawk	1,000	Subsonic	110 minutes
NSM	115	Subsonic	12.5 minutes
SM-6	150	Mach 3.5	4 minutes

Figure 1. A table of U.S. anti-ship missiles and their estimated maximum flight times.[4] (Author graphic)[/caption][caption id="attachment_56426" align="aligncenter" width="556"]

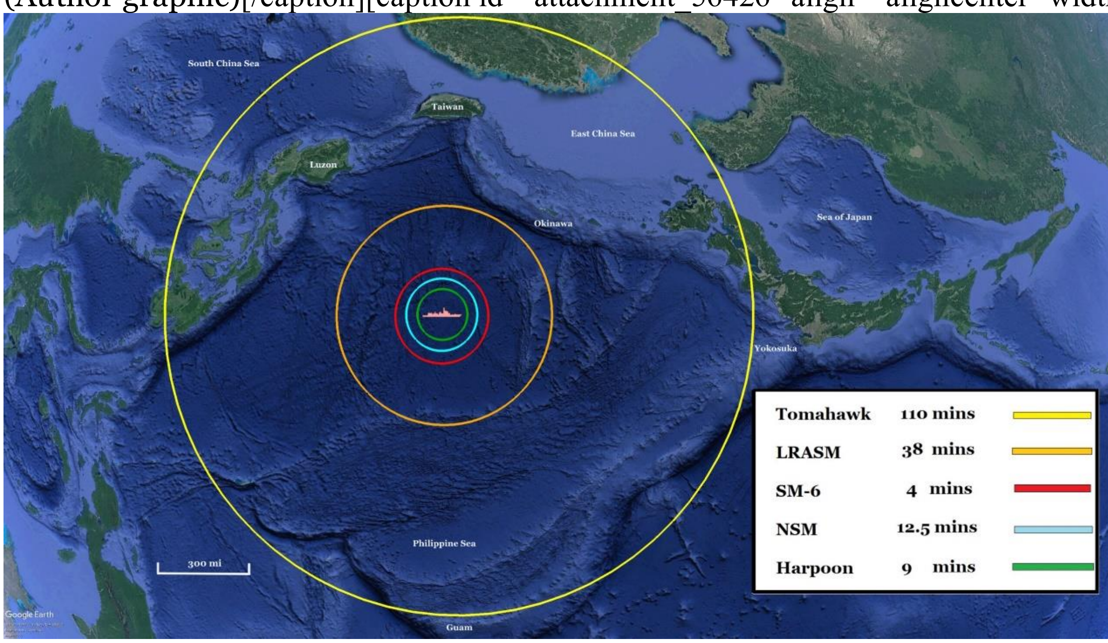

Figure 2. A map of "reverse" range rings centered on a target warship, demonstrating the relationship between range, aggregation potential, and the listed maximum flight times of U.S. anti-ship missiles. (Author graphic)[/caption]

If missiles of similar speeds are to be combined to grow the volume of fire, then the weapon with the shorter range must wait for the longer-ranged weapon to close enough distance to make combination possible. When range overlaps, the time-to-target will also overlap for missiles of similar speed. Once the longer-ranged weapon aligns with the range of the shorter-ranged weapon, then the latter can be launched to combine fires. If a Harpoon salvo is to combine with a Tomahawk salvo, then the Harpoon launchers must wait for the Tomahawk salvo to be 80 miles or less away from the target to be able to combine with the salvo.

Assuming launch platforms will try to make the most of the range of their weapons, platforms firing Tomahawk will often fire first and platforms launching any other U.S. anti-ship missile will be firing much later in the firing sequence. By necessity those other platforms will have to be much closer to the target than those firing Tomahawk. They could have to wait as long as an hour or more for a Tomahawk salvo to get close enough for them to combine fires.

Combining weapons of widely differing speeds can require limiting tactical opportunities to create a viable firing sequence and achieve a larger volume of fire. The fastest weapons will often have to be fired last in sequence so they can catch up to slower weapons within the narrow timeframe of overlapping the target (Figure 3). The platforms with the fastest weapons will often have to wait the longest to fire, even though they may face the greatest pressures and opportunities to fire first. The potential of capitalizing on a faster weapon's ability to strike a target earlier can be constrained by the need to combine with slower weapons to achieve enough volume of fire. This constraint stems from the relatively rare nature of the fastest weapons and how subsonic missiles are more common. Otherwise, firing salvos wholly composed of the most high-end and faster missiles can be especially expensive, depleting, and a less distributed form of massing firepower.

Consider how when firing an SM-6 missile in a standalone attack, a target can have as little as four or less minutes of potential warning against the incoming strike. But when SM-6 is a part of contributing fires, the missile's launch platform will be forced to wait until the aggregated salvo is around four or less minutes away from striking before the SM-6 can be fired.

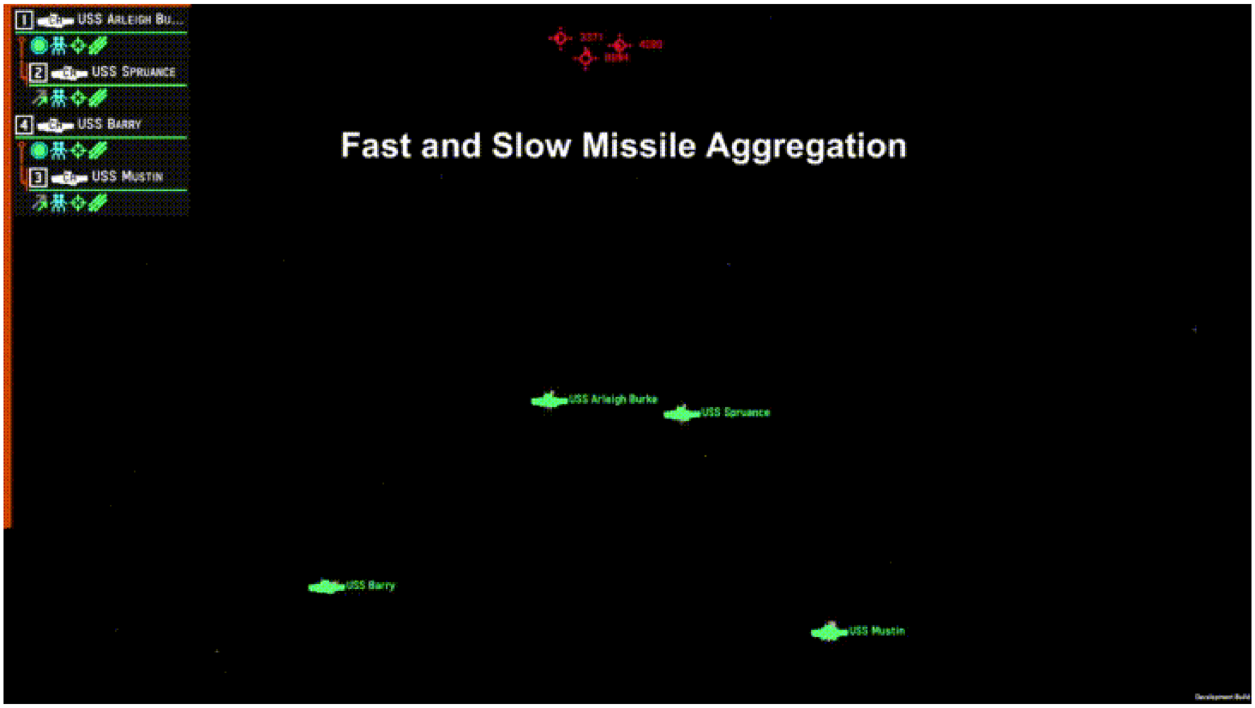

Figure 3. Click to expand. Three warships launch contributing fires of equal speed that surpass a fourth warship (USS *Arleigh Burke*). The fourth warship is still able to combine fires by using missiles of higher speed. (Author graphic via Nebulous Fleet Command)

But faster weapons offer many advantages, such as how they can help an aggregating salvo recover from failing or failed strikes. They can be quick enough to be inserted into an active firing sequence, giving commanders flexible options to augment the salvo as it is unfolding. If contributing fires are destroyed on the way to the target, high-speed weapons can be fired to recover lost volume and bolster the salvo into overwhelming dimensions (Figure 4). If a salvo is defeated by defenses, but those defenses were heavily depleted of anti-air weapons in the process, then high-speed weapons can quickly seize the opportunity to finish the target. Faster weapons can also spare commanders from the lengthier process of organizing fires from slower weapons when needed.

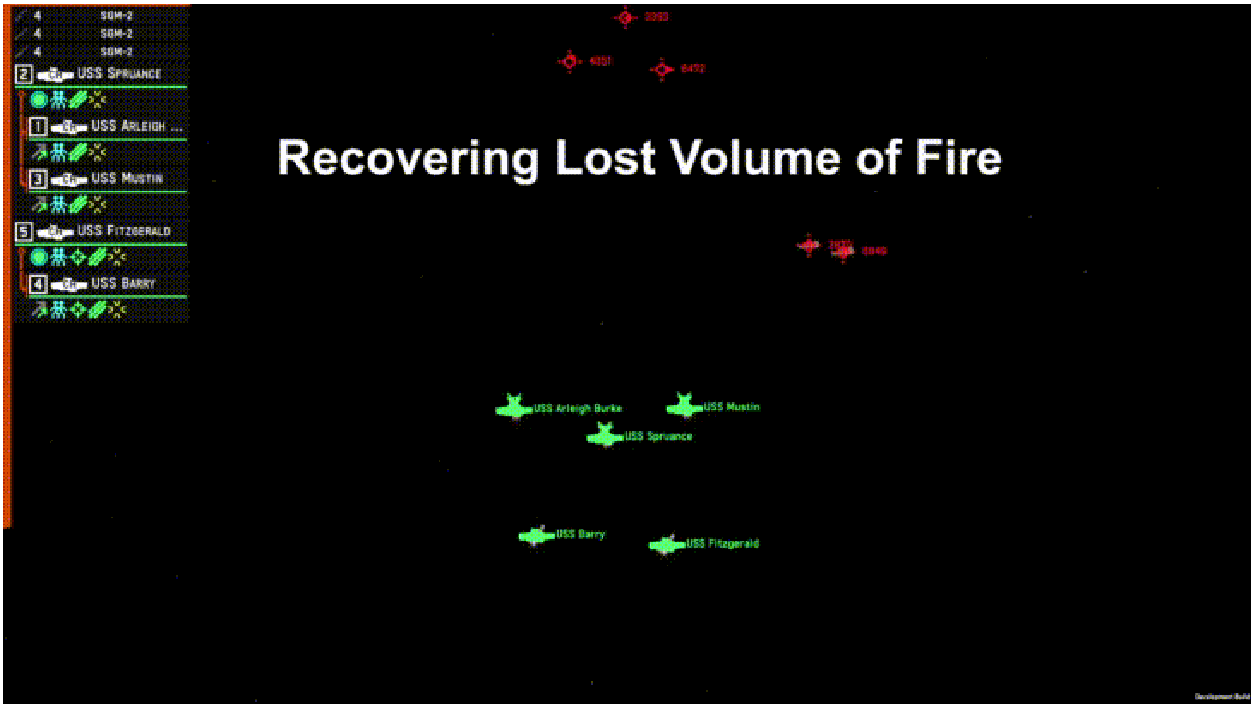

Figure 4. Click to expand. Faster missiles are used to recover lost volume of fire after a set of slower contributing fires suffer attrition. (Author graphic via Nebulous Fleet Command)

Yet in the context of a massed firing sequence, even if a platform fields the fastest missile, it could be the last to fire. It may have to wait the longest even though it could hit the earliest. The longer a platform has to wait for its turn in the firing sequence, the more opportunity the adversary will have to preemptively attack the archer before it can contribute its fires. As commanders organize mass fires, they must be wary of the predictability of their firing sequences and the risk of suffering interruptive strikes.

The Risks of Predictability and Interruptive Strikes

The way a distributed posture is presented to an adversary will flex and evolve during the course of a mass firing sequence. As an aggregating salvo closes in on a target, the options for growing the volume of fire will narrow, and the remaining distribution of potential launch platforms becomes increasingly concentrated. These dynamics simplify some of the adversary's targeting challenges, where a force will strive for broad-area awareness partly to understand how an adversary's massed fires are coming together and pinpoint opportunities to disrupt the firing sequence as it is unfolding.

The staggered nature of building an aggregated salvo from sequenced fires increases the risk to friendly platforms whose contributing fires come later in the firing sequence. If an adversary discovers that standoff fires are being launched against them from distant forces, they may view closer forces as pressing targets demanding immediate strikes. Those closer forces are potential candidates for contributing to the volume of the incoming salvo. They could be archers waiting their turn. By targeting these forces before the salvo gets close enough to be combined with, a defender can preemptively destroy platforms to restrict the growth of the salvo and kill targets with fuller magazines (Figure 5).

Figure 5. Click to expand. Sensing a mass firing sequence, an adversary launches high-speed missiles at a pair of warships it believes will soon add contributing fires. (Author graphic via Nebulous Fleet Command)

When a firing sequence is initiated and an aggregated salvo is born, the burden of destroying archers before they fire arrows considerably intensifies. But those distributed archers must realize that a friendly salvo fired by someone else can make them prime targets of opportunity. If a platform has to wait an hour or more to combine fires with a Tomahawk salvo, then that can offer plenty of time for them to be preemptively attacked by an adversary. The earlier a platform can launch in the firing sequence, the more it reduces its attractiveness for preemptive strikes during the course of assembling massed fires.

The process of assembling massed fires will take on a much more predictable pattern when most of a military's anti-ship missiles have similar speeds, such as the U.S. military's mostly subsonic arsenal. In this case an aggregated salvo can take the predictable pattern of gradually building in volume as it closes the range to the target. The outermost platforms initiate the strike by firing the longest-ranged weapons, then platforms closer to the target and with shorter-ranged missiles contribute their fires in turn. As the aggregated salvo closes the distance, each platform that becomes further away from the target than the salvo can be ruled out as a candidate for adding more contributing fires. The potential scope of remaining fires and launch platforms predictably shrinks as the aggregated salvo gets closer to the target. As the salvo closes the distance, the resulting distribution of potential contributors becomes tighter and more concentrated, making clearer to the adversary which archers may remain (Figure 6).

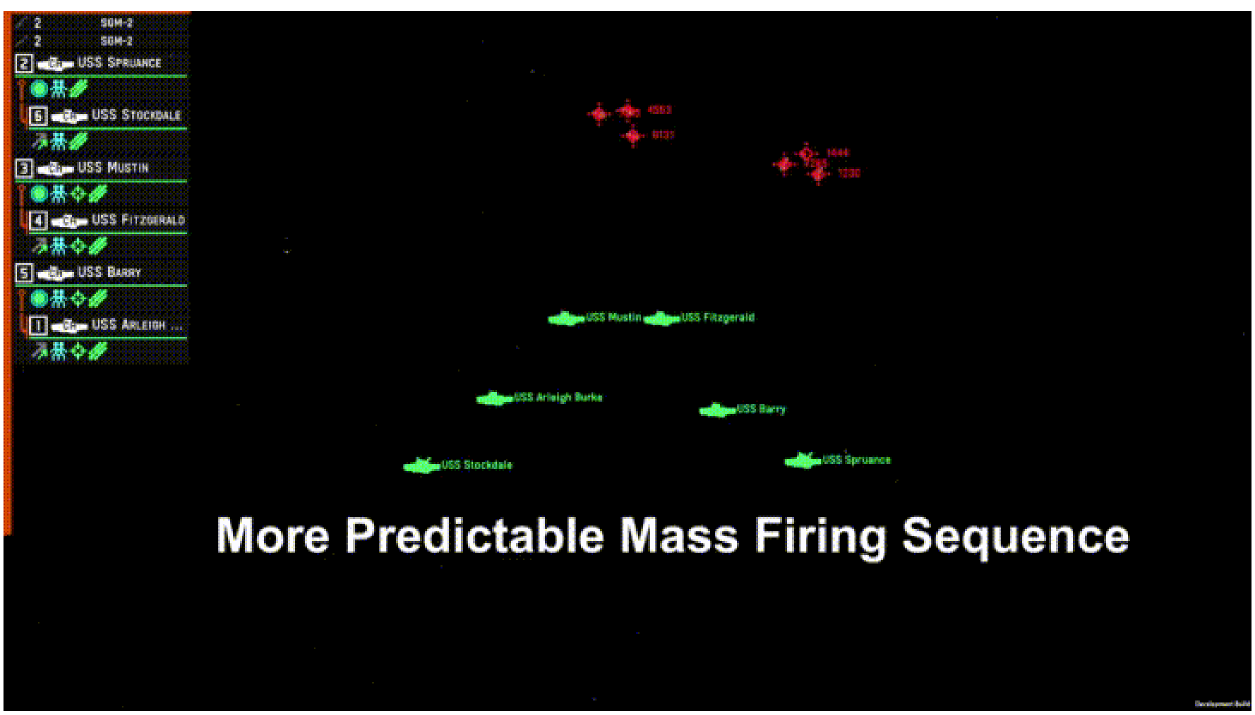

Figure 6. Click to expand. A mass firing sequence takes on a predictable pattern of

aggregation by using missiles of similar speed. (Author graphic via Nebulous Fleet Command)

This predictability can be mitigated through several measures, including by combining fires with weapons featuring widely different speeds. Platforms with faster weapons can remain a candidate for contributing fires even if they are further away from the target than the aggregated salvo, which helps preserve force distribution as the salvo closes in (Figure 7). An adversary that sees an incoming salvo of Tomahawks 100 miles away can rule out that any platform well beyond that range cannot add further Tomahawks to that salvo. But warships 150 miles away can still pose a threat by launching SM-6s that are fast enough to catch up to the Tomahawks and combine over the target in the final minutes.

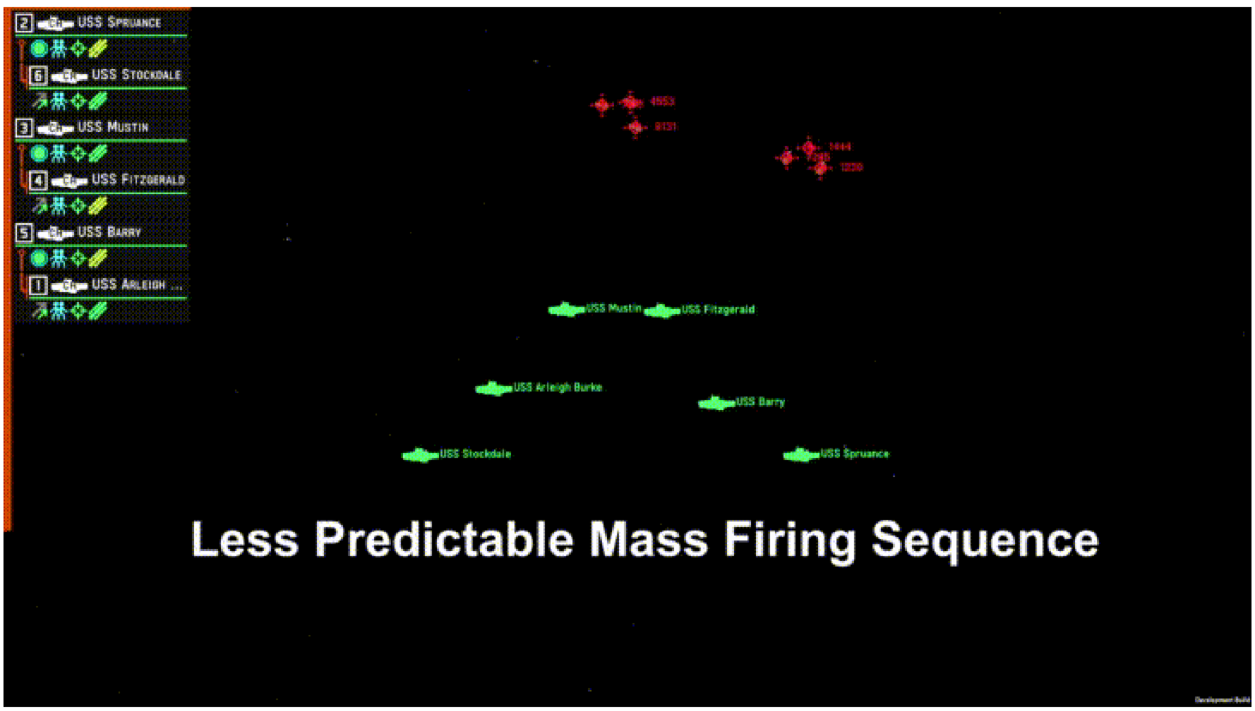

Figure 7. Click to expand. A mass firing sequence takes on a less predictable form of aggregation by combining missiles of mixed speeds. (Author graphic via Nebulous Fleet Command)

In a similar vein, Chinese forces firing subsonic anti-ship weapons can still have ballistic and hypersonic missiles combine with their fires, despite those faster weapons being launched from positions that are potentially hundreds of miles behind the platforms firing the subsonic weapons. Weapons with a combination of extremely long range and high speed can be on call to rapidly combine with a large variety of other salvos on a theater-wide scale. Forces fielding weapons with a variety of speeds therefore present more complex forms of distribution that make it more difficult to predict how their contributing fires can come together.

Waypointing is a critical tactic that can make aggregation less predictable and complicate an adversary's options for preemptively striking waiting archers. Weapons with both long range and long flight times can allow commanders to program waypoints into flight paths to artificially increase the time-to-target and therefore lengthen the opportunity to combine fires. Waypointing can allow platforms closer to the target to launch their contributing fires earlier than if they had simply waited for their time-to-target to overlap with the traveling aggregated salvo.

Consider a warship that is waiting to contribute fires to a salvo that is 30 minutes further away from striking a target than the warship's own fires. Waypointing can allow that warship to fire immediately and make up the time difference through nonlinear flight paths (Figure 8). This tactic of waypointing contributing fires can allow warships to deprive adversaries of the opportunity to destroy archers before they fire arrows, even if those archers can have a shorter time-to-target than the salvos they are aggregating with.

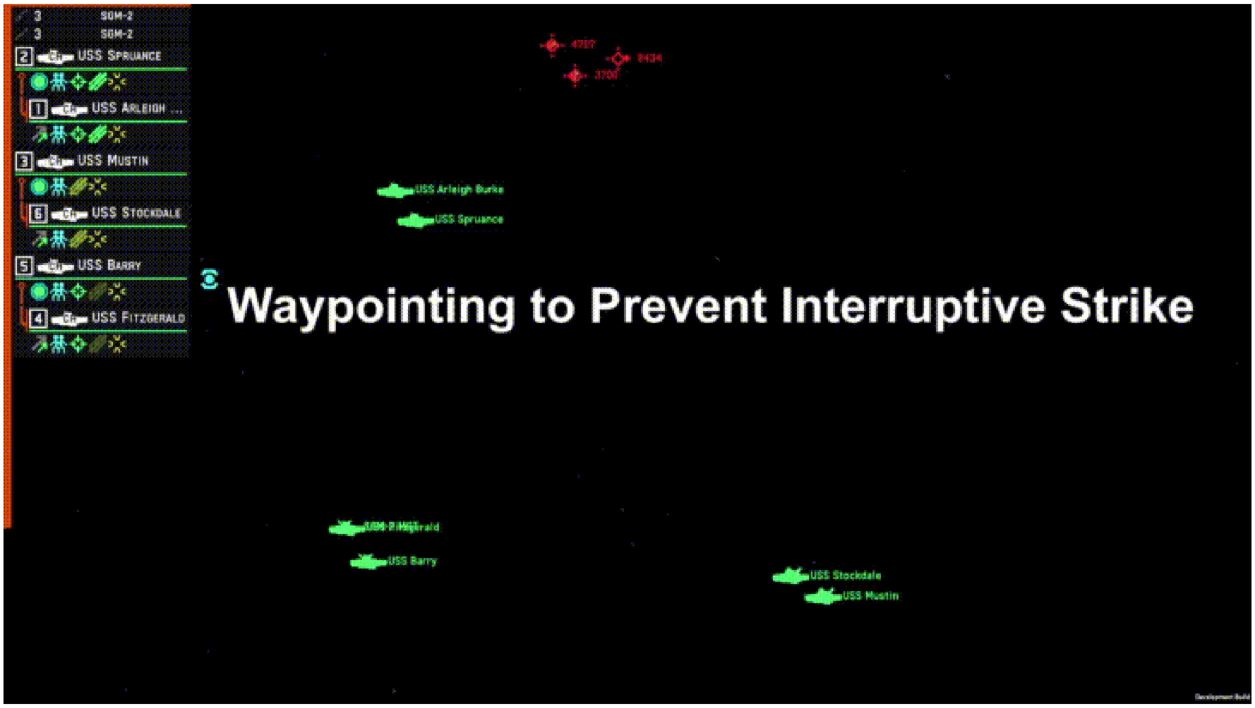

Figure 8. Click to expand. A pair of warships much closer to the target than distant platforms uses waypointing to launch early in the firing sequence while still aligning the time-to-target with the other contributing fires. (Author graphic via Nebulous Fleet Command)

When contributing fires consist of weapons with similar speeds, the methods of waypointing and in-flight retargeting can allow those salvos to not only combine over the target, but to also merge together on the way to the target. By selectively merging contributing fires and creating more distinct masses earlier in the firing sequence, an attacker can manipulate an adversary's perceptions and lure defensive airpower toward certain directions. Merging contributing fires can make an adversary falsely perceive that a given formation fired a larger salvo than is actually the case, which can create illusions of greater force concentration and magazine depletion (Figure 9). An adversary may believe a formation is more heavily armed and concentrated than previously believed and redirect more attention toward it. Or the adversary could believe the formation has diminished its value as a potential target by assuming it depleted much of its offensive firepower, and redirect attention away from it.

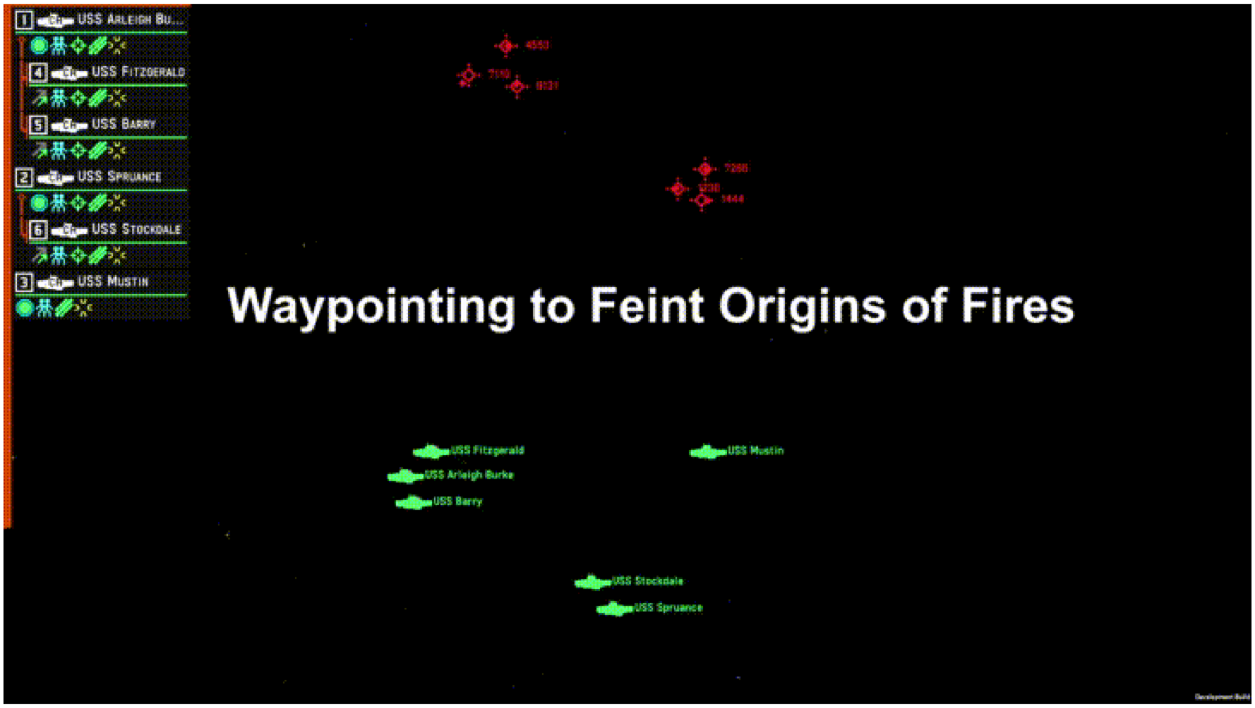

Figure 9. Click to expand. Two naval formations of several warships use waypointing to give the impression that a large standalone salvo was fired from the vicinity of a single warship (USS *Mustin*). (Author graphic via Nebulous Fleet Command)

By offering the ability to artificially increase the time-to-target, waypointing allows a force to make its firing sequences much more unpredictable in how they unfold. The path a waypointed salvo can take to the target is not linear, making it unclear to the adversary when exactly the salvo may arrive, what it is targeting, and what other contributing fires it may combine with. A sequence of waypointed fires may not predictably grow an aggregated salvo from the outside in. Rather, each platform uses waypointing to align its contributing fires with the time-to-target of other salvos that are being fired from a variety of ranges and are taking a variety of paths to the target. Through waypointing, the order of the firing sequence is no longer purely defined by who is farther or closer to a target, complicating the adversary's ability to set priorities for interruptive strikes. This method is potentially one of waypointing's most powerful force multipliers for enhancing distribution.

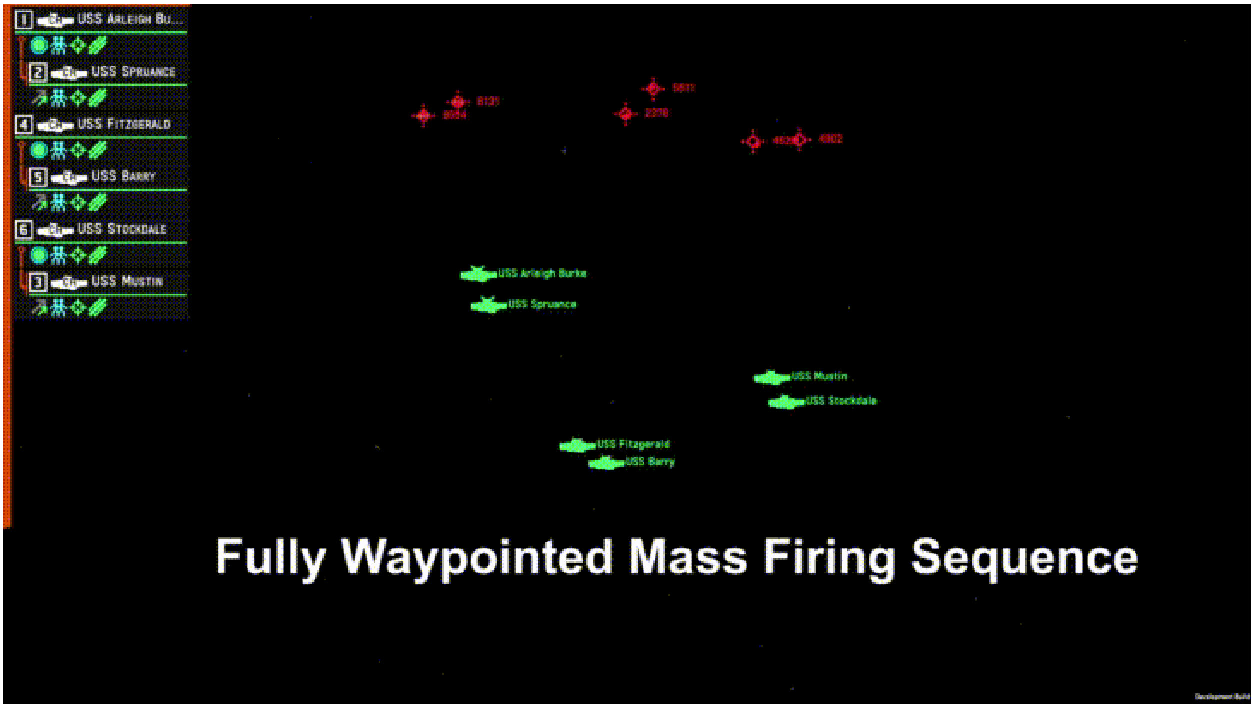

Figure 10. Click to expand. Distributed forces launch a mass firing sequence that consists entirely of waypointed salvos. (Author graphic via Nebulous Fleet Command)

Creative methods of assembling massed fires are not only useful for producing overwhelming firepower, but for manipulating the adversary's interpretations of massed fires for tactical effect. In line with the fundamental tenets of distributed warfighting, missile waypointing is a valuable means of challenging an adversary through complex threat presentations.

Distributing Volume of Fire Across Time

At what point in the firing sequence will the aggregated salvo take on enough volume to be overwhelming? As various contributing fires are launched during the course of massed fires, tactical advantage and disadvantage will come into play depending on when exactly the salvo reaches overwhelming volume on its way to the target. Preserving distribution is not only a matter of managing the physical locations of platforms and contributing fires, it is also a matter of distributing launches across points in time within a firing sequence. Well-distributed launch timing can allow a volume of fire to grow robustly yet unpredictably. Understanding the distribution of launches across time is central toward knowing how to disrupt a massed firing sequence through interruptive strikes and to secure tactical advantage.

A backloaded firing sequence depends on contributing fires to push the aggregate salvo into overwhelming dimensions near the end of the firing sequence. If an aggregated salvo does not reach overwhelming volume until the firing sequence is almost over, then the attack is more fragile and easily disrupted by attacking the contributing fires and waiting archers. A long-range Tomahawk salvo that heavily depends on combining with Harpoon salvos launched by an air wing would take the form of a backloaded firing sequence.

A frontloaded scheme achieves overwhelming volume of fire early in the firing sequence. A large amount of contributing fires are launched early on, but the salvo receives few if any contributing fires for the rest of the firing sequence. The adversary can focus more of their attention and command and control on managing defenses, because a frontloaded firing sequence can spare the adversary the pressure of having to rapidly initiate their own firing sequence in pursuit of interruptive strikes. Multiple warships firing large Tomahawk salvos in tandem and from distant standoff ranges would take the form of a frontloaded firing sequence.

These two schemes of firing sequences – frontloaded and backloaded – are disadvantaged forms of concentration with respect to timing. Various drawbacks are incurred by concentrating the growth of the volume of fire toward the frontend or backend of a firing sequence. If an adversary confronts a distributed force that repeatedly uses concentrated firing sequences, then distribution is diminished and massed fires become more predictable.

A well-distributed firing sequence makes the growth of the volume of fire less predictable and combines the advantages of frontloaded and backloaded schemes. By achieving high volume of fire early in the sequence like a frontloaded scheme, more contributing fires can be added later to increase the margin of overmatch and ensure the salvo can remain overwhelming. There will be more opportunity for new launches to join the active firing sequence, especially to recover volume of fire if it is lost to attrition or if friendly platforms are preemptively destroyed before they can contribute fires.

By also featuring a meaningful number of launches later in the firing sequence, distributed launch timing can make an adversary believe that both offensive and defensive actions are necessary to restrict the growth of the salvo. They may believe they must preemptively attack waiting archers to interrupt the firing sequence and inhibit the growing volume of fire. Adversaries would feel pressed to defend against missiles while also interrupting an active firing sequence through striking waiting platforms, stretching their decision-making across both offensive and defensive efforts.

A well-distributed firing sequence may be more logistically intensive, where a force would expend enough munitions to achieve overwhelming volume of fire early in the sequence, and still have plenty more launches occur later. This sort of firing pattern is more depleting, but it achieves the critical aim of reducing dependence on launches later in the firing sequence while still leveraging them to enhance distribution and further grow the volume of fire. Ideally an aggregated salvo has enough volume of fire to not only remain overwhelming against enemy defenses, but to also remain overwhelming when multiple friendly archers have been destroyed before they could contribute their planned fires. Launching enough volume of fire to withstand disrupted firing sequences will add to the extreme expense and potential for overkill that characterizes this form of warfare.

The pressure to interrupt an active firing sequence can force commanders to expend more of their fastest and most high-end weapons in interruptive strikes. These weapons can have low enough flight times that they can be fired after an adversary initiates massed fires and still reach targets in time to disrupt the firing sequence. Subsonic salvos by comparison will have far less potential for interruptive strikes. There may be significant opportunity to disrupt the massed fires of the U.S. Navy when its principal land-attack and anti-ship cruise missile will be a weapon that can take almost two hours to travel to the limits of its range, and when China fields anti-ship ballistic missiles of similar range that can reach targets within 15 minutes.[5]

The distribution of maximum flight times across U.S. anti-ship missiles will make for a more backloaded firing sequence when more weapons have to combine with Tomahawk fires (Figure 11). If Tomahawk is to be fired from near the limits of its range yet still combine with other types of anti-ship weapons, then the launch platforms firing those other weapons will have to wait around an hour before they reach their turn in the firing sequence. A shorter overall firing sequence can be achieved by foregoing Tomahawks and using the other U.S. anti-ship weapons, but those weapons require much denser platform concentration to mass enough fires, especially for air wings. The U.S. can accomplish a well-distributed firing sequence mainly by having enough Tomahawk shooters throughout the battlespace and at widely different ranges from targets, while also leveraging the missile's potent waypointing and retargeting capabilities. The figures below illustrate different forms of distribution and concentration across firing sequence timelines (Figures 12-14).
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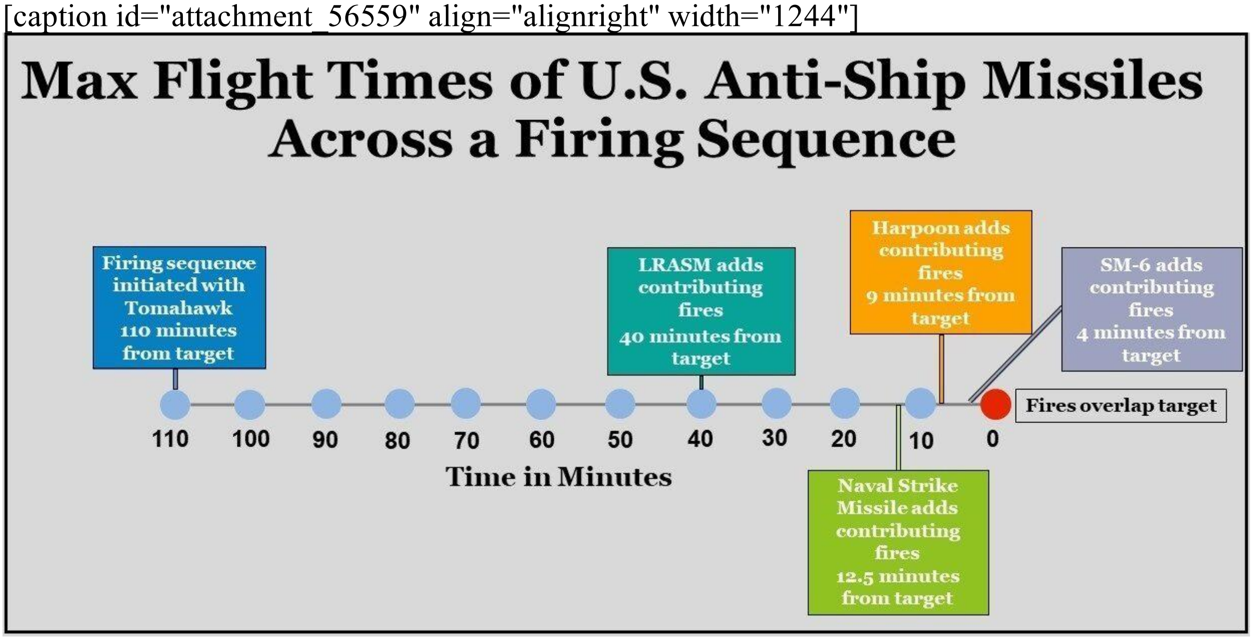

Figure 11. Click to expand. A firing sequence timeline depicting the maximum flight times of all U.S. anti-ship missiles, and the earliest each weapon could be fired in a sequence featuring all listed missile types. (Author graphic)[/caption][caption id="attachment_56491" align="alignright" width="1260"]

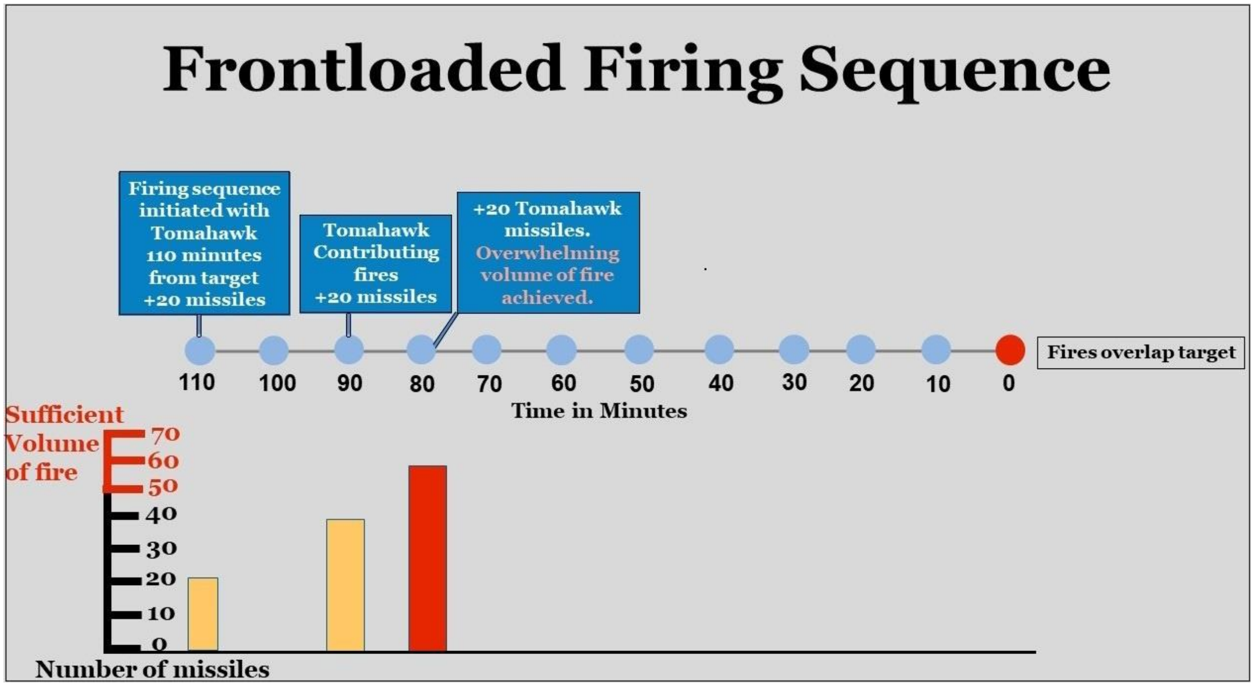

Figure 12. Click to expand. A frontloaded firing sequence achieves an overwhelming volume of fire early in the sequence, but features few if any launches toward the end of the sequence. (Author graphic)[/caption][caption id="attachment_56489" align="alignright" width="1280"]

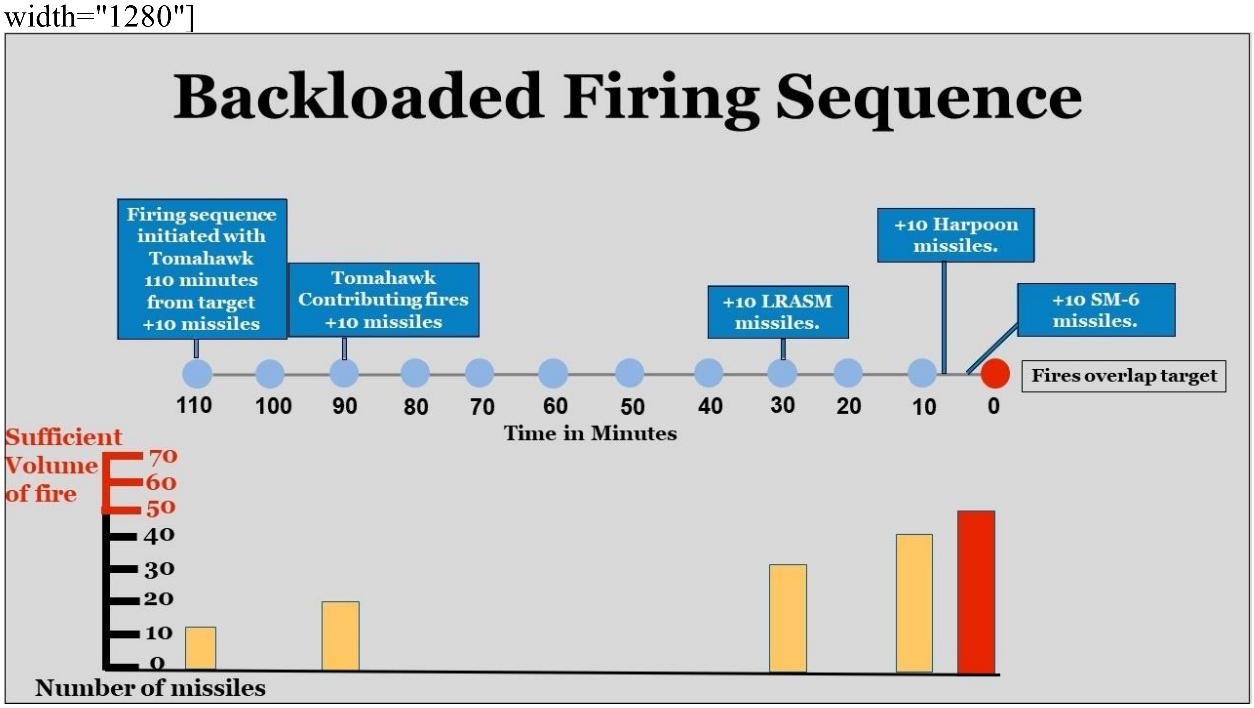

Figure 13. Click to expand. A backloaded firing sequence achieves overwhelming volume of fire only toward the end of the firing sequence. This is more typical of firing sequences that rely more heavily on combining faster weapons with slower weapons, or many short-ranged weapons with fewer long-ranged weapons. (Author graphic)[/caption][caption id="attachment_56488" align="aligncenter" width="1280"]

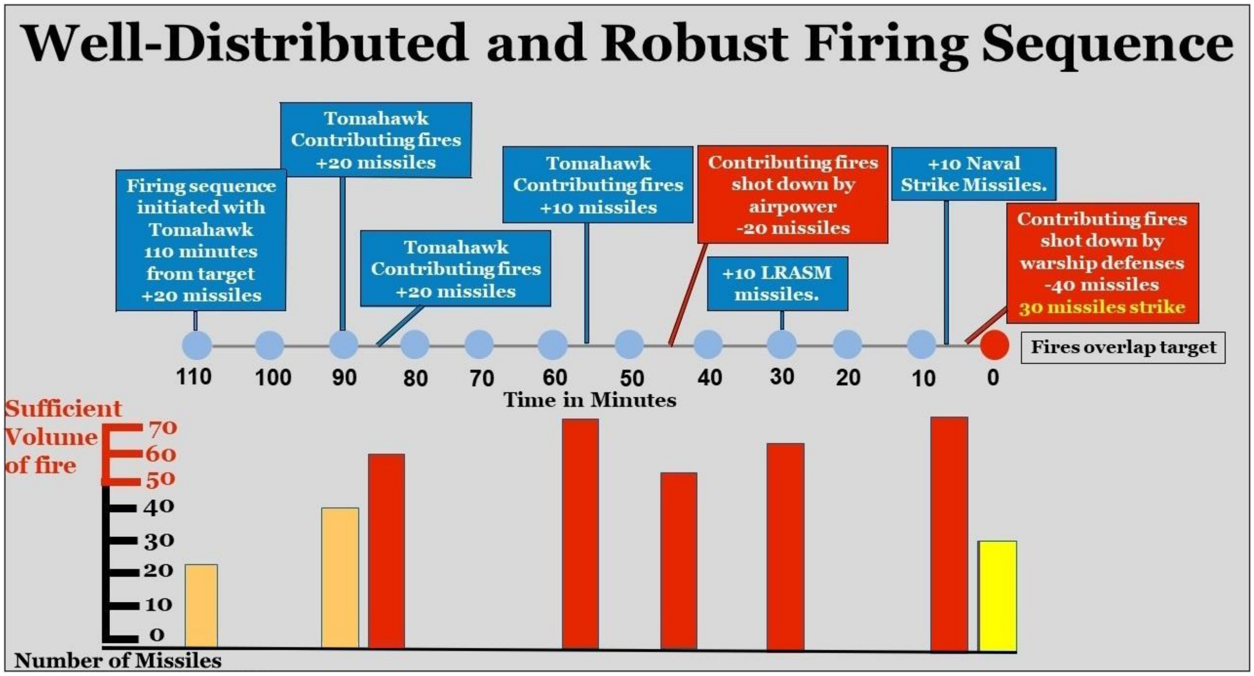

Figure 14. Click to expand. A well-distributed and robust firing sequence achieves an overwhelming volume of fire early in the sequence. It also continues to add contributing fires throughout the sequence to further reinforce the volume of fire against attrition and sustain distributed firings to further complicate the adversary's challenge. (Author graphic)[/caption]

These dynamics create a conundrum for using higher-end weapons. These weapons typically feature very low flight times by virtue of their especially high speed. Their speed will often place them later in the firing sequence where they can combine with more common weapons over the target. Using higher-end weapons is therefore more likely to backload the firing sequence of a mixed salvo. Since the weapons that could contribute the most to a salvo's lethality would often be fired last, this creates more dependence on ensuring those forces and their kill chains survive until the final minutes of a firing sequence. If those platforms are destroyed or suppressed, or if the handful of high-end missiles are shot down by defenses, then the rest of the aggregated salvo may be at risk of failing and with virtually no time left to add more contributing fires. Counting on higher-end missiles to push a mixed salvo into overwhelming dimensions near the very end of a firing sequence leaves little room to recover lost volume during the course of the attack.

Commanders may not want to risk these dependencies. Therefore they may opt to shorten the overall length of the firing sequence, such as by firing salvos that mainly consist of higher-end weapons. Firing salvos primarily of the fastest weapons will shorten the decision cycle considerably compared to having to wait tens of minutes or longer for more common weapons to form massed fires. A greater number of firing sequences and mass firings could take place within the same span of time it takes to launch a single slower salvo. More than 20 consecutive SM-6 strikes or seven DF-21 anti-ship ballistic missile strikes could be conducted within the time it takes a single Tomahawk salvo to travel the limits of its range (Figure 15). This assumes of course that enough SM-6 and DF-21 inventory is available, targeted, and ready to fire.

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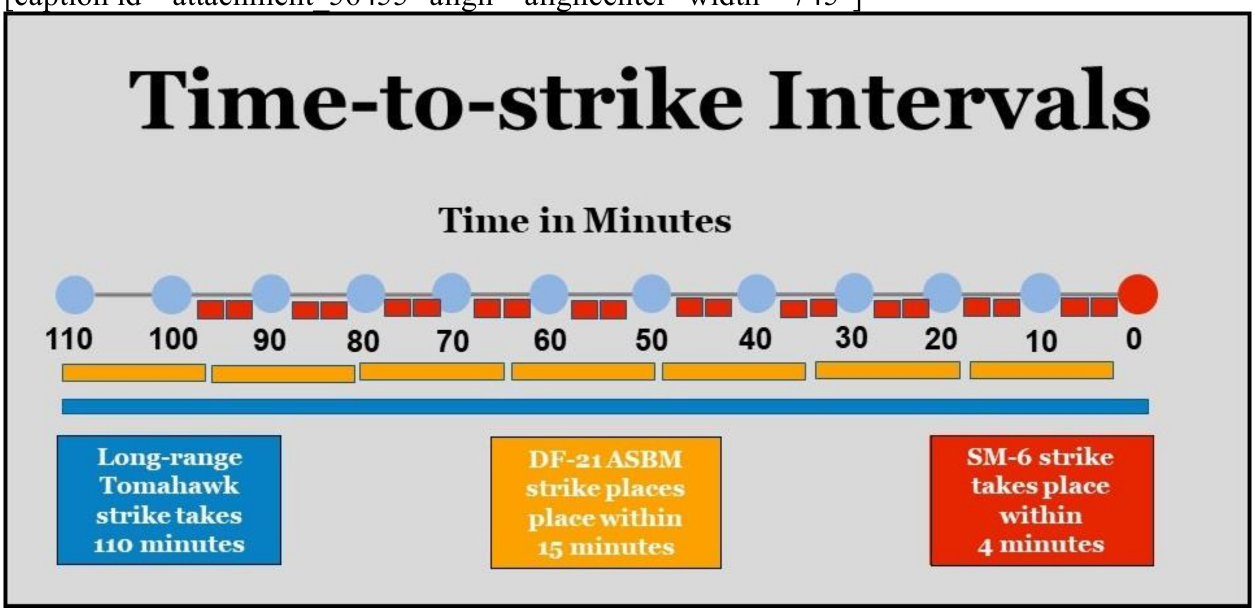


Figure 15. Click to expand. Weapons with shorter flight times can cycle through multiple engagements within the same period of time it takes a weapon with a longer flight time to conduct a single engagement. (Author graphic)[/caption]

Faster weapons can result in a faster kill chain and increase decision-making advantage. A faster kill chain creates more opportunity to launch more attacks, adjust volumes of fire as needed, improve understanding of adversary defenses, and move on to new targets. These advantages may come at a steeper logistical price by depleting high-end inventory at a faster rate. Yet distributed forces that heavily depend on more common weapons with long flight times, like the

Tomahawk, may suffer considerable disadvantage in the speed of their decision cycle.

Conclusion

Assembling massed fires from distributed forces will be a complicated challenge. It will involve mixing and harmonizing the kill chains of different payloads, platforms, communities, and services. Each of these factors comes with a variety of its own dependencies and pitfalls. As the services look to operationalize mass fires, they must be mindful of how too much complexity and too much sensitivity to tight coordination can threaten to yield brittle operational designs.

General Thoughts/Ideas

Structural: Combine carrier air wing perils section with massing fires with aviation section in part 3 into a new chapter….

Untapped force structure point, say it earlier in the introduction

Maybe give NSM more credit for advanced seeker, smart behaviors, low signature…

These traits are only point of departure for tactics….risks of using these things, as illustrated in the section on Harpoon….

Point out next block upgrade for LRASM, with more range

Besides mass firing traits, how do we have a framework for force-multiplying attributes capability of these missiles? Speed, penetration aids, algorithms, smart behaviors, etc?

CONOPS change dramatically if the weapon is in low supply

Consider commissioning graphics from Louis Vezian?

Arsenal deficiencies can be compensated with by effective tactical and operational designs, and leveraging combined arms approaches, such as heavily depending on U.S. submarines to take out high-end PLAN combatants to help pave the way for air wings…offset/circumvent/asymmetric strategies

Consider extent of concentration to use a weapon like Harpoon….so concentrated it can require only a single opposing salvo to wipe out that concentration of platforms.. ….distribution, you want each element to be distributed enough that it amounts to a separate kill chain for the adversary, a separate salvo and engagement….if too many warships are clustered so close together that they can all be held at threat with the same salvo, that is too much concentration….a key goal of distribution is to minimize the loss that is taken against a successful individual attack….

It will have taken the U.S. Navy more than half a century to field a meaningful replacement to Harpoon

For certain range ring graphics, consider including a line from the central unit to the limits of the circle, as in here (perhaps better for single-ring graphics)

Sources for (MST?) procurement quantity: FY21, FY22 (USAF on pg 237), FY23

CSIS wargame has figures on LRASM and JASSM procurement figures for Navy and USAF

Acknowledge potential for classified capabilities as game changers……..but still need broad-based firepower….it is not a good diea to count heavily upon exquisite capabilities and tactics to carry the day…..

you don't always want to fire near the limits of your range…..you want a large WEZ to overlap the opponent's potential area of maneuver, and maintain opportunities for follow-on fires if needed…opportunities for tactics increase the more range a missile can burn in nonlinear fashion on the way to the target…linear engagements fired at the limits of range tightly constrain missile behavior….more excess range gives the missile more time and space to increase the complexity of its threat presentation and better support scouting….**excess range as a metric for engagements**…..can't simply look at range rings and think that they will automatically fire to the limits of range…..

Arsenal distribution: A high number of low-end missiles (well distributed) a small number of high-end missiles (over concentrated).....stretched thin: You are hard pressed to have enough of either to achieve overwhelming volume of fire….consider how the principles of distribution applies to the ASCM arsenal itself…..

Excellent article on LRASM capabilities.

SM-6: Multi-modal seeker? Based on AMRAAM?? Is it purpose-built for maritime targets and being able to discriminate against decoys, chaff, etc….does MST have a larger and more sophisticated, purpose-built anti-ship seeker than SM-6, and does it need because of its longer killchain? ….SM-6 is one of the most important missiles to understand, because of attributes and joint force and a mature production line…..may be at the forefront of the U.S. Navy's ability to both deliver and withstand massed fires……flight trajectory may mean it will be more dependent upon advanced swarming/autonomous behaviors to withstand a longer depth of defensive fires…..(See this quora response).......

primary AAW and ASCM weapon? Will markedly increase the depletion of the weapon…..production line is split between Army and Navy buys, which may stretch the inventory thin until it is built up enough to be well-distributed…

Update table graphic to show SM-6 compatibility with aircraft

SM-6 for submarines, unlikely to put it on a submarine even if VLS compatible because the submarine lacks the radar arrays and combat systems needed to support the defensive AAW capability of SM-6, and deep penetrating nature of submarine operations mean that the rest of the SM-6 killchain may not be able to be handled by non-organic targeters like an E-2…the dual-capable nature of SM-6 makes it unlikely that the submarine force can confidently field the weapon unless only for anti-ship purposes, which again is something the Navy may be forced to do given that SM-6 is the only modern weapon with the production numbers…..

Investigate implications of air-launched SM-6…….

FY25 budget justification books for SM-6….aiming for 300/yr production

SM-6 intelligent swarming capabilities? Advanced sensors and algorithms? Like LRASM and NSM? Seems unknown, but some of those capabilities seem more for anti-ship weapons than anti-air weapons….

Unsure/Unused

Arsenal: Are all Block IV Tomahawks being converted into Block V?.....source on delivery of first BlockV, also sources all BlockIVs being converted, and Raytheon source saying the same., another Navy source saying the same……all Tomahawks will have land-attack and anti-ship roles? Block Va is the specific addition of maritime strike ability….will all Tomahawks have that capability or just those recertified into Va? Maybe call the program office?....Implications for aggregation if land-attack and anti-ship capable?...and make sure to say that when you mean anti-ship Tomahawks, you are referring to that particular use, not a particular exclusive type of weapon…..

[**Sources** for SM-6 procurement history: 2022, 2017. Appears to be slightly more than 1,000 missiles.]

Attempting to use heavily concentrated groups of Harpoon-equipped warships to attack more distributed forces fielding longer-ranged weapons amounts to the naval equivalent of bringing a musket to a sniper rifle fight.

A navy's ability to mass fires against opposing fleets rests upon a foundation of firepower.

The ability to combine fires against warships heavily depends upon the traits of the weapons themselves. These traits can be combined into a valuable framework for defining the potential of individual weapons and the broader force's ability to mass fires.

Weapons heavily dictate tactical possibilities, and poor weapons can force fleets into executing dangerous tactics. In the following breakdowns of tactical dynamics and weapon capabilities, it should become clear that virtually all of the U.S. military's current anti-ship missiles are lacking crucial traits that are essential for massing fires. The consequence is a force with few good options for sinking ships with missiles and how it may need to take major risks to make much use of its scant firepower.

In many respects, the U.S. Navy is more than a half-century late to fielding a modern naval force structure in the missile age. The confines of the carrier-centric paradigm have prevented it from developing into a force that is comprehensively armed with offensive missile weaponry. But new game-changing weapons are on the way, and DMO is the concept that is poised to harness a major transformation in the U.S. Navy's firepower.

A Mass Firing Framework of Weapon Traits

Range is only one critical variable for assessing the ability to mass fires. Other critical traits include launch cell compatibility, platform compatibility, number of weapons procured, and numbers of weapons fielded per platform.

These traits combine to highlight the true extent of a navy's offensive firepower.

Weapon	Range (miles)	Launch Cell Compatible	Platform Compatibility	Estimated Procurement Rate	Estimated Inventory
Harpoon	80	No	Multi-role aircraft Submarines Surface warships Bombers Land-based launchers	Unclear	6,000
SM-6	150	Yes	Surface warships Land-based launchers	125/yr.	1,300
LRASM	350	No	Multi-role aircraft Bombers	Avg. 55/yr.	350 (USN and USAF)
Maritime Strike Tomahawk	1,000	Yes	Submarines Surface warships Land-based launchers	Avg. 50/yr.	100
NSM	115	No	Surface warships Land-based launchers	Avg. 20/yr.	110

Click to expand. A table of U.S. anti-ship weapons and key weapon traits for massing fires. (Author graphic)[/caption]

Time attribute…..dealt with in another chapter

Weapon Range and Defining Limits of Distribution

There is a fundamental tension between spreading forces out and combining their firepower. The range of weaponry is a critical factor that limits the extent to which forces can distribute from another while still being able to combine their fires. This core tension between distribution and aggregation has a strong influence over the tactics and dispositions of a distributed force.

Longer-ranged weapons allow for the broader distribution of launch platforms, while shorter-ranged weapons will force greater concentration. This dynamic can be illustrated using range rings that show the area forces must reside within if they are to combine their fires against a shared target. Range rings are typically used to show the range of a weapon and are centered on the weapon's launch platform. In this different method of using "reverse" range rings (for lack of a better term), the ring is centered on the target, and shows the area from where the target can be hit by a given weapon. In other words, to strike a target within the range of the Tomahawk missile, a launch platform must be within a 1,000-mile ring of the target.[1] Other platforms using the same weapon must also be within this ringed area, highlighting the extent of distribution that is possible while still combining fires. By comparison, platforms using SM-6 or Harpoon have to distribute within much tighter spaces to combine fires (Figure 1).

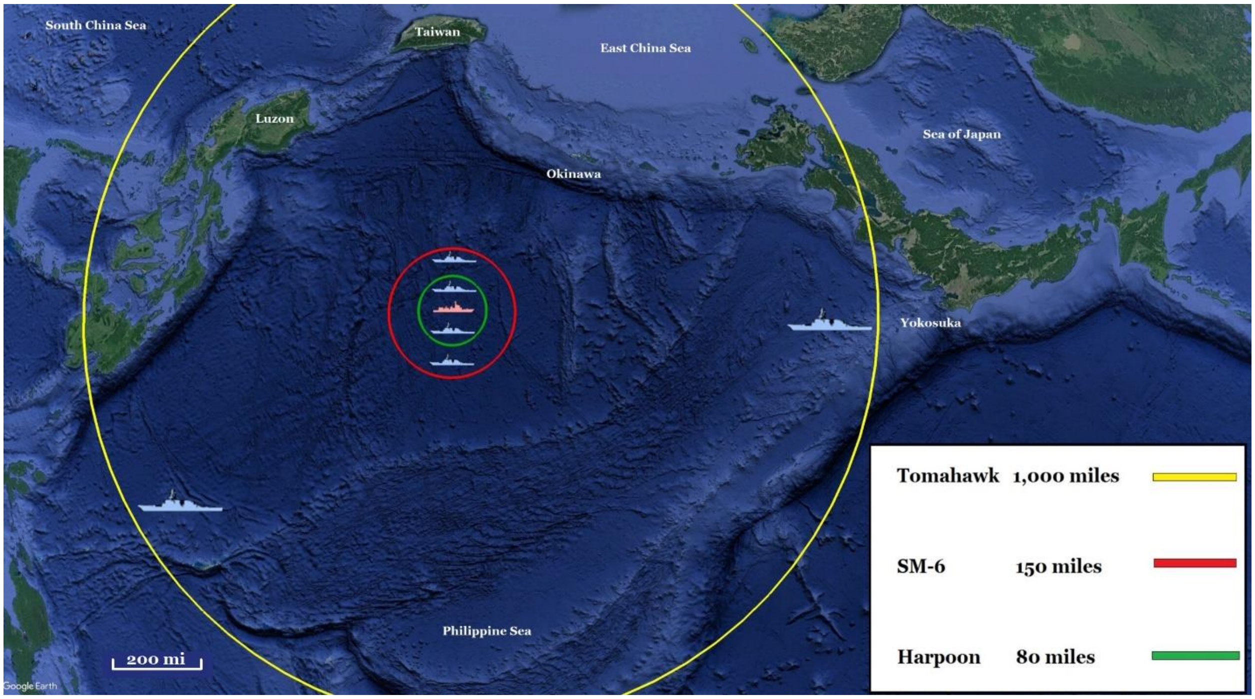


Figure 1. Click to expand. Range rings centered on a target illustrate the scope of distribution that is possible with various weapons while still being able to combine fires. (Author graphic)[/caption]

Launch platforms using different weapons with different ranges must have the rings overlap with one another, at least by the time their fires are combining over the target. These reverse range rings show how longer-range weapons allow for the broader distribution of launch platforms, and how shorter-range weapons, especially versions of the common Harpoon missile, force much tighter concentration around a target (Figure 2).

[caption id="attachment_56359" align="aligncenter" width="636"]

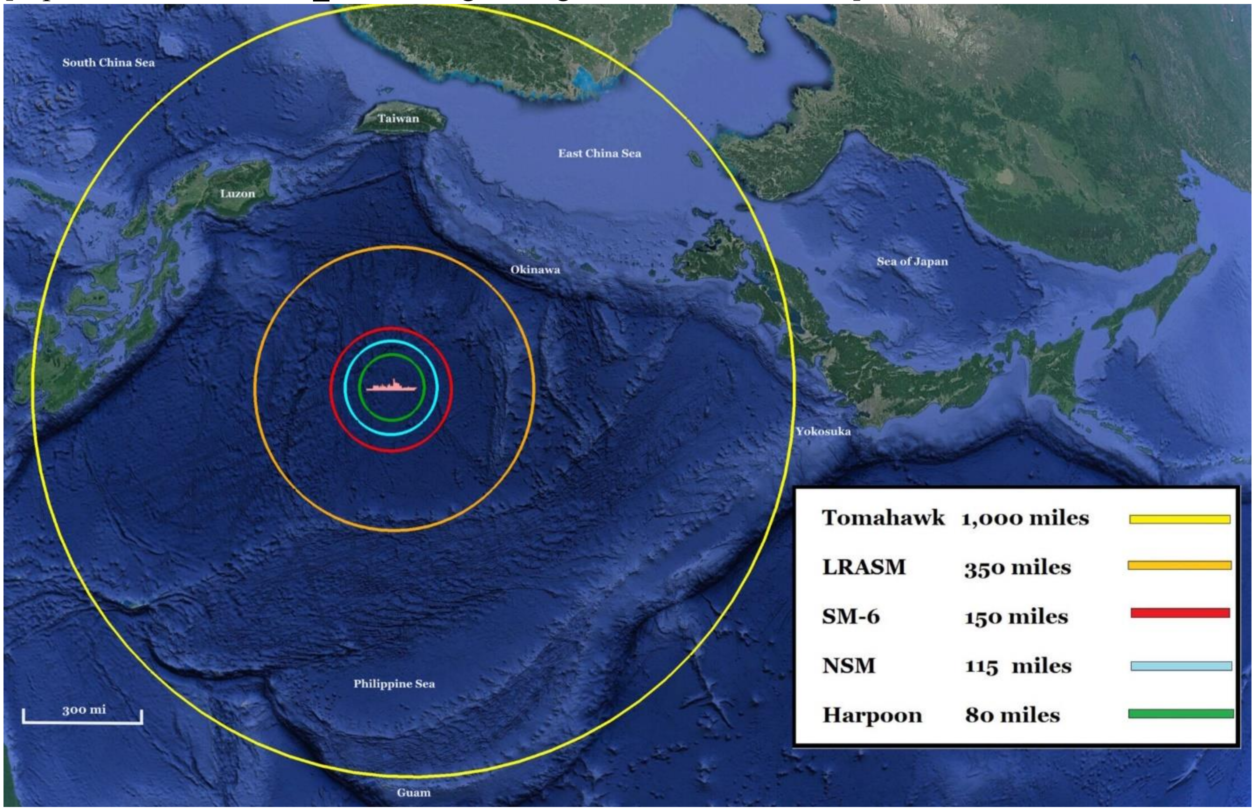


Figure 2. Click to expand. "Reverse" range rings featuring all U.S. anti-ship missiles. (Author graphic)[/caption]

The specific ranges of missiles are strongly affected by their flight profiles and are not always a linear, set amount in practice. Missiles and aircraft that fly higher earn longer range, partly through the thinner air at higher altitudes.[2] But this comes at the cost of being more detectable and potentially less survivable. Low altitude sea-skimming flight maximizes the element of surprise by tightly compressing the amount of time and space warships have to defend themselves, but this flight profile comes at a major cost to range and fuel economy. This tradeoff between range and detectability is a foundational factor in shaping the tactics and behavior of naval salvo warfare.

This variability of flight profiles adds another dimension of complexity to combining fires. Different flight profiles can be programmed into missiles depending on the tactical circumstances, and many anti-ship missiles can be programmed with non-linear flight paths and waypoints.[3] It is often unclear in publicly available information what kind of flight profile is associated with the published range of the missile. These factors make range rings more elastic than they appear.

For the sake of consistency in the graphics used here, it is assumed that all missiles of the same type are using the same flight profile in linear attacks. Another elastic factor is the maximum effective range of a weapon, which is not the same as the maximum flying range. The distance to which a missile can be effectively targeted can be less than the maximum range of how far the missile can travel. Maximum flying ranges are used here for consistency.

Having long-range weaponry is extremely valuable in modern naval warfare because weapon range helps shifts the burden of maneuver from the slower platform to the faster payload. This advantage is especially critical to navies because of the significant speed differential between ships and missiles. A warship with a short-ranged anti-ship missile would have to maneuver for hours and even days to strike multiple targets spread across an ocean. But a warship with a long-ranged weapon could hold all those same targets at risk simultaneously with no maneuver. A single warship with Tomahawk can hold targets near Luzon, Taiwan, and Okinawa at risk simultaneously, while a ship with SM-6 could only hold one of those areas at risk at a time. The warship with SM-6 would have to spend significant time maneuvering to eventually hold all of these areas at risk, and only in sequence (Figure 3).

Anti-ship weapons that are specifically designed for multi-role aircraft are often much smaller than warship-based weapons that are fielded in large launch cells, which often causes these aircraft-based weapons to have lesser range. Aircraft can compensate for lesser weapons range with their faster platform maneuver, whereas warships can compensate for their slower platform maneuver with the longer range of their larger weapons. Understanding this relationship between platform maneuver and payload maneuver and how they can complement and compensate for one another is critical to assembling massed fires.

[caption id="attachment_56354" align="aligncenter" width="2560"]

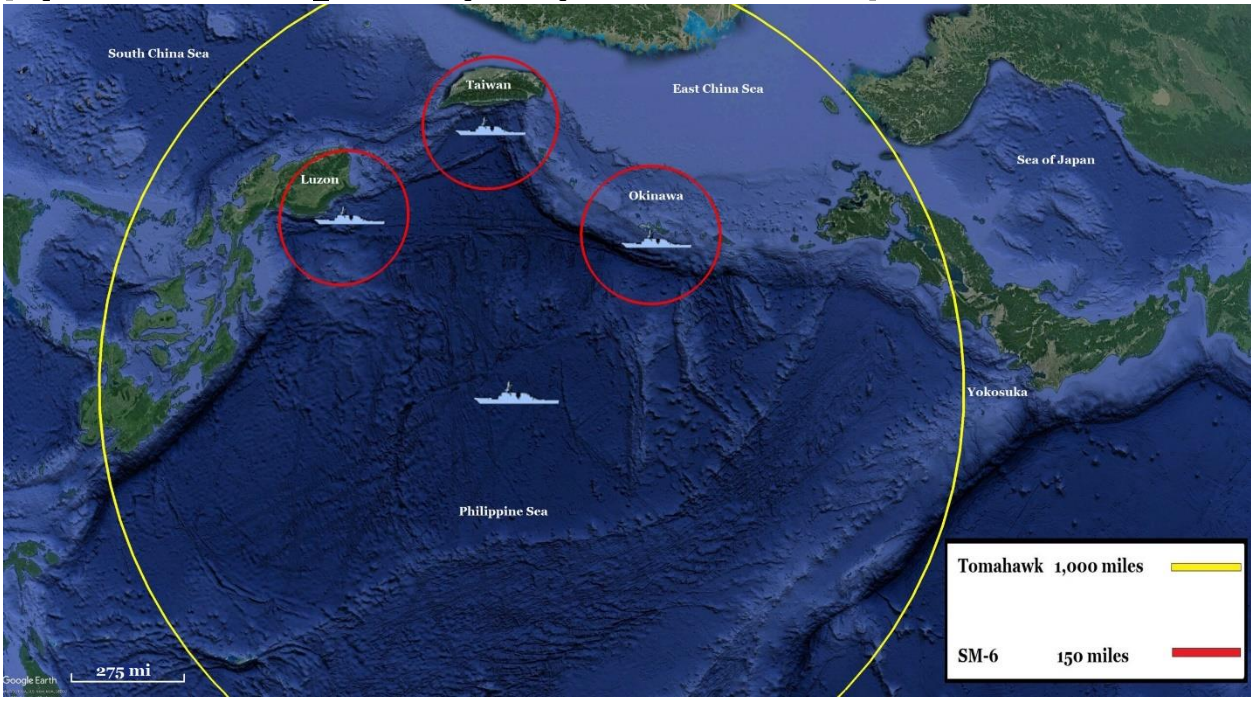


Figure 3. Click to expand. Conventional range rings centered on the launch platform highlight the ability of longer-ranged weaponry to hold many more targets at risk simultaneously compared to shorter-ranged weaponry. (Author graphic)[/caption]

Anti-ship weapons that are specifically designed for multi-role aircraft are often much smaller than warship-based weapons that are fielded in large launch cells, which often causes these aircraft-based weapons to have lesser range. Aircraft can compensate for lesser weapons range with their faster platform maneuver, whereas warships can compensate for their slower platform maneuver with the longer range of their larger weapons. Understanding this relationship between platform maneuver and payload maneuver and how they can complement and compensate for one another is critical to assembling massed fires.

This relationship between range and maneuver highlights the critical dynamic of how one force's distribution can make the adversary's stretched thin or concentrated. If one formation has shorter-ranged weapons than its adversary, it has less space it can distribute within and still combine fires. The shorter-ranged formation is more concentrated than its opposition, and may only be able to threaten one portion of the opposing distributed force at a time, if it can even get within range. By comparison, many more elements of the longer-ranged force can hold the shorter-ranged force at risk, and from safer standoff distances. Rings within rings can illustrate how the broader disposition of a force with longer-ranged weapons can result in a major distribution and mass firing advantage over a force with less range (Figures 4 and 5).

[caption id="attachment_56221" align="aligncenter" width="3610"]

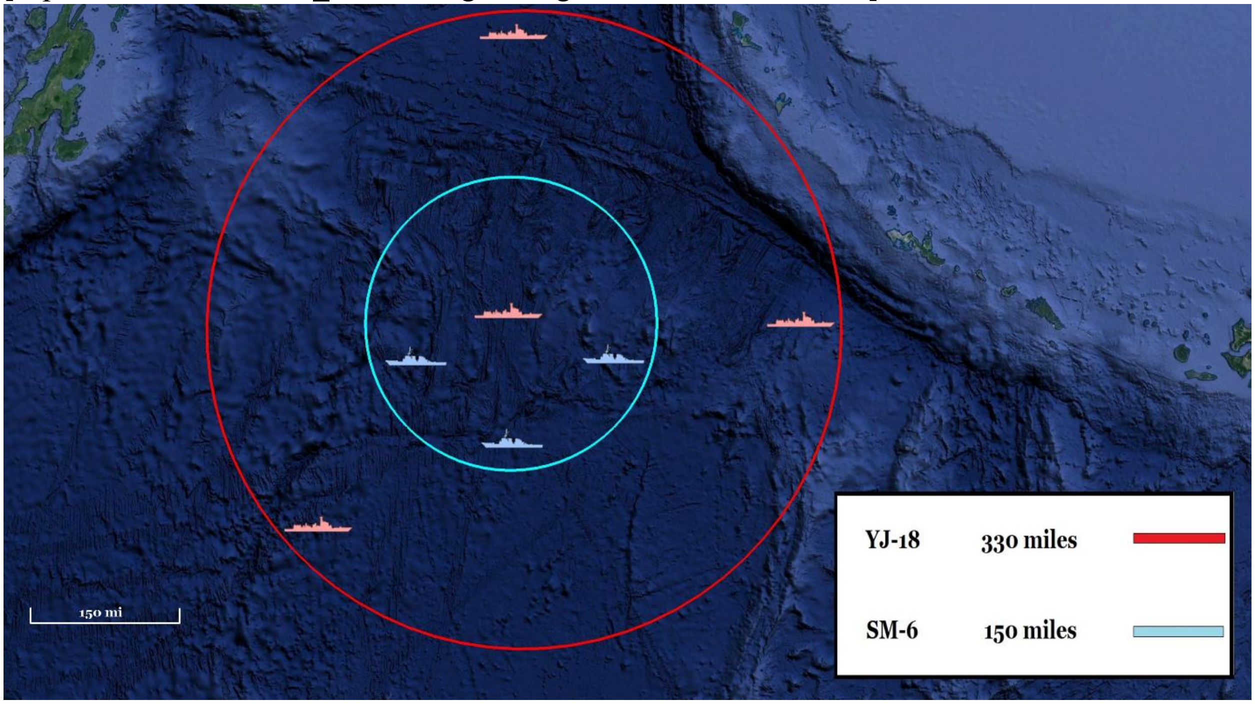


Figure 4. Click to expand. Reverse range rings centered on a REDFOR ship illustrate the extent of distribution for BLUFOR ships combining fires with SM-6, and the extent of distribution for REDFOR ships combining fires with YJ-18. The BLUFOR ships can only hold one REDFOR ship at risk at a time, if they can get within range, while all REDFOR ships can hold all BLUFOR ships at risk simultaneously. A majority of REDFOR ships can fire from standoff ranges. (Author graphic)[/caption][caption id="attachment_56214" align="aligncenter" width="2560"]

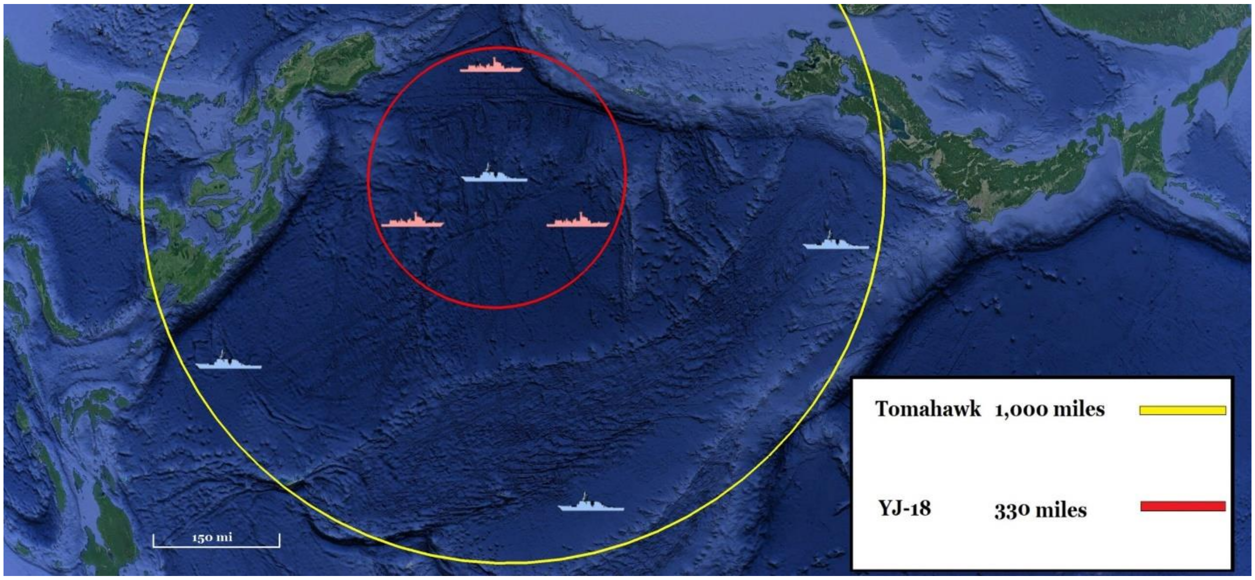


Figure 5. Click to expand. Reverse range rings centered on a BLUFOR ship illustrate the extent of distribution for BLUFOR ships combining fires with Tomahawk, and the extent of distribution for REDFOR ships combining fires with YJ-18. The REDFOR ships can only hold one BLUFOR ship at risk at a time, if they can get within range, while all BLUFOR ships can hold all REDFOR ships at risk simultaneously. A majority of BLUFOR ships can fire from standoff ranges. (Author graphic)[/caption]

What can be defined as distributed, concentrated, or stretched thin is less a matter of a specific range or density of forces. Rather, it is better understood as a relative relationship between the spread of one's own capabilities, and how that compares to the spread of capability of the adversary. A force that believes it is well-distributed could actually be heavily concentrated in the context of an adversary with much longer-ranged capability.

Harpoon and the Perils of Carrier Strike

The Harpoon missile was the U.S. Navy's first anti-ship missile and has remained its primary anti-ship weapon for more than 45 years.[4] The way the U.S. Navy has continued to field this missile has created severe operational liabilities for U.S. sea control and the credibility of American security guarantees in the Indo-Pacific writ large. The Harpoon missile underscores a critical capability gap of major strategic significance by highlighting just how little anti-ship missile firepower the U.S. military has. The weapon's shortcomings are emphasized by the especially risky tactics the U.S. would be forced to use in war to make much use of it.

The Harpoon missile's greatest weakness comes through its combination of short range – 80 miles for the more common variants – and the lack of meaningful magazine depth in all its compatible launch platforms save for one – aircraft carriers.[5] The short range of this missile draws the U.S. Navy's most expensive and least risk-worthy platform deeper into the battlespace, while funneling carrier air wings into exceedingly concentrated anti-ship attacks. But because the U.S. Navy has lagged for decades in fielding a meaningful replacement for Harpoon, the highly risky method of attacking ships with carrier air wings is the only tactic the U.S. military effectively has for sinking high-end warships at long range.

The Harpoon missile has the broadest platform compatibility of any U.S. anti-ship weapon, where it can be fielded by submarines, surface ships, bombers, land-based launchers (which the U.S. sells to partners but does not procure for itself), and carrier air wings. But despite the U.S. Navy having more than 9,000 vertical launch cells for missiles, the Harpoon is incompatible with these launchers.[6] Instead, it has to be kept in torpedo racks or in launchers mounted topside, which are highly uneconomical methods that severely reduce the number of weapons that can be fielded per warship. U.S. Navy destroyers and cruisers only carry eight Harpoon missiles despite having around 100 launch cells per platform, and the number of torpedo tubes per submarine typically numbers in the single digits. What launch cells offer is significant magazine depth on both an individual platform and force-wide basis, making launch cell compatibility a crucial trait for massing fires.

PACIFIC OCEAN (Feb. 18, 2008) Note the four Harpoon missile launchers in the background and the 64 vertical launch cells in the foreground. Original caption: Seaman Robert Paterson, of Norgo, Cal., stands watch next to the aft vertical launch missile platform on the fantail while underway on the guided-missile cruiser USS Lake Erie (CG 70). (U.S. Navy photo by Mass Communication Specialist 2nd Class Michael Hight)[/caption]

As a general rule of thumb, any alert and modern warship larger than a corvette should be able to hold its own against a salvo of only eight subsonic anti-ship missiles, or else the warship can hardly justify its cost. U.S. surface and submarine launch platforms are hardly able to muster enough volume of fire to credibly threaten most modern warships with their handful of Harpoon missiles. This shallow magazine depth creates a strong dependence on having large numbers of platforms to achieve enough volume of fire. But the extremely short range of Harpoon means this weapon has barely any potential for aggregation with other ship-launched Harpoon missiles, unless commanders are willing to concentrate numerous warships to an extreme degree.

This combination of launch cell incompatibility and short range in the Navy's mainstay anti-ship weapon forces carrier aviation to shoulder most of the burden of massing enough volume of fire. Only the air wing can conceivably mass enough platforms to create enough volume of Harpoon fire, while also having a credible chance of getting those platforms close enough to a target warship to launch an attack. These factors make aircraft carriers the only platform that can muster a combat credible volume of Harpoon fire.

An F/A-18 Hornet can equip up to four Harpoon missiles, where only two of these aircraft can match the Harpoon firepower of a U.S. Navy cruiser or destroyer. But against high-end warships, achieving combat credible volumes of Harpoon fire requires massing large numbers of carrier aircraft. Overwhelming a single surface action group of several modern destroyers, each with dozens of anti-air weapons and several layers of hardkill and softkill defenses, could easily require the majority of an air wing. The remaining few aircraft would be thinly stretched between maintaining combat air patrols, providing tanking and jamming support to the striking squadrons, among other roles. By heavily concentrating the burden of massing volume of fire on air wings, those air wings are subsequently stretched thin across a multitude of other critical missions.

Attempting to mass fires with a missile that is very short-ranged creates severe tactical risks. The short range of Harpoon forces an extremely tight and dense concentration of carrier aircraft around the target to muster enough firepower to be overwhelming. Harpoon’s short range also makes it a weapon that cannot always be confidently fired from standoff distances beyond the range of modern air defenses, unlike many anti-ship missiles. Instead, Harpoon can force air wings to concentrate themselves well within the range of opposing shipboard air defenses. Warship air defense weapons, such as China’s HHQ-9B missiles, can approach and even exceed the short ranges of the Harpoon, putting adversaries into the more favorable position of being able to threaten archers before they can fire arrows (Figure 6).[7]

[caption id="attachment_56353" align="aligncenter" width="2560"]

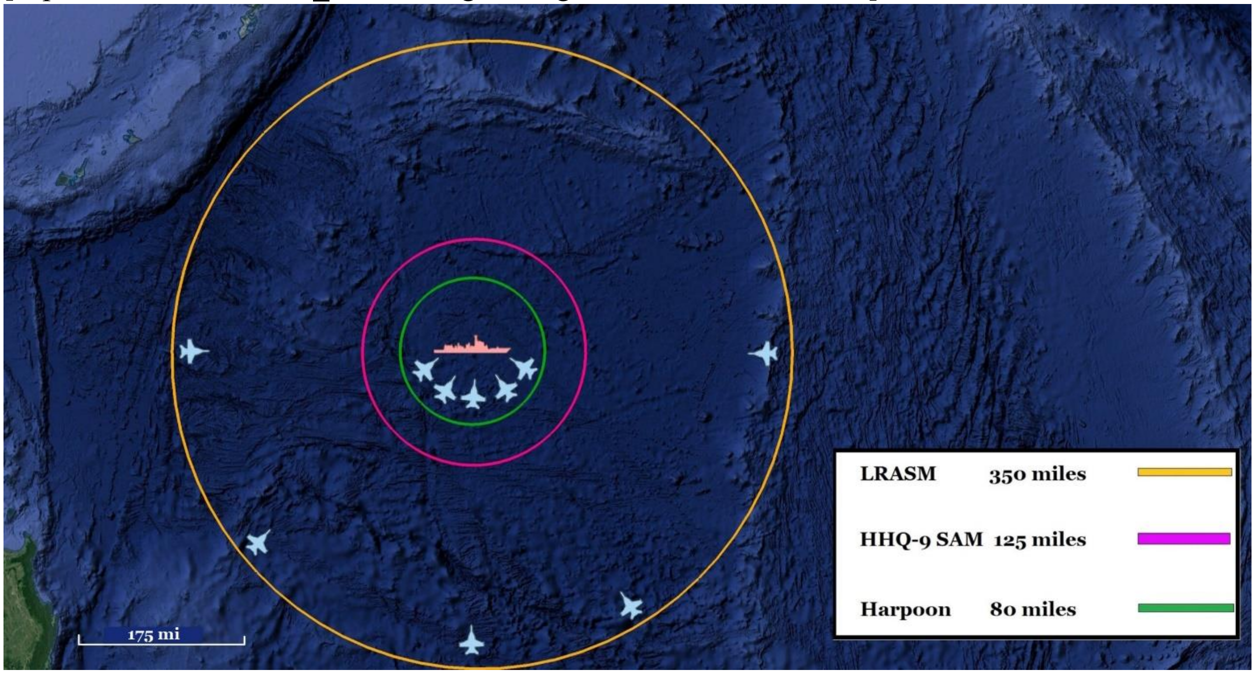
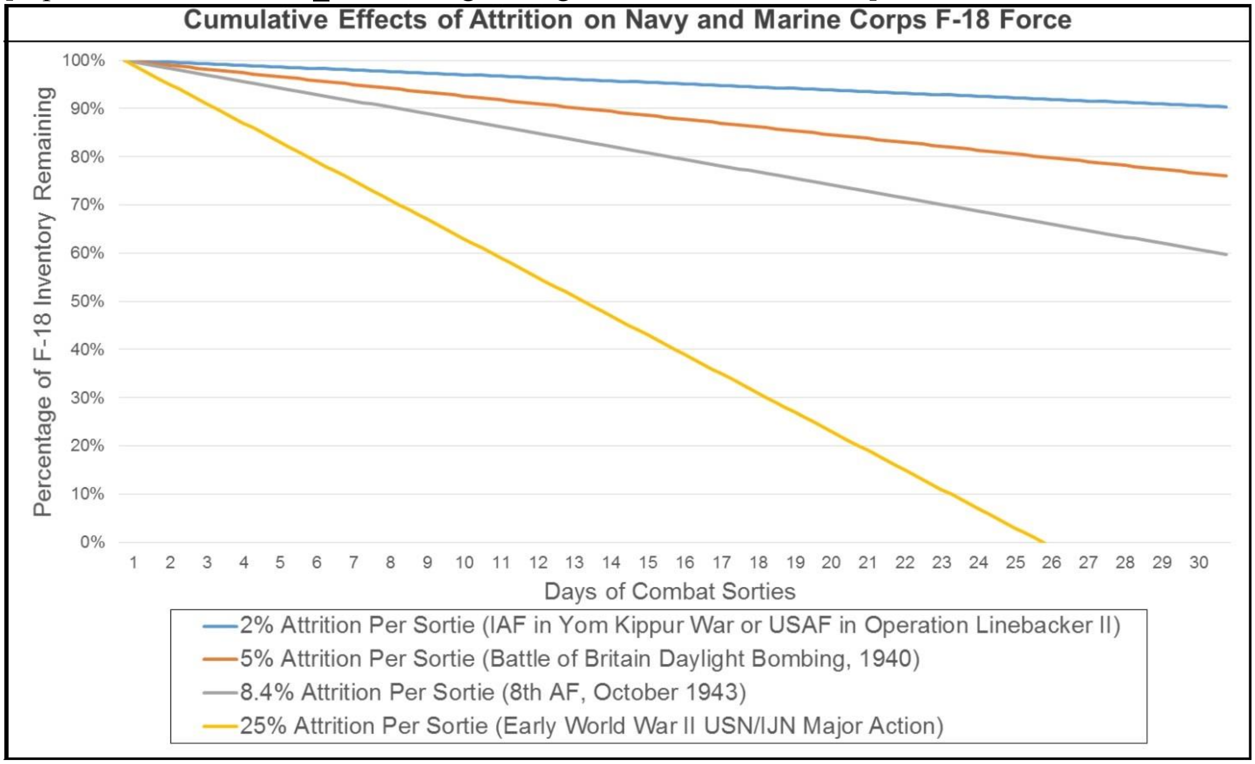


Figure 6. Click to expand. Harpoon and LRASM reverse range rings centered on a target illustrate the limits of distribution while massing fires. The center ring illustrates the range of the target's longest-range air defense weapons, showing how Harpoon-equipped aircraft will have to enter within range of these air defense weapons to mass fires. (Author graphic)[/caption]

Survivability concerns not only apply to carriers, but to their air wings as well. Air wings are highly sensitive to attrition, where losing even a few aircraft per attack can quickly render certain missions unsustainable. This is especially true for anti-ship missions that require large numbers of aircraft to achieve sufficient volume of fire. The Navy's air wings can be risking substantial losses by using a missile that is so short ranged that it can force them to send large and tightly concentrated aerial formations into the teeth of modern naval air defenses. The air wing's ability to mass enough anti-ship firepower would be rendered impotent in a matter of days if not hours by suffering even minor losses on only a few of these risky strikes.

[caption id="attachment_56139" align="aligncenter" width="1474"]



A visualization of aircraft attrition rates. (Graphic via slide deck of "Sharpening the Spear: The Carrier, the Joint Force, and High-End Conflict" by Seth Cropsey, Bryan G. McGrath, and Timothy A. Walton, Hudson Institute, October 2015.)[/caption]

Carrier air wings may be resisted by far more than warship air defenses. The signature posed by a mass of carrier aircraft heading toward a target at high altitude could provide plenty of warning to vector opposing airpower into position to blunt the strike. Compared to the aircraft defending the airspace, anti-ship squadrons would likely be at a hardpoint and maneuverability disadvantage. Many of their hardpoints would be taken up by a combination of heavy anti-ship weapons and drop tanks, with potentially fewer anti-air weapons loaded compared to the opposing dogfighters. If the anti-ship aircraft are intercepted before they are within range of attacking warships, they may be forced to dogfight and evade missiles while having their maneuverability impaired by the heavy anti-ship weapon loadouts. Drop tanks, anti-air, and anti-ship weapons will compete for similar hardpoints on carrier aircraft, setting the stage for difficult tradeoffs between survivability, concentration, and mustering enough volume of cruise missile fires.

An F/A-18E flying with a varied weapons loadout. (Lockheed Martin photo)[/caption] **(Change photo to open source)**

Anti-ship strikes can be conducted near the limits of the air wing's range to maximize standoff distance. But the short range of Harpoon combined with the relatively short range of current-generation carrier aircraft (compared to past and planned future generations of air wings), forces the carrier deeper into the contested battlespace and potentially incurs more risk. Harpoon not only threatens the tight concentration of valuable carrier aircraft around targets, it threatens to pull the carrier itself deeper into riskier territory.

Extending the range of the air wing through drop tanks or tanking aircraft can help keep the carrier further out, but this will diminish the volume of firepower by devoting hardpoints and aircraft to fuel instead of weapons. This can benefit the survivability of the carriers more than the air wings, where adding range to the air wing can improve the carrier's survivability by allowing it to launch strikes from further away. But this will do less for the air wing's survivability because the short range of their anti-ship weapons will still force tight concentration around the target regardless.

When it comes to managing the signatures of aircraft carriers, not only does the signature of the carrier have to be taken into account, but the signature of the air wing as well. The signatures and footprints of air wing operations can contribute toward concealing or revealing the carrier's location. Maximizing the standoff range of an air wing launching a massed anti-ship strike encourages a more linear flight path to and from the target, a denser concentration of aircraft throughout the flight path, and higher altitude flight that extends the range but increases the detectability of the aircraft. Even though it maximizes standoff distance, a linear flight path could more easily lead an adversary back to the carrier by virtue of predictability.

Shortening the carrier's range to the target or devoting more hardpoints and aircraft to fueling can give the air wing more margin to increase the complexity of force presentation. It can allow the air wing to more widely distribute itself and take nonlinear paths to and from the target, which can help conceal the carrier's location (Figure 7). However, ensuring a disaggregated air wing can effectively come together on time to mass fires poses more complex challenges for mission planning compared to a more linear strike, especially when combining fires with other types of platforms. And a distributed nonlinear flight profile may have to come at the cost of decreasing the overall striking range of the carrier and pull it deeper into the battlespace.

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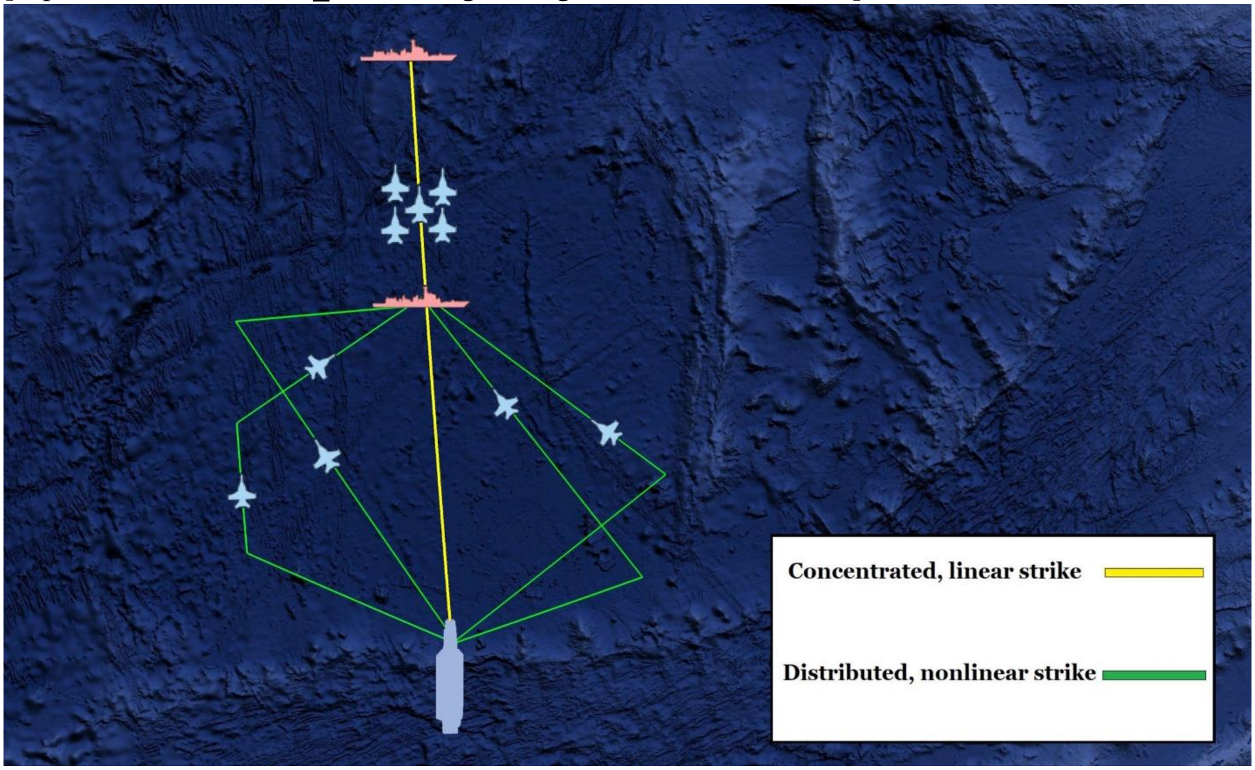


Figure 7. Click to expand. A visualization of carrier strike flight profiles, where each flight path is 500 miles from the carrier to the target. A concentrated linear strike has more overall range, but offers less complex force presentation in some respects than a distributed, nonlinear strike. Yet the distributed flight profile shortens the overall range of the carrier's striking power. (Author graphic)[/caption]

The major advantage Harpoon has over all the other anti-ship weapons in the U.S. arsenal is its inventory numbers. While recent public information on current figures appears unavailable, data from the 1990s suggests an inventory of as many as 6,000 missiles.[8] It is reasonable to assume that the figure today remains in the thousands, compared to most other U.S. anti-ship missiles which have been procured only in the hundreds or dozens. But the ability to leverage the depth of the Harpoon inventory is tightly bottlenecked by the shallowness of the individual platform magazines it is fielded in, given its launch cell incompatibility.

Overall, many of the survivability challenges and tradeoffs of using air wings and carriers in anti-ship roles are substantially worsened by the Harpoon missile’s traits. Due to the major risks air wings and carriers must take to effectively mass the very short-ranged Harpoon, maybe the Navy’s carriers would be better served by not using this weapon in a fleet-on-fleet fight.

Doing so could enhance the survivability of carriers, air wings, and the surface ships that escort them. But it would mean coming to terms with how the vast majority of the U.S. Navy's force structure and missile arsenal is hardly able to threaten modern naval formations with anti-ship firepower. Virtually all of the U.S. military's anti-ship capability could then be narrowly confined to what the submarine force can accomplish with torpedoes alone.

One has to be careful about extrapolating specific tactics from basic weapon limits, given how shortcomings in capability can be compensated by creative operational design. Maybe the Navy is counting on the submarine force sinking the adversary's high-end surface combatants to pave the way for more favorable carrier anti-ship strikes. But that will do little against the land-based airpower those carrier aircraft may still have to tangle with.

November 2015 – An F/A-18 armed with a Harpoon Block II+ missile during a free flight test at Point Mugu's Sea Range in California. (U.S. Navy photo)[/caption]

This design of having the entirety of the U.S. military's long-range anti-ship capability completely concentrated in massive aircraft carriers, who must in turn heavily concentrate their valuable air wings to execute the tactic, is extremely contrary to the principle of distribution. What Harpoon tactics reveal is that after severely lagging in anti-ship missile development for more than half a century, the U.S. Navy has deprived itself of many critical options for fighting another great power navy.

SM-6 and Diluting Capability Across Missions

The SM-6 is unique among the Navy's anti-ship missiles. It is the only supersonic anti-ship weapon in the Navy's arsenal, it can be used against both aerial and warship targets, and it has the highest production rate of the Navy's latest generation of anti-ship weapons. Featuring 150 miles of range for the more common variants, it offers a modest improvement of range over the latest Harpoon variants.[9] It is also the only Navy shipboard anti-air missile that may be used to aggregate defensive firepower at long range. However, some of the supposed strengths of SM-6 create drawbacks when it comes to massing firepower for anti-ship strikes.

The high speed of the SM-6, which is more than Mach 3, improves the survivability and lethality of the missile when it comes to breaking through warship defenses and striking the target at high speeds.[10] However, the high speed of the missile complicates its ability to combine fires with the Navy's other anti-ship weapons, which are all subsonic. If SM-6 is to combine with subsonic missiles, then it must either be fired near the end of a mass firing sequence to ensure timely overlap, or the platforms firing subsonic missiles must be much closer to the target than the warship firing SM-6. Although the speedy SM-6 may be able to reach a target first, it may have to be fired last if it is to combine fires with slower weapons. (This dynamic will be discussed more closely in the next chapter.)

The multi-mission versatility of the weapon poses challenges for effective mass fires by complicating release authorities. If a distributed force is to combine anti-ship fires across multiple platforms, then the release authority for offensive anti-ship weapons may naturally reside at a higher echelon than the commander of an individual ship, who typically lacks the organic sensors to target these weapons against warships at long range. But the intense speed and lethality of missile attacks on warships means individual commanders should be afforded the authority to prosecute their local air defense missions with great initiative, especially to avoid defeat in detail. If a unit-level commander feels compelled to employ SM-6 for the sake of ship self-defense, then that may diminish a higher-echelon commander's options for massing anti-ship fires.

The typical flight profile of long-range anti-air weapons poses another challenge to the effectiveness of SM-6 as an anti-ship weapon. While long-range anti-air weapons can certainly hit sea-level targets, their initial phase of flight typically involves a boost phase that takes them to higher altitude.[11] Higher altitude makes it easier for the missile to achieve its maximum speed and range before it descends back down to hit lower-altitude threats. However, a higher altitude flight profile creates disadvantages when attacking warships. High-altitude flight broadens the area from which a missile can be detected and engaged from, possibly giving more warships the opportunity to engage the missile and with more time to take multiple shots. Sea-skimming flight by comparison can confine air defense engagements into the immediate area of only the target warship. The SM-6 missile's high speed is not so great that it effectively compensates for these risks of high-altitude flight. The boost phase of an SM-6 launch can give almost double the reaction time to a target warship's radars compared to a slower subsonic missile that is only detected after it breaks over the target's horizon.[12]

It is unclear if SM-6 can be fired on a flatter trajectory and maintain an end-to-end sea-skimming flight profile. Doing so would likely deprive it of a significant amount of range. It would also make it more difficult for the missile to apply the greatest source of its lethality against warships – its high speed. The warheads of anti-air weapons are much smaller than those of purpose-built anti-ship weapons, where the warhead of SM-6 is about only 15 percent of the size of an LRASM or Tomahawk warhead.[13] SM-6 needs to reach high speeds to be at its most lethal against warships, but achieving those speeds is heavily dependent on higher-altitude flight profiles that make the missile less survivable.

The U.S. Navy Arleigh-Burke class guided-missile destroyer USS John Paul Jones (DDG-53) launches an SM-6 missile during a live-fire test of the ship's Aegis weapons system in the Pacific Ocean. (U.S. Navy photo)[/caption]

The range of SM-6 is not so long that its offensive anti-ship roles can be cleanly separated from its defensive anti-air roles. The concept of "standoff" fires implies that a valuable margin of survivability can be earned by outranging an opponent's ability to strike back. But the range of many great power anti-ship missiles is great enough to where SM-6 cannot be comfortably used in a purely standoff role for attacking modern warships. If a warship is within range of attacking another high-end warship with SM-6, then it is also likely within range of anti-ship missile threats that could force the ship to expend SM-6 on defense instead. This effect becomes even more relevant when longer-ranged weapons like opposing anti-ship ballistic missiles can cast a long shadow over thousands of miles of ocean.[14] Commanders may opt to reserve their most capable air defense weapon for protection against the adversary's most capable anti-ship missiles.

Because modern anti-ship weapons tend to outrange most anti-air weapons, it is much more feasible to combine offensive firepower than defensive firepower from across distributed forces. SM-6 may mark an exception by using the unique NIFC-CA capability that allows it to be targeted beneath the radar horizon of the launching warship. The range of SM-6, its high speed relative to the subsonic anti-ship missiles it could be used against, and its ability to be retargeted beneath the horizon make the aggregation of defensive firepower possible.[15] This is an especially unique capability, but adds more complexity to the command-and-control arrangements undergirding massed fires.

Compared to all of the Navy's other modern anti-ship missiles (excluding the aging Harpoon), SM-6 has an advantage in being produced at consistent full-rate production for a number of years since being introduced in 2013, with more than 1,300 missiles in the inventory.[16] By comparison, all of the Navy's other latest generation of anti-ship weapons currently exist in very low numbers that make them hardly applicable to the large-scale salvo requirements of modern naval warfare.

However, most of the SM-6 production runs to date have been for earlier variants whose anti-ship ranges are only marginally better than the latest Harpoon variants.[17] While longer-ranged versions of SM-6 are forthcoming, the vast majority of the current inventory will offer little improvement in broadening the extent to which warships can distribute and still be able to combine fires.

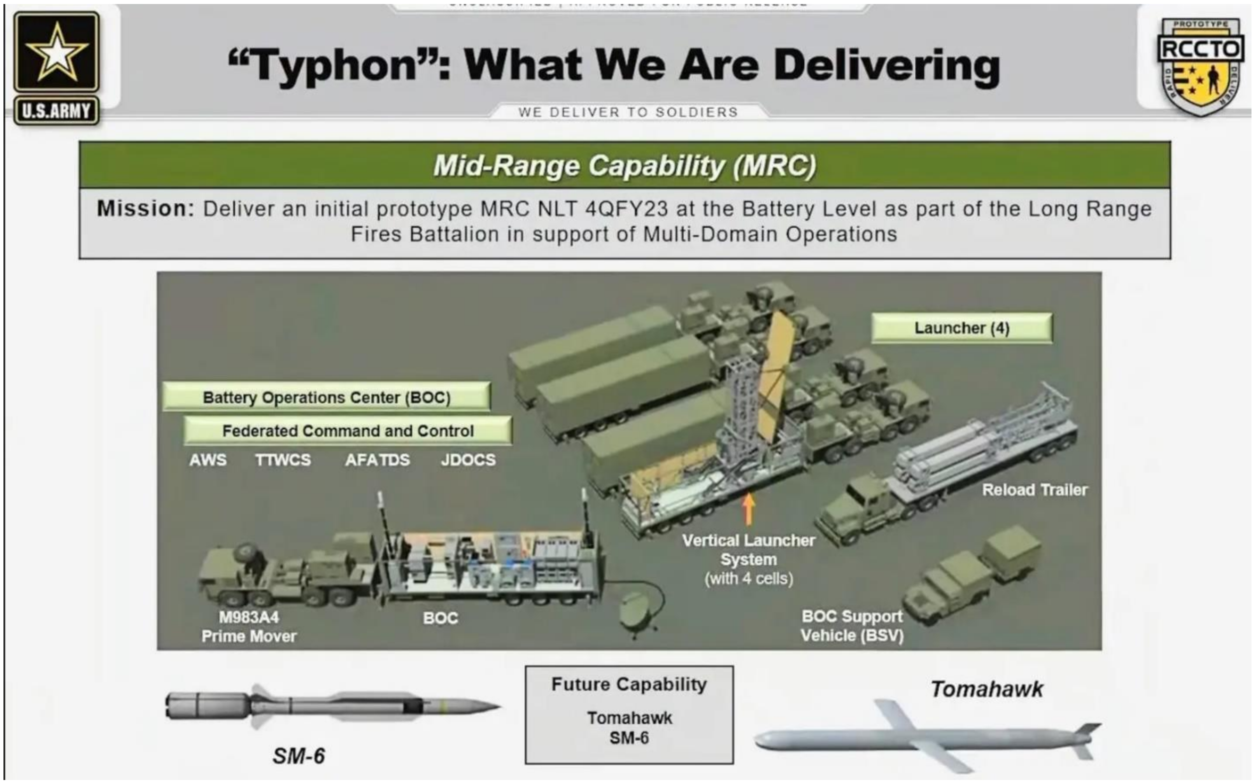
Even if longer-ranged versions of SM-6 quickly arrive in large numbers, much of the missile's versatility could have to be set aside to fill the Navy's critical anti-ship capability gap through the near term. SM-6 is currently the Navy's only somewhat numerous, launch-cell compatible, and long-range anti-ship weapon. But its multi-mission capabilities threaten to dilute the inventory across diverse threats. The Navy may be forced to maintain SM-6 as its only somewhat viable anti-ship missile until other anti-ship weapons are produced in large enough numbers to make a real difference and free SM-6 to fulfill its air defense potential. But given how current production runs are trending, this could take at least 10-15 years to accomplish. If the Navy finds itself in a major naval conflict this decade, it may be forced to forego much of SM-6's cutting edge air defense capability for the sake of retaining a modicum of anti-ship firepower.

Maritime Strike Tomahawk – The Foundational Enabler of Massed Fires

More than 40 years after an anti-ship Tomahawk first struck a seaborne target in testing, the Navy will be reintroducing an anti-ship variant of the missile.[18] More so than any other U.S. anti-ship weapon to be fielded in the coming years, the Maritime Strike Tomahawk holds the greatest promise in fostering a major evolution in the Navy's ability to distribute platforms and mass anti-ship fires.

Tomahawk's great advantage is its combination of launch cell compatibility, potentially deep inventory, and very long range at more than 1,000 miles.[19] Many platforms will be able to carry large numbers of an especially long-range weapon, creating a wide range of options for massing fires. Long range also gives the weapon more opportunity to vary its flight paths and use waypointing, which can be used to execute a variety of tactics, increase the complexity of threat presentation, and facilitate aggregation with other fires.

By finally having an anti-ship missile that is both long-range and launch cell compatible, the Navy will be poised to drastically increase the amount of anti-ship firepower across a much greater distribution of platforms. Land-based Tomahawk launchers are also on the way for the U.S. Army and Marine Corps, which will significantly increase options for massing fires if those services procure the weapon in major numbers.[20]



U.S. Army Mid-Range Capability ground-based missile launcher program. (U.S. Army slide)[/caption]

However, the Maritime Strike Tomahawk's potential will not be fully realized until many years from now. It will not reach initial operating capability until 2024 and is currently in its early years of low-rate initial production and testing, with only about 100 MST kits procured so far.[21] The Navy is looking to upgrade all of its Block IV Tomahawks into Block V variants, and it is possible up to 300 recertification kits may be installed per year.[22] But it is unclear if every recertification will also add the maritime strike capability through the specific Block Va configuration.[23]

At this rate, it could take 10 or more years before the Navy has enough inventory of the foundational missile that will allow it to truly make distributed and massed anti-ship fires a reality.

Jan. 27, 2015 – A Tomahawk cruise missile hits a moving maritime target after being launched from the USS Kidd (DDG-100) near San Nicolas Island in California. (U.S. Navy video)[/caption] **(Use a still photo)**

LRASM – A Leap Forward Yet Still More of the Same

The Long-Range Anti-Ship Missile (LRASM) will mark an important upgrade to the Navy's anti-ship firepower. Featuring a stealthy profile and an estimated range of around 350 miles, LRASM outranges all of the Navy's other anti-ship weapons except for Tomahawk.[24] Yet LRASM does little to enhance the Navy's ability to mass fires from across distributed forces.

LRASM's potential for mass fires is heavily constrained by platform compatibility because it is not a launch cell compatible weapon. LRASM can only currently be fielded by bombers and carrier aircraft. Despite tests suggesting that LRASM can be fired from launch cells, the Navy continues to describe the program as "a key air launched component of the Navy's overall Cruise Missile Strategy..."[25] In 2021, industry partnered with an Australian firm to refine the development of a surface-launched variant of LRASM that has been termed "LRASM SL," suggesting that launch cell compatible versions of this weapon are distinct from what the U.S. Navy is procuring for itself.[26]

A July 2016 test of the LRASM from a MK-41 launcher on the Navy's Self Defense Test Ship. (Lockheed Martin photo)[/caption] **(Change photo)**

Even though LRASM's range makes it a much less risky missile for air wings to fire at targets compared to Harpoon, these strikes would still tie down a large portion of the air wing to mass enough firepower to be overwhelming. LRASM does not alleviate the need for large volume of fire, which strains the air wing's ability to cover multiple other roles besides strike. Even with its advanced capabilities, LRASM will not change certain fundamental disadvantages of massing air wings to conduct long-range strikes against warships.

The amount of LRASM inventory is extremely low at about 250 missiles procured for the Navy so far.[27] The Air Force's inventory is even smaller and only numbers slightly less than 100.[28] Although the Air Force's bombers can equip Harpoon missiles, the short range of that weapon and their especially low procurement rate of LRASM may mean the U.S. military's bombers will have barely any anti-ship firepower to contribute to U.S. sea control for the foreseeable future.

LRASM shares a production line with the much more numerous, land-attack Joint Air-to-Surface Standoff Missile (JASSM) it is adapted from. More than 2,000 JASSM weapons have been procured by the U.S. Air Force so far and the Navy started procuring the weapon within the past few years.[29] The newest forthcoming "extreme range" variants of JASSM will feature ranges of up to 1,000 miles, making it one of the first air-launched cruise missiles that can rival the ranges of Tomahawk.[30] The JASSM production line is also the most robust of any of the missiles described thus far, with annual production runs numbering in the hundreds as opposed to the other missiles that are only being procured by the dozens.[31]

August 12, 2015 – A Long Range Anti-Ship Missile (LRASM). (Photo via Wikimedia Commons)

Sept. 13, 2018 – An inert AGM-158A Joint Air-to-Surface Standoff Munition (JASSM) being used in a training exercise on a B-1B Lancer at Al Udeid Air Base, Qatar. (U.S. Air Force photo by Tech. Sgt. Ted Nichols/Released)[/caption]

The two anti-ship weapons that hold the most promise, LRASM and Maritime Strike Tomahawk, are adaptations of existing munitions that have been produced in far greater numbers – JASSM and the land-attack Tomahawk. Upgrading these existing weapons with anti-ship capabilities and seekers may be a more rapid and cost-effective way to ramp up the anti-ship weapon inventory of the U.S. military compared to building new weapons wholesale. If the forthcoming extended-range variants of JASSM can feature anti-ship capabilities, then the U.S. military will open up a vast array of new options for the distribution and aggregation of firepower between naval and air forces.

However, even upgrading existing stocks of weapons may take too long to close the anti-ship capability gap in the near-term. Forces can consider intensive tactical development programs that create methods for employing land-attack cruise missiles as anti-ship weapons. While there can be a wide disparity between the two types of weapons, there may be enough seeker, datalink, and autonomous targeting capability in land-attack missiles to employ them against warships. These types of killchains could be especially information-intensive and depend heavily upon offboard targeting support to the weapons, given how the organic seekers of land-attack missiles often are not as robust as those of anti-ship missiles. **(Source fixed targets only for Tomahawk, and MST seeker upgrade, JASSM/LRASM seeker difference)** But these tactics may be a valuable stopgap measure in the near-term as the Navy awaits years of weapons production before having a genuine ability to mass fires against warships.

Older source on adding moving target capability for Tomahawk seeker during Block IV recertifications….

Naval Strike Missile – Only Slightly Better Than Harpoon

The Naval Strike Missile (NSM) features a stealthy profile and an advanced seeker, but it brings only a marginal improvement over Harpoon. Similar to Harpoon, NSM has relatively short range at 115 miles and it is not compatible with launch cells.[32] It is mainly being fielded by the Navy's Littoral Combat Ships with only eight weapons per ship, and the Marines are procuring a land-based version. Its short range and launch cell incompatibility make this weapon poorly suited for massing fires from distributed forces. Low procurement rates put the current inventory at slightly more than 110 missiles, hardly enough to make the weapon widely fielded and available for mass fires.[33] The main utility of both Harpoon and NSM in a major naval conflict may be relegated to engagements against smaller and more isolated combatants, perhaps in secondary theaters and areas peripheral to larger salvo exchanges.

[caption id="attachment_56160" align="aligncenter" width="1181"]

A Naval Strike Missile in flight. (Photo via U.S. Department of Defense DOT&E)[/caption]

A Brittle Spear

The ability to mass fires is fundamentally enabled by fielding a large number of long-range missiles across a wide variety of platforms. In terms of numbers, range, and variety, the U.S. military falls woefully short. The U.S. military cannot execute the tactic of distributed massed fires against warships today because it simply does not have the weapons to make it possible. Its current anti-ship missile firepower is extremely concentrated in aircraft carriers and tightly stretched thin everywhere else.

None of the newer U.S. anti-ship missiles will do much to improve the Navy’s ability to distribute and still combine fires, except for Tomahawk. LRASM can somewhat broaden the scope of physical distribution of launch platforms, but it is still a heavily concentrating weapon due to its narrow platform compatibility. LRASM will do little to alleviate the carrier’s heavy burden of shouldering most of the U.S. Navy’s anti-ship capability.

The Maritime Strike Tomahawk strongly stands out as the weapon with the most transformational promise, and it is absolutely fundamental to manifesting DMO. Finally the U.S. Navy will have anti-ship weaponry that is both long-range and compatible with its launch cells, and finally the U.S. military will have more viable anti-ship missile platforms than just carriers. This stands in sharp contrast to great power competitors, who have already broadly distributed anti-ship firepower across their surface fleets, bombers, land-based forces, and submarines.[34]

(Insert graphic with X'd out fundamental attributes? Used in CNAS FDMO presentation)

A central risk factor is considering what proportion of the overall volume of fire each type of weapon may contribute. Based on these key traits, more risk is incurred the less suitable a weapon is for mass fires. Weapons such as Harpoon or the Naval Strike Missile can certainly add a fraction of the contributing fires, but the more these weapons make up mass fires, the more risk the force will have to assume.

Among the weapon traits analyzed, the depth of inventory stands out as an especially critical constraint in the capital-intensive nature of modern naval salvo combat. Even if highly capable missiles are being procured, inventory depth is the key variable that will prevent the U.S. military from having enough modern anti-ship missile firepower through at least the rest of this decade. Current stocks of modern U.S. anti-ship missiles are not remotely close to satisfying the demands of a type of combat that can require more than a hundred missiles to overwhelm the defenses of only a few destroyers, where a decade's worth of weapons procurement can easily be discharged in a matter of hours.

As it currently stands, most of the inventory of the Navy's anti-ship missiles except for Harpoon could be spent in a handful of salvo engagements. The appropriate amount to meet great power naval threats is not dozens or even hundreds of weapons, but thousands – a figure that grossly exceeds the inventory of all of the U.S. military's latest generation of anti-ship weapons. And even if procurement rates have substantially grown the inventory 15 years from now, competitors could have grown their own arsenals over the same period, such as by building out deep inventories of anti-ship ballistic missiles and hypersonics that sustain a critical margin of overmatch.

It is unclear how exactly the U.S. military has chosen to distribute or concentrate its small but growing inventory of modern anti-ship weapons. A major crisis could force the U.S. military to scrounge across the force in a rush to assemble enough weapons to field an adequate volume of fire. If these rare weapons are spread across the east- and west coast-based fleets, the Navy may be forced to engage in an elaborate act of transcontinental crossdecking to concentrate enough credible firepower in crisis response units.

The recent introduction of offensive anti-ship firepower across a broad swath of untapped force structure may come across as an evolution to some only because of the narrow, carrier-centric paradigm that has dominated the U.S. Navy since WWII. But this is what modern naval force structure and firepower was meant to be in the missile age all along. The Soviet Union understood this more than a half-century ago when it broadly distributed it anti-ship missile firepower across a wide range of platforms and force structure. The Soviet military had to be able to fight carriers without having carriers of its own, and so it pioneered the development of anti-ship missiles to have a long-range striking capability not unlike that of an air wing. This asymmetric difference between the two rival navies was not just a matter of doctrine, but of vision. As the venerable Director of the Office of Net Assessment Andrew Marshall noted in 1972 about the Soviet Navy, "They are ahead in a number of key technologies, especially those connected with missiles launched from aircraft or ships to attack surface vessels...perhaps they are building the right kind of Navy and that we have been building the wrong kind." **(Source: pg 27 of LTC paper, read his source from Proceedings).**

These pervasive capability gaps have created a major window of opportunity for great power challengers to capitalize on the strategic liability posed by the weakness of the American naval arsenal. Until new weapons are fielded in large enough numbers, the U.S. military may be forced to endanger its single most expensive platform to close the gap – aircraft carriers.

"Why study tactics? It is the sum of the art and science of the actual application of combat power. It is the soul of our profession." –Vice Admiral Arthur K. Cebrowski, foreword to the second edition of *Fleet Tactics* by Captain Wayne P. Hughes, Jr.

In the Western Pacific, the U.S. Navy is facing one of the most powerful arrays of anti-ship firepower ever assembled.[1] The Navy is attempting to evolve its capabilities and doctrine to meet this challenge and transform the future of naval warfare. In this pursuit, the U.S. Navy has made the Distributed Maritime Operations concept (DMO) central to its evolution and relevance, with DMO being described by the Chief of Naval Operations as "the Navy's foundational operating concept."[2] DMO can serve a defining role in guiding the development of the U.S. Navy and how it will fight for years to come.

But while DMO has lasted longer than other recent Navy warfighting concepts, it is still relatively new and much work remains to be done on its practical implementation.[3] What exactly does DMO mean for the Navy, how is it different than current naval operations, and how could a distributed force fight a war at sea? This series focuses on these questions as it lays out an operational warfighting vision for how DMO can transform the U.S. Navy and be applied in modern naval warfare.

Part 1 will focus on defining the DMO concept and illustrating core frameworks of distributed warfighting.

Part 2 will focus on the U.S. Navy's anti-ship missile shortfall and the implications for massing fires.

Part 3 will focus on assembling massed fires and modern fleet tactics.

Part 4 will focus on weapons depletion and the last-ditch salvo dynamic.

Part 5 will focus on missile salvo patterns and their tactical implications.

Part 6 will focus on the strengths and weaknesses of platform types in distributed warfighting.

Part 7 will focus on revamping the role of the aircraft carrier for distributed warfighting.

Part 8 will focus on China's ability to mass fires against distributed naval forces.

Part 9 will focus on the force structure implications of DMO.

Part 10 will focus on force development focus areas for manifesting DMO.

This series will mainly focus on how the U.S. Navy can apply DMO and mass fires, but important fundamentals of the concept apply to other services and militaries as well. In crucial respects, China's military is far closer to realizing the potential of DMO and mass fires than the U.S. Navy. What will be analyzed does not only apply to how the U.S. Navy can use DMO to fight adversaries, but how adversaries can use DMO to defeat the U.S. Navy.

Why Define a Warfighting Concept?

Warfighting concepts can mean many things. They can espouse lofty operational goals, cutting edge capabilities, and extraordinarily complex tactics. Public definitions can feature broad principles and vague points but little substance. Meaningful specifics can be relegated to the labyrinth of the classified world, which is hardly a guarantee of actual utility or force-wide understanding. An official concept can suggest more organizational and intellectual coherence on future warfighting than what may actually be the case.

Warfighting concepts can be abused, acting as little more than bumper stickers attached to initiatives in service of preconceived interests.[4] Some concepts can be more politics and marketing than real change agents, such as by serving as budget battle weapons rather than drivers of genuine reform or operational innovation. The rapid rise and fall of various naval net-centric warfighting concepts in recent decades suggests a lack of clarity on what is desired or sustainable. This regular procession of short-lived concepts has taken a genre of thinking that once seemingly sparkled with transformational promise and often relegated it into stale generics.

Yet warfighting concepts are absolutely necessary. Militaries must have a vision for the overarching frameworks of how they intend to fight and compete. Concepts are needed to combine various capabilities and tactics into a conscious integrated whole, rather than letting individual elements yield disjointed operational designs. Concepts offer holistic frameworks for valuing the combat power of force structure, and evolve analysis beyond more superficial measures of capability such as hull counts, launch cell quantity, or reputation. Concepts serve critical functions in guiding force development toward earning distinct advantages, and providing a common point of departure for how operational commanders can tailor the employment of forces.

To provide clarity and to prevent misuse, warfighting concepts require careful definitions and measured expectations. Actionable coherence requires specificity. Concepts require that key effects and capabilities be defined as priorities to organize focus. They must have specifically defined features that distinguish them as unique and evolutionary. Warfighting concepts demand discipline of vision, pinning success more on plausible attainability rather than breathtaking transformation. A critical part of examining the promise of DMO is considering whether it may be too good to be true.

The way the Navy has defined DMO deserves careful assessment. Core tenets of DMO and distributed warfighting need to be described and evaluated through the fundamentals of modern naval warfare. How exactly do these concepts expect to create advantage? Central terms need to be established to create consistent understanding of how to define warfighting success and how it can be achieved. All beliefs about future conflict reflect implicit assumptions on the theory and practice of war, and what theory of victory is superior. These underlying assumptions need to be made explicit to acknowledge limits and respect much of warfighting’s fundamental unpredictability.

Ultimately, achieving sharper clarity will give more shape and form to this warfighting concept that could define the future of naval warfare for years to come.

Defining DMO and Core Warfighting Lexicon

DMO is happening for several reasons, where the drive toward distributed warfighting is part defensive reaction and part offensive evolution. The considerable missile firepower fielded by China especially has encouraged distribution for the sake of survivability. But offensive developments on the part of U.S. services are also driving distribution. DMO is poised to harness a major transformation in the anti-ship firepower of the services, with each service now beginning to procure weapons that will bring substantial anti-ship missile firepower to U.S. communities that have never fielded it before, including surface warships, submarines, and land-based aviation and launchers.[5] Fielding this major expansion of anti-ship firepower across the fleet and the other services will significantly elevate the maritime threat posed by a broad swath of force structure, and allow far more forces to disperse across greater distances and still combine fires. In this sense, DMO and the overarching Joint Warfighting Concept are an attempt to manage a defensive problem while seizing an offensive opportunity.[6] The problem is the considerable missile firepower of competitors, and the opportunity is the major expansion of anti-ship missile firepower across U.S. force structure.

In this context, Navy leadership has communicated central tenets of the DMO concept with some consistency. These definitions provide a helpful point of departure in understanding the concept and going from theoretical understanding to practical implication. These definitions also suggest how Navy leadership believes that realizing the DMO concept is critical to securing the Navy's future. CNO Admiral Gilday captured defining features of DMO in testimony before Congress:

"Using concepts such as the Joint Warfighting Concept and Distributed Maritime Operations (DMO), we will mass sea- and shore-based fires from distributed forces. By maneuvering distributed forces across all domains, we will complicate adversary targeting, exploit uncertainty, and achieve surprise…Navy submarines, aircraft, and surface ships will launch massed volleys of networked weapons to overwhelm adversary defenses...Delivering an all-domain fleet that is capable of effectively executing these concepts is vital to maintaining a credible conventional deterrent with respect to the PRC and Russia."[7]

In the tri-service maritime strategy *Advantage at Sea*, DMO is defined as:

“[a concept] that combine[s] the effects of sea-based and land-based fires…[and] leverages the principles of distribution, integration, and maneuver to mass overwhelming combat power and effects at the time and place of our choosing.”[8]

The concept has featured some consistency across Navy leadership turnover. CNO Gilday’s predecessor Adm. Richardson stated in *A Design for Maintaining Maritime Superiority* (2019):

“We will fully realize the inherent flexibility of DMO when we provide the capability to mass fires and effects from distributed and networked assets.”[9]

These explanations of DMO contain several defining traits that have consistently featured in the Navy’s public definitions of the concept. They include the massing and convergence of fires from distributed forces, complicating adversary targeting and decision-making, and networking effects across platforms and domains.

These elements of DMO encompass a broad multitude of naval tactics and capabilities. This series will anchor its focus on one of the defining features of DMO – massing anti-ship missile firepower from across distributed forces. It will concentrate on this core tactic of massing fires as an organizing framework for analyzing DMO. Developing the ability to execute this tactic has profound implications for the transformation of the U.S. Navy and the U.S. military writ large. It is one of the most critical features that distinguishes the evolutionary character of DMO from what the U.S. military is capable of today. By focusing on this central tactic, this series hopes to give more concrete precision and practical clarity for how this concept can work in practice.

Concepts of massing fires strongly apply to how forces can threaten well-defended land targets as well. Whether the targets or the attacking forces are on land or sea, a central operational challenge of high-end warfare is how to mass enough missile firepower to break through strong air defenses and achieve effects. Using distributed forces to launch massed fires against land targets is also a far more developed capability for the U.S. military and U.S. Navy than anti-ship fires.

The terms used to describe these fires can include *massed*, *combined*, or *aggregated*. Distributed forces are looking to combine their missile salvos to build massed fires. These salvos are *combining* and *aggregating* with one another into a larger salvo, where the term aggregating means "to collect or gather into a mass or whole."[10] *Contributing fires* are individual missiles and salvos that aim to increase the overall volume of the primary aggregated salvo. *Aggregation* is the main term used here to frame how fires can be combined, and *aggregation potential* is the ability of different types of platforms and payloads to offer contributing fires.

As opposed to massed fires, s*tandalone fires* describe independent salvos that are launched from an individual unit, force package, or force concentration. Standalone fires can still feature considerable mass and volume of fire. But standalone fires have no expectation or intention of combining with the fires of outside, non-organic forces.

Overwhelming fire is the goal of aggregation, and it achieves this through mustering enough volume. Contributing fires come together through aggregation to increase the volume of fire until it is enough to be overwhelming. Forces are attempting to mass enough missile firepower to break through strong missile defenses, and once broken through, score enough hits to achieve the desired effect.

The term "overwhelming" can still describe volumes of fire that go far beyond what is necessary. Therefore the specific goal of overwhelming a target is understood as massing the *minimum* amount of firepower required to confidently surpass a defensive threshold and then score enough hits. Overwhelming fires that go well beyond these thresholds are termed *overkill*, which can be difficult to predict and is highly likely given the natural combat dynamics involved, such as how only one missile hit can easily be enough to put a warship out of action.[11]

The ability to overwhelm a target with missiles will be described as mainly a function of achieving enough volume of fire. This is a central assumption because defenses can be overwhelmed not so much by pure volume, but by advanced capability. Specific capabilities can improve the ability of a missile to find and discriminate targets while enhancing the ability to penetrate defenses. Hypersonic weapons are more difficult to defend against by virtue of their speed and flight profiles. Outside capabilities and tactics such as jamming and deception can also serve as force multipliers to a missile salvo. But even though high-end weapons and force multiplying tactics can lower defensive effectiveness, these weapons may be fired in salvos because some level of payload attrition is still expected. Modern warship defenses are relatively dense and consist of multiple layers and varieties of capability, suggesting there is still a role for volume of fire even for higher-end weapons and tactics.

It is true that large anti-ship missile salvos have never featured in the modern history of naval warfare, despite the capability existing for more than half a century and numerous sunk warships.[12] The history of warships being struck by anti-ship missiles, whether they be the *Moskva,* the *Sheffield,* or the *Stark*, is mainly a history of poor situational awareness and woefully unprepared crews.[13] The naval missile duels of the 1973 Arab-Israeli war featured decently ready warships, but were primarily small salvos exchanged between small combatants.[14] Salvos fired at warships that resulted in no hits, such as in Operation Desert Storm or in the Red Sea in 2016, also consisted of very few missiles.[15]

[caption id="attachment_56009" align="aligncenter" width="603"]

A port quarter view of the guided missile frigate USS Stark (FFG-31) listing to port after being struck by an Iraqi-launched Exocet missile, May 17, 1987. (U.S. Navy photograph)[/caption]

All of the historical experience to date of warships being attacked by missiles, successfully or not, consists of extraordinarily small volumes of fire. Despite this being the case, for decades the design of high-end naval capability has long been predicated on launching and defeating volumes of missile firepower that are far larger than the historical experience so far. This is not to suggest that naval capability design could be deeply misguided. Rather, the historical circumstances that yield large naval missile exchanges have yet to manifest. But the contours of those capabilities and circumstances are plainly visible today. Therefore this series assumes that much of the combat effectiveness of modern naval forces in high-end warfighting will continue to be predicated on their ability to launch and defeat large volumes of missile firepower. It also assumes that crews, platforms, and capabilities will mostly function as intended, a core assumption that cannot be made lightly.

In terms of force packages and geographic dispositions, the term *distributed forces* is not used here to describe the disaggregated U.S. naval formations of the past few decades. A distributed naval force is not envisioned here as a force where each element is almost completely independent, and operational effectiveness is mainly a function of accumulating individual, unit-level victories. Rather, a distributed force is a collection of forces that are widely separated yet generally still acting in concert in key respects. Unity of action is still a fundamental requirement for critical warfighting functions, especially for massing fires. As Vice Admiral Jim Kilby described it:

"Distributed Maritime Operations is fleet commanders controlling ESGs, CSGs, SAGs, individual units, that's a little different for us…At a very simple level [DMO] is many units in a distributed fashion, concentrating their fires and their effects."[16]

This complements guidance published by the previous Chief of Naval Operations on the need to "master fleet-level warfare" and that "Our fleet design and operating concepts demand that fleets be the operational center of warfare."[17] The current CNO has continued to emphasize the fleet-level imperative, stating that "If we're going to fight as a fleet – and we moved away from fighting just as singular ARGs, as singular strike groups, to fighting as a fleet under a fleet commander as the lead – we have to be able to train that way."[18]

DMO is a form of fleet-level warfare, and it is closely connected to the U.S. Navy's push toward wielding larger-scale naval formations. A distributed naval force is a coordinated fleet, and a fleet is something larger in scale than the typical naval formations of the past few decades, such as carrier strike groups.

A carrier strike group can still be an appropriate formation to use in a distributed force if it is a component of a larger fleet. Distribution can be achieved not only by spreading formations, but also by increasing the overall number of forces within a theater of operations. This series envisions a distributed force as mostly consisting of large numbers of surface action groups, naval aviation, bombers, and land-based forces acting together to mass fires, with other formations and platforms featuring as well. Many of this series' concepts are also ungirded by the critical assumption that the U.S.

can surge enough forces to field enough platforms and firepower to pose a distributed threat and mass fires.

Central Frameworks of Distributed Naval Warfighting

DMO marks a departure in being a network-centric warfighting concept instead of a platform-centric concept. The latter requires that platforms be closely co-located in order to mass their firepower, which is concentrated, not distributed, warfighting. In network-centric warfare, firepower can be massed without co-locating the launch platforms themselves. This capability is a product of increased weapons range and the networks that allow widely separated forces to coordinate their fires across great distances. Massing firepower in this way can be described as an attempt to earn the benefits of concentration without incurring its liabilities. Distributed warfare is therefore distinct from what could be termed as concentrated warfare. Distributed warfare is now being regarded as the superior method by the U.S. Navy, which is a marked departure from millennia of high-end naval battles often characterized by decisive clashes between heavily concentrated main battle fleets. A framework is needed to differentiate what is distributed from what is concentrated, and how these different configurations affect advantage.

The question of what is distributed or concentrated is often centered on how to arrange the density of capability. This can include the density of capability in individual payloads, platforms and force packages, and how the density of capability is spread across an entire force structure or theater. At first, the definition of distribution may be interpreted as lessening density, where distribution is seen as the act of spreading capability outward and more broadly. But distribution does not inherently imply a stretching or dispersal of capability. Rather, this perception is often based on the traditional force employment and force design of a service, and what direction it must take to achieve better distribution. A force that is stretched thin could certainly achieve a better state of distribution by slightly concentrating itself.

Distribution is better defined as an ideal balance in the spread of capability. In this sense, distribution is at the center of a spectrum (Figure 1). On one end of the spectrum is the concentrated force, in the center is the distributed force, and at the other end is the force that is stretched thin. Being stretched thin can be defined as the spread of capability being too wide to be mutually combined and reinforcing, when those capabilities were meant to be combinable. Being concentrated can be defined as the spread of capability being so dense that it incurs more liability than benefit. Distribution implies an ideal balance in the spread of capability, a happy medium between the two extremes of overconcentration and being stretched thin.

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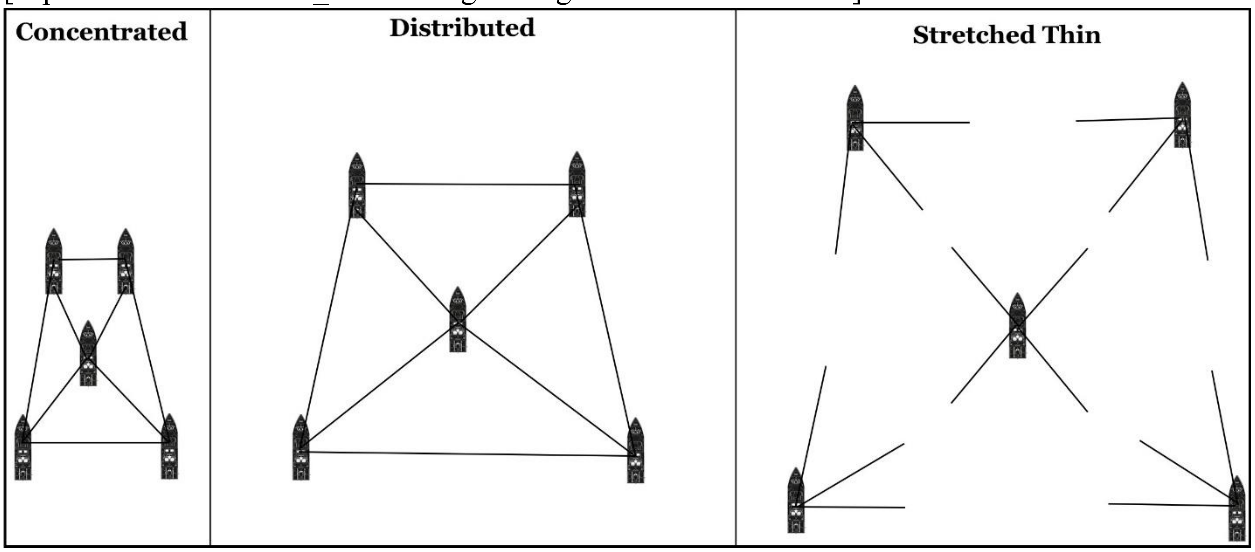


Figure 1. A spectrum of the spread of capability. (Author graphic)[/caption]

As will be demonstrated throughout, the core aspect of being distributed, concentrated, or stretched thin applies to many realms of naval capability besides spatial and material factors. These aspects can apply to firepower, timing, and other elements. Each can describe a separate manner of configuring missile loadouts, of sequencing fires in time, or of spreading weapons depletion across a force during mass fires. These recurring themes will provide a common frame of reference for describing the configuration of various operational elements and their state of advantage.

Spatial factors can help with distinguishing these configurations. In spatial terms, concentration means the area of overlapping capability and influence between assets is nearly one and the same. Distribution means there is still a substantial area of capability overlap between assets, but also a substantial separate area of influence (Figure 2). These two areas can complicate an adversary's decision-making because these distributed assets maintain options for combining their fires, but also options for exercising initiative independently of one another in distinct areas. The geographic space between distributed units can blur the perception of which forces constitute distinct force packages. This makes it less clear to the adversary how distributed forces will behave and support one another operationally, and can obscure which assets are the leading elements or the supporting elements. This overlap of distributed capability creates more vectors of attack, and the more viable options that are available to a commander, the less clear the next moves will be to the adversary.

[caption id="attachment_56089" align="aligncenter" width="572"]

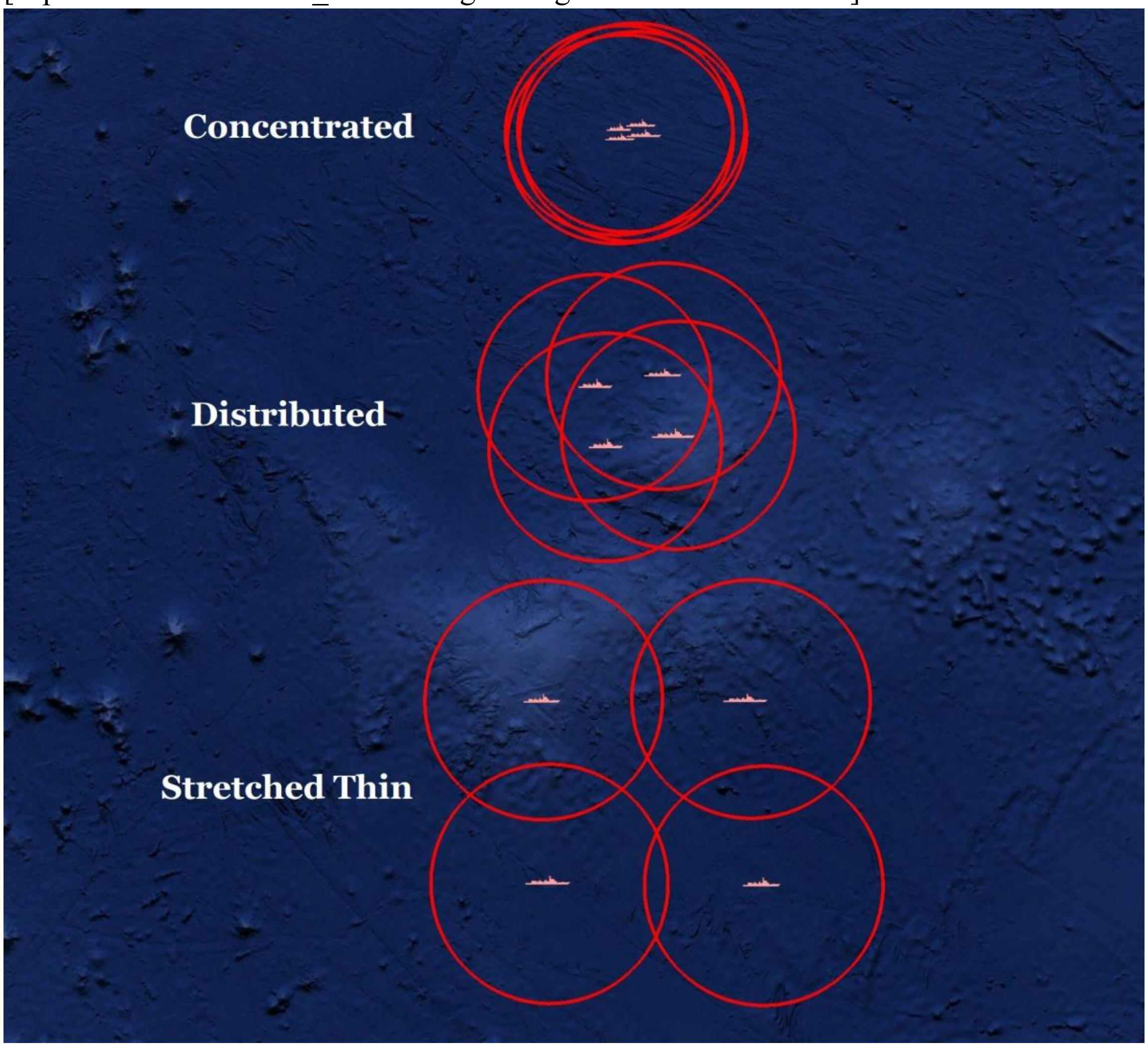


Figure 2. Click to expand. The spectrum of the spread of capability represented spatially, with each warship fielding a weapon of similar range, denoted by range rings. (Author graphic)[/caption]

Distribution is distinct from being stretched thin, which is a vulnerability that is incurred when the spreading of capability is taken to an extreme. Being stretched thin suggests that weakness can be exploited at the capability gaps between forces. Stretched forces struggle to support one another and combine their effects. Commanders must use discretion to limit distribution so that widely spaced forces are still able to support one another or combine effects to support an overall operational design.

Offensively, the amount of maneuver that is required for distributed forces to initiate massed fires against a shared target can represent how stretched these forces are. A force with long-range weapons would require less preparatory maneuver than a force with short-ranged weapons. It takes far less space to stretch thin a force trying to combine Harpoon missiles compared to longer-ranged Tomahawks. With respect to offense, forces are more stretched the more they must maneuver to create overlapping fires, with weapons range being a key limiting factor in identifying the gaps.

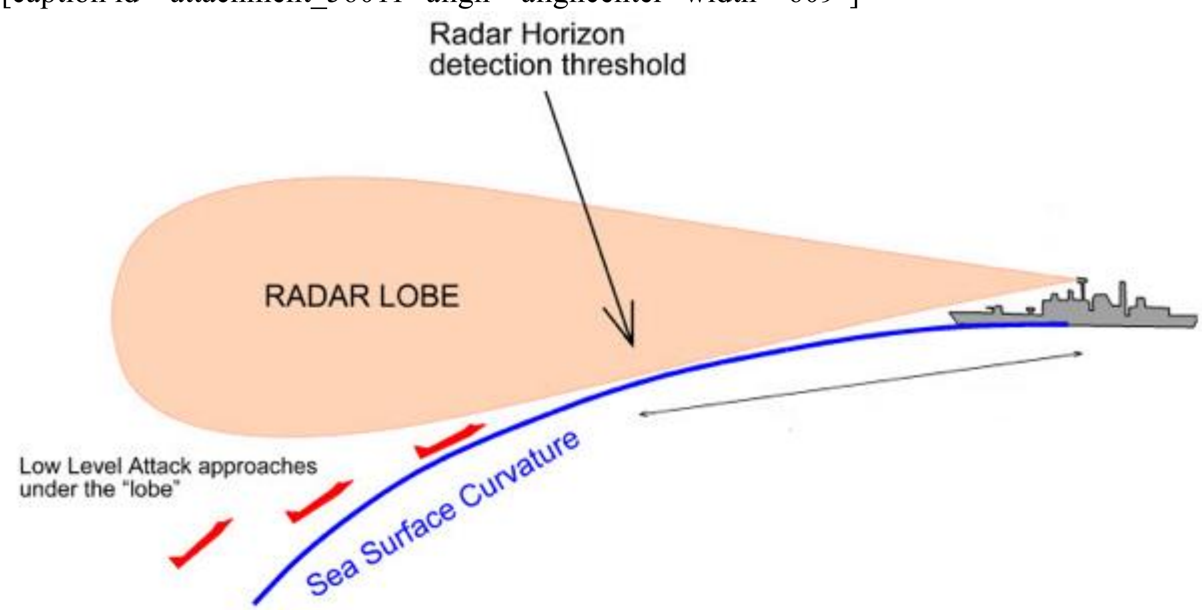
This spectrum highlights a central paradox of distributed warfighting and the arguments that are often made in favor of it.[19] Why is it favorable for a force to proactively distribute its own assets and platforms, but unfavorable to cause an adversary to do the same? The answer may lie in the distinctions that occur on the ends of this spectrum, that one force's distribution can cause its adversary's to become stretched thin. This paradox also applies to the decision-making advantage that is central to success in distributed warfighting. Concentration simplifies command and control, but distribution complicates it. Some of distribution's effectiveness is therefore predicated on the belief that the command-and-control burden of wielding a distributed force can be more manageable than the C2 burden of targeting that force.

The nature of being concentrated, distributed, or stretched thin does not hold evenly across functions, especially offensive and defensive warfare. A configuration that appears distributed for one way of combining capability can be stretched thin for another. When forces are to mutually support one another, it is far easier in naval warfare to be distributed and combine offensive missile firepower than it is to combine defensive firepower. In the case of defense, even naval formations that seem heavily concentrated can have their defenses stretched thin by the fundamental dynamics of naval warfare.

Since many radar systems cannot see through the curvature of the Earth, the radar horizon limit has an intensely isolating effect on naval defense. The low-altitude, sea-skimming flight profiles of many anti-ship missiles take advantage of these radar horizon limits to tightly compress the amount of time and space warships have to defend themselves. Much of the advantage offered by long-range sensing and defensive weaponry is negated by sea-skimming flight profiles that force defensive engagements to begin mere miles away from warships (Figure 3).

Given how the limits of the radar horizon can typically be as little as 20 miles away, warships will have their mutual defenses stretched thin by the radar horizon dynamic unless proximity and concentration is taken to extreme lengths.[20] Ships that are close enough to help defend one another against sea-skimming threats are likely to be concentrated enough that they can be threatened by the same individual salvo, removing distribution's key advantage of diluting fires. Networking capabilities like the Navy's Cooperative Engagement Capability will only marginally increase the potential for defensive concentration, given how incoming missiles can still be tens of seconds away from impacting the warship illuminating the missiles for outside defensive fires.[21] While some environmental conditions can allow radar to bend around the horizon, this adds more complexity to the engagement and is not a panacea for mitigating sea-skimming threats.[22] When sea-skimming salvos break over the horizon and are only tens of seconds away from impact, warships are more likely to fight alone.

[caption id="attachment_56011" align="aligncenter" width="609"]



Visualization of the radar horizon limitation. (Source: Aircraft 101 Radar Fundamentals Part 1)[/caption][caption id="attachment_56020" align="aligncenter" width="671"]

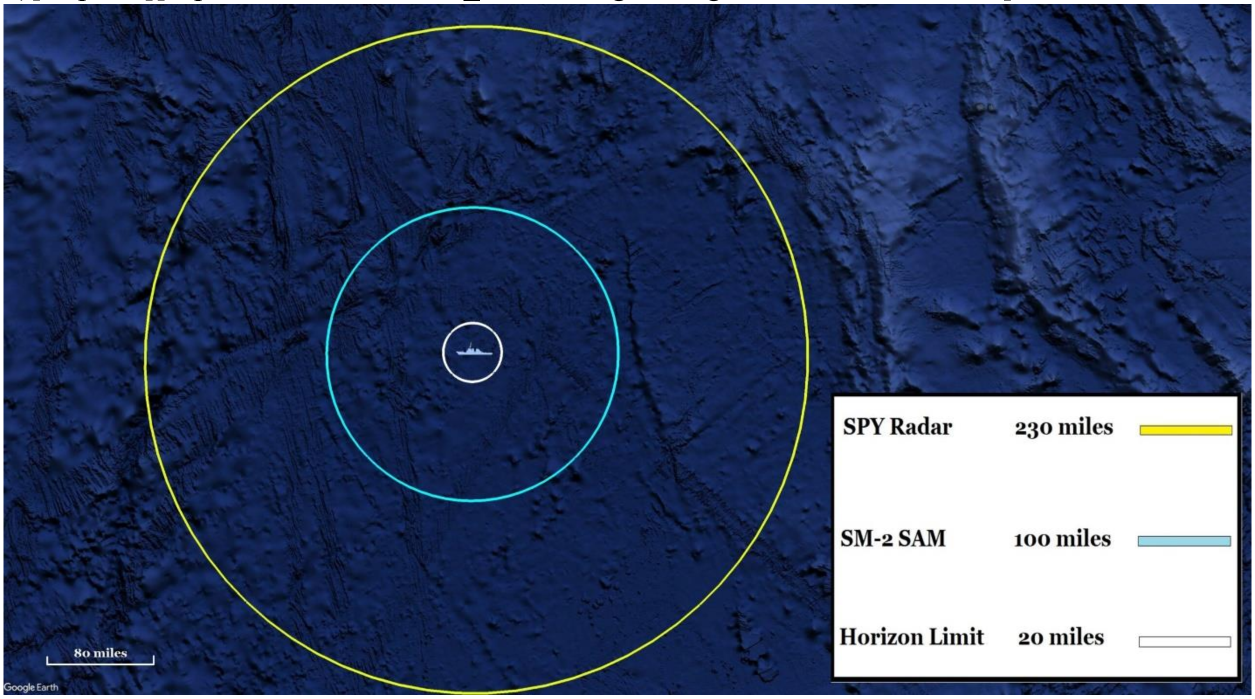
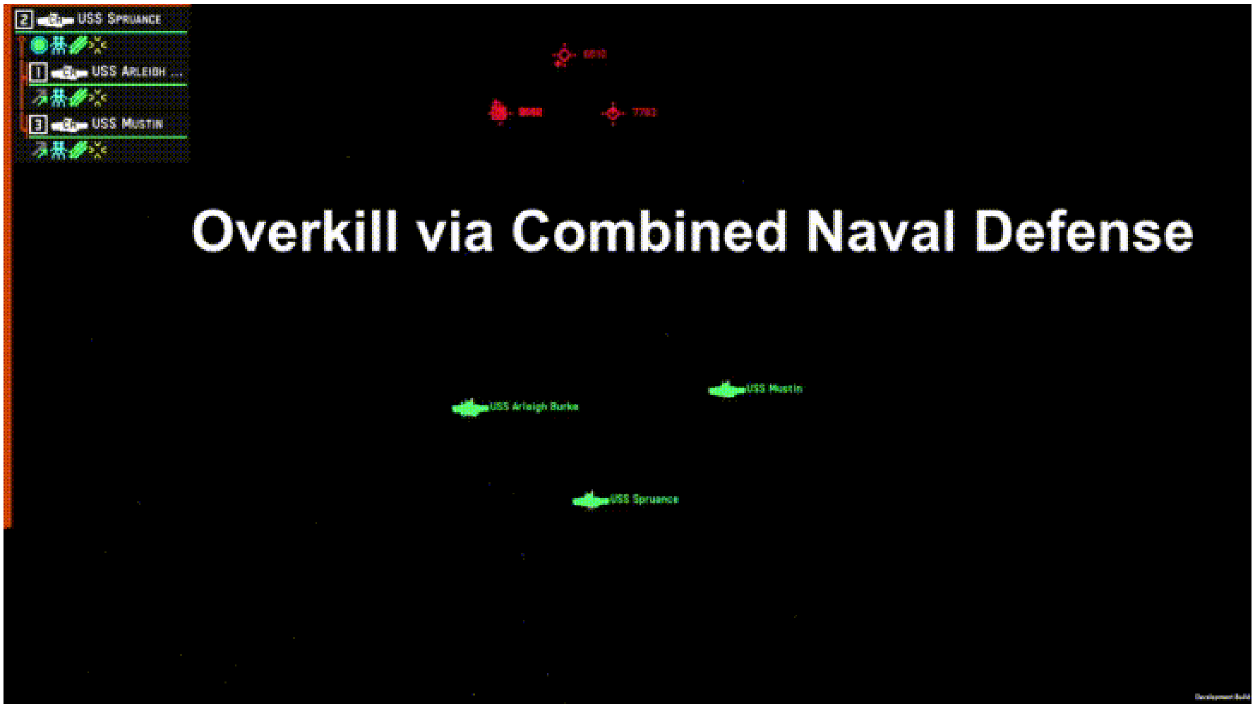


Figure 3. Click to expand. A visualization of three layers of ship self-defense capability: The outer ring of radar range, the middle ring of air defense weaponry range, and the innermost ring of the radar horizon limit.[23] (Author graphic.)[/caption]

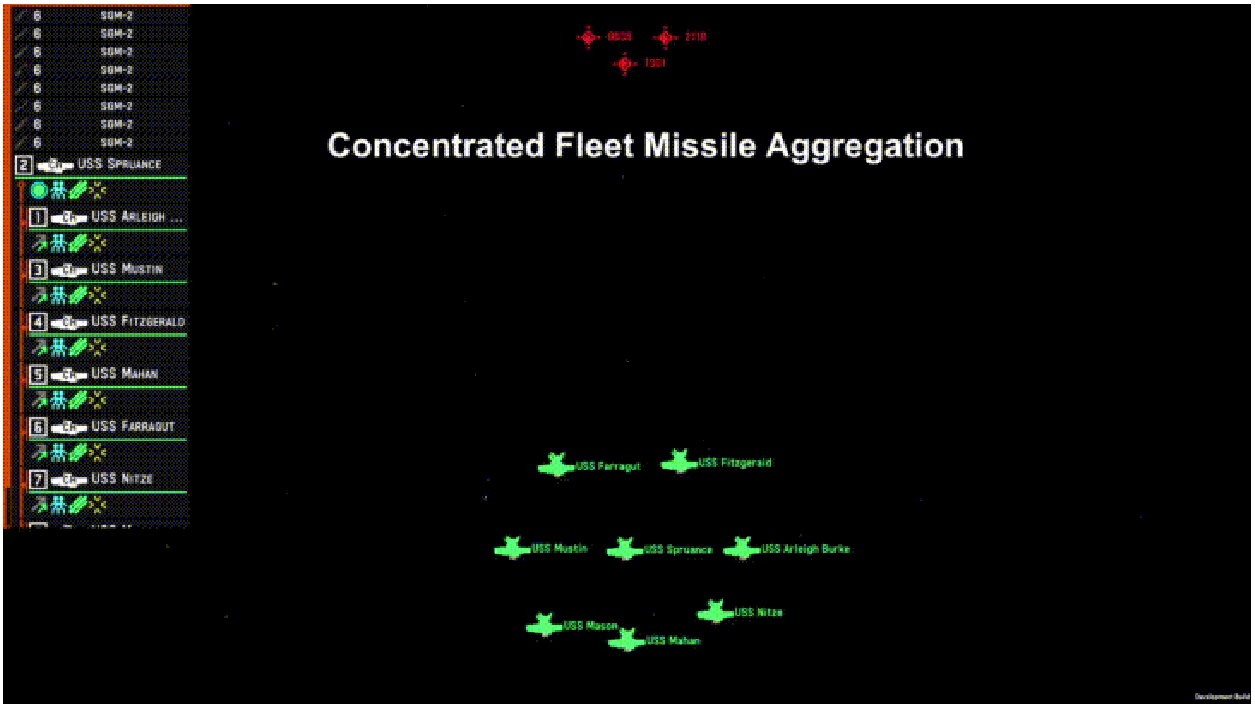
Even if missiles attack from higher altitudes that give warships more scope for mutual defense, the act of combining defensive fires from multiple warships can incur major inefficiencies in weapons depletion. If incoming missiles penetrate into the overlapping air defense zones of a fleet, the pre-programmed doctrines of heavily automated combat systems could easily generate defensive overkill. If multiple Aegis warships reflexively execute the standard "shoot-shoot-look-shoot" doctrine against the same missile, far more anti-air weapons than necessary could be wasted against individual targets.[24] The fleet's magazines would be depleting at a disproportionate rate relative to the number of missiles being shot down, and the attackers would be operating at a more favorable exchange ratio. Simply depleting magazines of anti-air weapons can be more than enough to put commanders in untenable positions and force ships out of the fight as they retreat on a long journey home to rearm. Tightly coordinated networking and automation would be required to efficiently expend defensive fires across multiple platforms, especially for a concentrated fleet. Yet there would also be an especially strong incentive to do everything possible to preserve a concentrated fleet, since it likely represents a major center of gravity whose loss cannot be afforded.



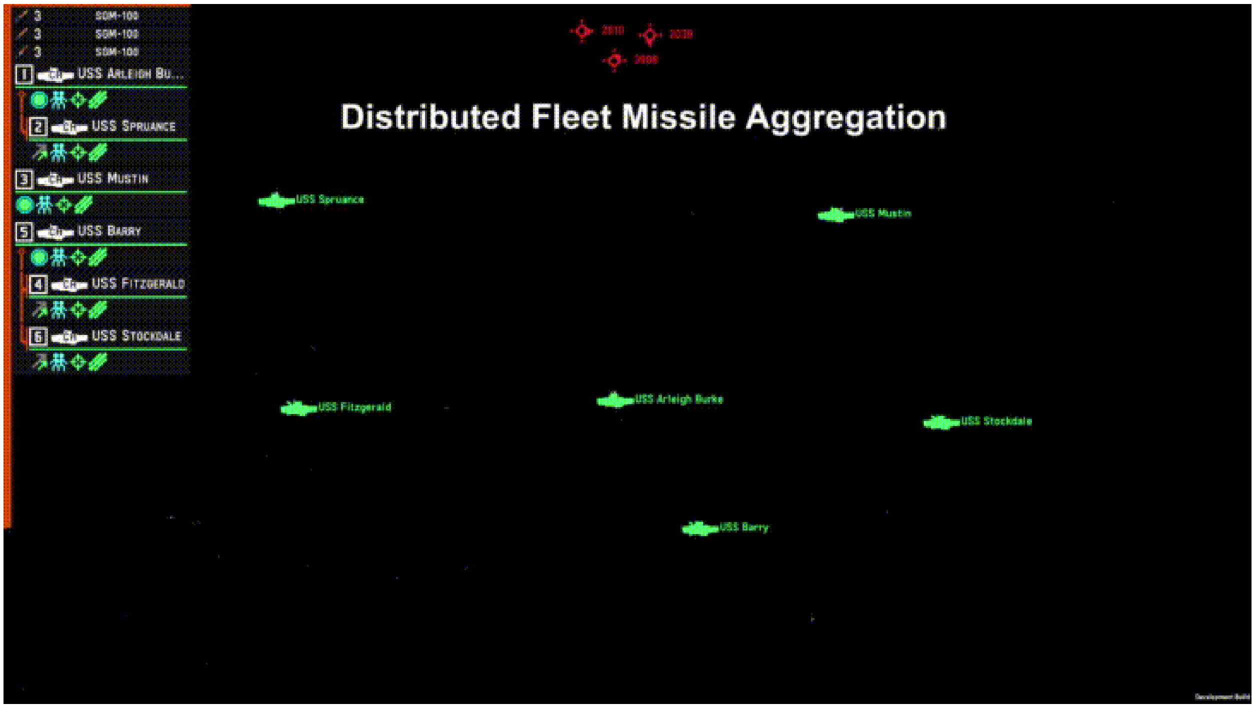
Click to expand. Three warships, each using a firing doctrine of two interceptors per incoming missile, defeat a small salvo with highly inefficient expenditure. (Author graphic via Nebulous Fleet Command)

Concentration does offer several advantages in naval warfare compared to distribution. One of the hallmark advantages of concentration is simpler command and control, which could prove invaluable in a heavily contested electromagnetic environment. Concentration allows for offensive fires to be launched with less networking and communication demands compared to distribution. The contributing fires of a concentrated force can also become aggregated and massed shortly after launch, where the salvo takes on overwhelming volume early in its creation. Because there is less need for follow-on salvos to grow the volume of fire, the adversary’s options for preemptively destroying follow-on shooters is diminished. However, a salvo that combines into an overwhelming mass early in its creation can also present a distinct center of gravity. This creates clearer and more timely opportunities for an adversary to apply defensive countermeasures against the salvo, such as airpower.

By comparison, a distributed force is more challenged to ensure its various contributing fires combine over the target. This can require sequencing launches, which creates opportunities for adversary preemption during the course of building an aggregated salvo from contributing fires. But by combining fires from distributed forces, the aggregated salvo does not necessarily combine into a distinct mass until it is near the target, which complicates the defender's options. The visuals below show the difference in how the salvos of concentrated and distributed fleets can develop overwhelming mass.



Click to expand. A concentrated fleet launches a large salvo, which develops into a distinct mass shortly after being fired. (Author graphic via Nebulous Fleet Command)



Click to expand. A distributed fleet launches an aggregated salvo through a firing sequence, where the contributing fires coalesce into an overwhelming mass shortly before reaching the target. (Author graphic via Nebulous Fleet Command)

Distribution and Decision-Making Advantage

When it comes to massing fires, distribution offers many more options for combining offensive capability than defensive capability. Distribution reaps defensive benefits not by facilitating mutual kinetic support between warships, but by complicating the adversary's decision to strike.

As a force surveils a large ocean space, it must find opposing naval forces and then develop targeting information that enables effective fires. The force must also decide whether the target is worth striking and worth the weapons depletion. A large concentration of naval forces that takes the form of a single force package, such as a main battle fleet, reduces uncertainty by clearly presenting a distinct center of gravity. An adversary would then feel much more comfortable investing a large number of limited munitions in attacking such a distinct center of gravity.

A distributed force complicates this calculus by presenting multiple groupings of contacts across the battlespace rather than a distinct main body. An adversary scouting an ocean could discover some individual elements of a distributed fleet much sooner than a concentrated fleet. But finding those elements may not create enough clarity to warrant a prompt attack because they represent only a portion of the force, and other unseen forces are at large. A distributed force poses a larger number of force packages than a concentrated force, and having more force packages imposes more kill chains for the adversary to manage. Adversaries would have their scouting assets stretched and tied down by these distributed force packages, since discovered forces can require regular tracking and updating of targeting information to ensure offensive options remain timely and viable. While developing a growing menu of targeting options, the adversary may feel tempted to prolong the search for information to build enough confidence to set priorities for expending limited numbers of munitions. But there is an inherent tension between taking the time to gain more information and ceding the initiative to the opponent, allowing a distributed force to pressurize the adversary's tempo of decision-making.

While stealth enhances distribution, distribution can still act as a force multiplier even when the distributed force is in plain sight of the adversary. If an adversary has complete awareness of every distributed asset's location, that can still not be enough to clarify intent and clearly define priorities for action. As Vice Admiral Phil Sawyer stated, DMO "will generate opportunities for naval forces to achieve surprise…it will impose operational dilemmas on the adversary."[25] What a distinct main body of forces can disclose to an adversary is the crucial insight that this main body is likely the primary element through which commanders will exercise their intent. This creates more opportunity and temptation for firing first and preempting the actions of the main body.

What a distributed force poses is a vast array of interlocking firepower, making it less clear to an adversary which elements of the distributed force could be the first to initiate massed fires, or which forces pose the most pressing threat. Distribution also makes it more difficult to ascertain which forces are peripheral to main lines of effort, since forces in peripheral positions or secondary theaters can still bolster main efforts through contributing long-range fires. When deciding what distributed targets are to be fired upon first, it can be hard to know where to begin.

Distribution allows a force to better compete for the initiative and for options to fire effectively first, which is especially crucial to succeeding in naval combat. The 2016 Surface Force strategy expressed similar advantages of distribution, in that it can "influence an adversary's decision-making calculus" and "spreads the playing field for our surface forces at sea [and] provides a more complex targeting problem."[26]

A major driver of distribution is the growing capability of powerful land-based anti-ship forces designed to counter expeditionary fleets. These forces can include anti-ship ballistic missiles, coastal defense cruise missiles, and land-based bombers and air forces, which can produce especially large volumes of standoff fires. By virtue of operating from their homeland, these forces can enjoy far quicker logistical rearming compared to expeditionary naval forces. Land-based missile forces are especially threatening by fielding some of the most powerful and long-range missiles, requiring virtually no maneuver to keep their weapons within range of targets on a theater-wide scale, and employing highly survivable launch platforms. The experience of scud-hunting in Desert Storm was instructive in showing how extremely difficult it is to target land-based missile launchers, even with exhaustive effort, highly favorable terrain, and total air supremacy.[27] This makes it much more difficult to execute the favorable tactic of destroying the archer before the arrow is fired. When a fleet cannot meaningfully threaten a large scope of land-based firepower with attrition, distribution offers a way to circumvent this firepower by complicating the adversary's decision to strike.

A Vision of Future War at Sea

Distributed Maritime Operations can provide a framework for understanding modern naval warfare and illuminate its future. While plenty of unknowns remain, the DMO concept offers an important opportunity to foster debate on how to adapt naval warfighting and translate theory into practice. Great power navies will be able to secure their relevance in a time of rapid change by establishing a clearer vision of war at sea. Those who better articulate and manifest their vision can earn the decisive edge. The U.S. Navy has no time to waste, for its competitors are already ahead of the curve.

Threads

The optimal stationing of naval assets can be debated and analyzed at length…Aside from the many specifics and caveats, a fundamental challenge is recognizing that…A naval formation that is mathematically optimized to inflict maximum attrition against incoming missile threats may not be optimized for the qualitative dynamics of counter-targeting and deception. A densely packed and tightly structured naval formation could shoot down a major volume of fire, but its clear disposition could be what invites attack in the first place. (Should this go in Part 1?)

Pt 1. Title idea: Principles of Distribution in Naval Warfare?

Considering how the principle of distribution applies to many ways of organizing capabilities and effects….not just a DMO lens…..

Sun Tzu quote on distribution and concentration referenced near bottom of pg. 53 of Shattered Sword "If I am able to determine the enemy's dispositions while at the same time I conceal my own, then I can concentrate and he must divide. And if I concentrate while he divides, I can use my entire strength against a fraction of his…"……winning the ISR battle of figuring out dispositions to set the stage for effective concentration of capability…..

Distribution paradox….a stronger formation invites more firepower against it by virtue of being easily detected and distinguished…..self-fulfilling prophecy…..when does it make sense to group up versus spread out? Why is this so fundamental?....(make reference to distributed fleet formation chapter and how it will deal with other stuff?)....…..the desire to improve hardkill defensive capability (AAW/ASW) at the level of the individual formation is a major driver toward concentration….the paradox between improving hardkill density at the individual unit level and inviting larger volume strikes from the adversary…

Distribution, where shifting to a new target constitutes an entirely new killchain, rather than a minor retargeting update to an existing one…….think machine gunner going between individual targets and shifting their aim slightly or extensively, depending on their spacing….distribution also seeks to minimize the impact of area effect weapons….On a related note….Distribution and search, how many targets can be held in view by a single sensor at one point in time…..a concentrated naval force can be easily spotted in its entirety by an aerial recon platform…..if you are distributing to complicate search, hundreds of miles apart potentially….is there overlap in distributing to complicate their search while preserving options for mass fires…..

Elements of distribution…..findability, survivability, command and control…..

Belief that pervasive ISR makes maneuver impossible….but salvo warfare dynamic, as articulated in AC DMO work….you can earn maneuverability in spite of pervasive ISR if the enemy thinks you are not worth attacking with heavy firepower, or if they think they cannot muster the firepower….you can earn maneuverability with defensive firepower…….

Individual element of distribution…..the unit by itself is not worth the trouble of organizing an attack or suffering depletion if you're really trying to prioritize (Think of warno and seeing only small units of light forces spread out and not worth artillery salvos)....otherwise, you commit to a longer-term effort to systematically reduce each unit……

Distribution: "Catching only fragmented glimpses of their total strength" from Shattered Sword pg. 340

Core operational challenge of mustering enough volume of fire….."Sims, for his part, **was willing to factor in new metrics for long-range firepower and conceded that speed generated tactical advantage. He attacked Mahan's emphasis on the total weight of broadside or hits as a metric and <u>insisted the true goal was the volume of penetrating hits."</u>** Corollary for modern mass fires…..not just weight of broadside…what is the intended effect? Penetrating hits that inflict decisive damage…..how can we improve the penetration capability of our salvos aside from simply increasing the volume of fire? Aside from more exquisite penetration aid capability? How can we improve penetrative capability through tactical employment alone? This is a strategic imperative because we have very little in the way of inventory numbers, and so we have to figure out how to score hits with little firepower…..where can we discuss this? Has to be brought up in Part Two for sure, but the actual force multiplying tactics for penetrating air defenses? Elevate this….core tactical problem of mustering enough volume of fire to breach naval air defenses, and/or core tactical problem of providing enough force multipliers to salvos to give them better penetrative success….organic penetration aids, penetration tactics, non-organic aids and tactics……are we venturing into complex air defense equations and sciences with this? SEAD/DEAD tactics? One must know the science of missile defense in detail in order to know offense?

Unsure/Unused

Introduction

Threads

Intro section? Naval salvo warfare is extremely sensitive to small advantages in force..one hit kill, many missiles incoming, defense falling even slightly behind..….overkill more likely than not……rapidly snowball into decisive effects…..fleets can be lost in a single afternoon…..this makes tactical matters have strategic consequences…..equivalent to 2,000 tanks line……..tactical shortfalls can rapidly escalate into strategic liabilities…..as legendary naval tactical theorist Captain Wayne P. Hughes Jr., said, "The heart of a fleet can be cut out in an afternoon."

Not using salvo equations as explanatory devices…admit own lack of quantitative inclination, but for the sake of socialization and making things accessible….and for capturing human and qualitative factors….narratives of tactical interplays and envisioned combat interactions seem a more effective device….. "Expanding cumulative advantage" Lanchester equation quote (from Kaigun pg. 143)

Lots of these tactics are conceptual for now….but aim to be practical, realistic….trying to perceive the sequence of adaptation, the interactive nature of measure, countermeasure, and trying to perceive the second and third order effects of tactical countermeasures to see what more advanced methods look like…

DMO as a device for something to resolve the salvo warfare challenges of modern naval warfare……even if the Navy moves on from DMO, many of the methods and featured will likely remain enduring features of naval combat….

That line from Kaigun… "deductions based on prime considerations that shape courses of action"…

Non-kinetic, cyber, ISR, networks is beyond the scope of this work….but that stuff is extremely essential, and virtually all of the tactics and operations described in this work rest upon a critical foundation of network connectivity, sensing, and cyber resilience….mine warfare, ASW not thoroughly examined…..

Review CNA interview presentation on methodology of FDMO series

Written out of concern for tactical and operational literacy of the Navy….this historical turning point we find ourselves in…..

Kaigun final chapter that mentions failed IJN CONOPs……. "The specific combat situations appropriate for their use never materialized, or on-scene commanders judged them unworkable at the point of contact…."

Fleet combat is no longer isolated between fleets opposing each other at sea…..tremendous reach of land-based anti-ship capabilities and space-based sensors make them a fundamental part of modern fleet combat…..

Go the distance of key tactical dynamics without getting lost in rabbit holes……take a key tactical dynamic, go the distance with it, advance the logic through several rounds of measure/countermeasure competition, see where things may land……

Make sure to appropriately caveat how speculative it all is…..You must as a foundational rule of analysis, highlight analytic humility and caution, and be very explicit and upfront about that: "One of the most striking omissions in the prewar analytic literature was the failure to acknowledge the fundamental unpredictability of war. Analysts portrayed war as a matter of equipment and doctrine, something that could be planned and executed, more as a complex engineering project than as a contest of will, military skill, and personalities. Friction, the fog of war, and the unpredictable nature of military interaction on the battlefield were all notable in their absence from the analyses. This fact is not entirely surprising: the analysts, by and large, were not military historians but analysts of the Russian military and as such seemed not to have thought about war in this broader way. Analysts evinced little humility about their ability to predict the outcome of combat operations, which is, indeed, one of the most striking characteristics of these assessments. Many of the most prominent analyses lacked reservations, qualifications, or simply acknowledgment of the imponderables of war." -CSIS Report on analytic failure on Russia-Ukraine War…...

New Chapters

Table of Contents (TC1)

Combined Arms Missiles

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Threads

How does combined arms logic work with missile salvos? Different types of missiles working together to cover blindspots? A complementary relationship, not just an additive one….but with missiles? Missiles performing different roles….scouting, BDA, kill, etc? Covering types of sensor areas? Different attack angles and vectors……Some high-end missiles function more on penetrative capability, others are more numerous and low-end….Massing fires with different types of missiles being launched by different types of platforms involves combined arms logic between the launch platforms and the missiles….recall how BMD and ASCM were two different air defense modes until the later Aegis baseline updates, so a multi-axis attack along those lines would have likely been very effective…..can some types of missiles inflict more depletion than others, can some missiles carry penetration aids that help the broader salvo….higher rate of depletion in exchange for greater certainty of shooting down a missile, do more exquisite missiles warrant more depletion, like ASBMs or hypersonics? Think of S-S-L-S doctrine, that assumes there will be a reattack opportunity if the first shots miss, but faster weapons minimize that opportunity, meaning the first round of defensive fires may be the only one you get, and better to make that first round a larger volume of fire….

LRASM has more sophisticated algorithms and networking capability than Tomahawk presumably, better sensors…. so could an LRASM command a flight of Tomahawks…..C2 within a salvo….

Intelligent swarming behavior…..deciding distribution of missile firepower across the targets within a naval formation…..not all just blindly following their seeker lock-ons, but deciding high and low priority targets….ignoring destroyed targets so as to avoid overkill….

Distributed Naval Formations

A principal dilemma great power navies wrestle with as they prepare for war is the ideal fleet formation. **(source)** Fleet formations offer competing concepts of how to physically arrange naval forces in the battlespace, in what numbers, composition, spacing, and for what purpose. Similar to force structure and force packaging, fleet formations have long been a critical physical expression of the core beliefs on how to win naval battles.**(source)**

Formations establish a point of departure for optimizing the capability of the fleet and providing commanders with options for managing the evolving circumstances of combat. One of the fleet commander's foremost considerations is perceiving the asymmetry between the formation of their force and the formation of the adversary, and how that disparity creates opportunities to be exploited and liabilities to be guarded against.

Distributed warfighting concepts place a premium on optimizing fleet formations and dispositions by making the physical spacing between units – distribution – a central feature of their vision.

This spacing is fundamental to the counter-targeting value of distribution because it obscures the fleet formation to the adversary. Detecting a single distributed contact may reveal very little information about the broader disposition and composition of the fleet, unlike detecting a ship operating within the traditional bullseye formation of a carrier group. If an adversary is known to be operating in traditionally concentrated formations, then detecting a single ship contact can more reliably lead to detecting other nearby ships and understanding their disposition. **(A graphic can show this…a section/chapter on the counter-targeting value of fleet distribution?)**

Different fleet formations serve different purposes. Some formations are intended for long transits between theaters, some are for maximizing offensive firepower, and others are optimized for specific scenarios. **(Source WWII naval formations)** Some formations provide a more flexible foundation, while others are highly situational, more easily disrupted, and dependent upon narrow circumstances.

Fleet formations are not necessarily static constructs since warships are constantly on the move, allowing fleets to switch from one formation to another based on changing circumstances. This makes formation transition one of the fleet commander's critical means of adapting the fleet's capability in real time. A distributed fleet may convert into different formations as it goes from transiting across an ocean, penetrating into an adversary's weapons engagement zone, and then persisting within it. Different mass firing sequences can warrant different fleet formations, with each formation offering a different set of options for delivering and withstanding mass fires.

A distributed fleet formation does not necessarily require precise placing and spacing between units. That would actually reduce the counter-targeting value of distribution and make a force more predictable to the adversary. Instead, it can be a flexible arrangement, one that affords its forces enough maneuver space to blend in with the maritime backdrop and allow units to shift in relation to one another based on the needs of the fight. Blending in with the maritime backdrop requires a distributed fleet formation that is fluid and ever-moving, yet still bounded by some degree of cohesion. A distributed fleet may be challenged to switch formations within the maritime backdrop while maintaining its cover.

Formations are a testament to the importance of physical cohesion for unity of effort in naval operations. The breakdown of a fleet's cohesion can therefore manifest in the breakdown of its formations. The cohesion of a fleet can be directly attacked by exploiting the seams in its formations and driving wedges between forces that were intended to operate as a common whole.

The long ranges of modern naval weaponry and sensors have blurred the distinction between the fleet-level formation and the theater-wide disposition of naval forces. It is more difficult to precisely ascertain the degree of physical cohesion of a distributed fleet in the missile age than it was in the age of naval gunfire, whose tightly grouped formations were highly sensitive to small changes to speed and spacing between warships. The tactical level of naval salvo warfare can function on a theater-wide scale, offering two dimensions of fleet formations – that of closely grouped force packages, and the theater disposition as a whole.

Anti-Air Considerations

A distributed fleet poses a challenging and amorphous anti-air threat. Distributed surface warships can create a shifting spread of air defense bubbles hidden throughout maritime traffic and distributed fleet formations, complicating the ability to plan salvo attacks and air operations.

Aircraft and missiles have to be careful when flying over busy sea lanes toward a warship target because they may be overflying unknown surface contacts that could turn out to be warships lying in wait. Warships operating under restricted emissions could spring anti-air ambushes and rapidly inflict heavy losses against unsuspecting forces. The losses could be especially severe for heavily concentrated aircraft formations, such as those posed by large-scale Harpoon strike packages. Against such a force, a single destroyer could quickly destroy the majority of a carrier's air wing if its ambush is well-placed and well-timed.

The extended defense-in-depth of a distributed fleet formation poses a variety of potential air defense traps that aircraft and missiles may have to carefully navigate. The potential for unknowingly overflying waiting warships creates lucrative opportunities for those warships to inflict heavy losses in short order. Missiles and aircraft approaching targets from long range are more likely to fly at high altitudes to maximize their reach. These higher-altitude flight profiles pose more favorable anti-air opportunities to the warship compared to sea-skimming profiles that tightly compress the amount of time and space warships have to shoot down aerial targets.

These ambushes can allow a defender to start the process of attrition much earlier than the attacker expected and potentially stimulate irreversible last-ditch actions. Even if ambushers fail to inflict kinetic effects against the attacking forces, simply compelling aircraft and missiles to dive to break illumination could disrupt their formations and force them to pay a significant penalty in range, potentially even putting them beyond the reach of their intended target. Aircraft and missiles may be forced to redirect their attacks against the imminent threat posed by an ambushing warship, including launching last-ditch fires that were intended for other targets.

The potential for anti-air ambushes strongly shapes the calculus of attacking priority targets within a distributed fleet. If an attacker is forced to overfly surface warships on the way to a priority target, they may have to employ an even larger volume of fire to withstand the resulting attrition. Or they may have to accept the cost of shortening their reach by having aircraft and salvos fly at lower altitudes to minimize their potential exposure to ambush.

(Graphic of gaps and corridors)

The attacker may have their attacks delayed by a desire to adequately scout the opposing distributed fleet in order to identify the gaps and corridors in the formation. These corridors offer valuable maneuver space that can help minimize the attrition suffered on the way to the target. The challenge posed by hidden air defense bubbles throughout the depth of a distributed fleet and a bustling maritime space magnifies the ability of distribution to heavily complicate targeting and decision-making.

The extended defense-in-depth posed by a distributed fleet creates opportunities for surface warships to kill aerial archers before they fire arrows, which is counter to the U.S. Navy's fleet air defense doctrine of recent generations. The defense-in-depth posed by a distributed fleet is different than the fleet air defense scheme of the Cold War U.S. Navy, and more similar to the air defense scheme of the U.S. Navy in WWII. These two distinct methods of structuring formations for fleet air defense offer valuable lessons in organizing the modern distributed fleet.

In the Cold War, the fleet formation was structured in such a way as to offer three main layers of air defense. Interceptor and early warning aircraft operated at the outermost layer, and surface warships formed the bulk of air defense capability in the remaining two layers. **(Have a graphic depicting this, and Multiple sources: FFG-7 for Outer Air Battle**, **)** In this scheme, aircraft such as the E-2 Hawkeye and F-14 Tomcat would provide early warning to the fleet and begin the process of attrition, mainly against incoming regiments of Soviet Backfire bombers. Ideally these carrier aircraft would be able to extend the air defense envelope to such a range that with timely early warning and identification, they could shoot down archers before they could fire their arrows. By comparison, surface warships were placed relatively close to the carrier. The location of surface warships in this formation made them primarily charged with defeating arrows instead of archers.

This sharply contrasts with how the U.S. Navy structured its formations for fleet air defense in WWII, especially against the potent Kamikaze threat. Destroyers were stationed as pickets in the outermost layers of fleet air defense, where they played critical roles in early warning and diverting strikes away from high-value targets. Pickets help ascertain the composition, disposition, and direction of incoming attacks, while being postured to disrupt and attrit those attacks. Destroyers used radar to detect incoming threats, and specialized fighter direction teams aboard the destroyers would vector combat air patrols toward those threats. Kamikaze flyers, upon realizing they had been detected and would soon run into numerous intercepting aircraft, often changed targets and aimed their final dives at the picket ships. As a result of diverting and absorbing Kamikaze attacks, the destroyers killed many of the suicide craft, took heavy losses themselves, and ultimately prevented many larger warships from suffering devastating strikes.

The experience of Kamikaze defense offers useful lessons for employing warships as pickets. They can diminish the incoming volume of fire and force the adversary to redirect their attacks toward less valuable targets. But perhaps most importantly, pickets can strongly shape behavior by virtue of their early warning capability. After an adversary realizes they have been detected by a picket, they must consider the possibility they have lost the element of surprise, that intercepting forces may be quickly surging toward them, and that the targets they encounter will be in a heightened state of readiness. The picket serves a valuable role as a tripwire that activates the broader architecture of fleet air defense, allowing an encounter with a picket to cause an attacker to believe their chances of success are rapidly decreasing. The Kamikazes that redirected their attacks against pickets instead of the original capital ship targets resembles a desperate form of last-ditch fires.

The theater-wide character of naval salvo warfare creates opportunities for some platforms to serve as pickets on behalf of others, even if dispositions and formations were not explicitly structured for that purpose.

The early warning mission of the picket ship preserves much of its utility even if potential contacts are outside the range of its air defense weapons, given how a ship's active and passive sensors can greatly outrange its anti-air missiles. The picket ship also provides a more stable and enduring form of early warning compared to aircraft, whose presence and availability are much more transient. An aircraft's fuel and range confines the scope of its maneuver space and tethers it to its carrier, potentially allowing an adversary to use passive detection of an airborne early warning radar to partially localize the carrier. The more expansive maneuver space of a warship can make it more challenging for an adversary to ascertain friendly dispositions based off the picket contact alone, reinforcing the counter-targeting value of fleet distribution.

(Cold War surface-based AAW missiles were very short-ranged…..small bubbles, easily bypassed, would have taken a lot of them….relative to the target, they were not great in terms of distribution, concentration….

Light, riskworthy forces have often served as fleet pickets. This highlights the danger of serving in the force that is most likely to make first contact with the adversary and how numerous units are needed to cover various potential angles of attack. In WWII, destroyers were the heavily armed small surface combatants of their era, rather than the much larger multi-mission ships that today constitute the bulk of the modern surface fleet's striking power. The corvette-sized, small surface combatants of today may not be able to strike aircraft and missiles flying at high altitudes with their anti-air weapons, which are often limited to short-range point defense systems. But their sensors may be enough to serve in the picket role, and allow them to shape adversary behavior in useful ways. Destroyers could potentially serve as heavily armed pickets that not only warn against attacks, but can outright destroy them with well-timed ambushes, heavily attrit volumes of fire directed at other platforms, or spoil attacks by redirecting their attention toward the destroyer. Destroyers can also feature the powerful sensors that allow them to perform the picket role for ballistic missile defense and warn forces against especially high-altitude threats.

The Dilemmas of the Picket Ambusher

A warship hiding at the forward edge of a defense-in-depth will face intense pressure in the battle of nerves. A warship waiting to spring an ambush may be receiving reports that a large number of missiles or aircraft will be flying near them soon. Yet the ship may be forced to maintain relative blindness and keep its radars off so it does not spring the ambush prematurely. It may also be unclear if the attack is truly meant for the ambusher, who may not realize their stealth has been compromised.

Launching an ambush on behalf of another platform's defense can involve different tactics and risk tolerances compared to maximizing one's own defensive depth. An ambusher may have to tolerate an adversary gaining much closer proximity to themself to make the most of the opportunity. A warship may have to allow overflying aircraft and missiles to penetrate deeply into its air defense envelope before it can open fire and inflict maximum attrition. This is different than maximizing one's own defensive depth by opening fire as early as possible to keep attackers at arm's length, which can afford attackers more time and space to circumvent the air defense envelope. The ambushing warship is attempting to catch a large number of unsuspecting missiles and aircraft in its air defense envelope simultaneously, while minimizing their opportunity to save themselves.

(Graphic for this?)

The battle of nerves will be intensified by the delicate timing of this type of ambush. There may be only a few minutes of opportunity to inflict maximum losses against a group of fires or aircraft flying overheard.

Ambushers often become the primary target of the ambushed. Once a waiting warship attacks an unsuspecting force flying overhead, it can instantly face severe last-ditch pressures by virtue of imposing those same pressures on the forces it is ambushing. A group of aircraft armed with anti-ship missiles may launch their weapons at an ambushing warship that may be only seconds away from shooting them down. As a salvo starts taking losses, missiles may change course and make the ambushing warship their new target. The prospect of immediate counterattack creates major last-ditch firing pressures for naval ambushers, potentially forcing those warships to discharge last-ditch fires under especially difficult circumstances.

A different set of serious risks can emerge after an ambush. If the immediate counterattack from ambushed forces fails to kill the warship, it may become an especially attractive target for follow-on attack because the ambush has caused the warship to reveal itself and suffer major weapons depletion. The ambushing warship will have likely broadcast its location by activating its radars to launch the attack while also emptying a large portion of its magazines, thereby simplifying the challenge of attacking it. By virtue of potentially inflicting heavy losses, spoiling an attack, and surviving, it may also earn priority focus from a vengeful adversary. Due to being closer to the forward edge of the battlespace, a picket ship may be closer to enemy forces than to friendly aviation that could be surged to cover the depleted warship against counterattack. A warship fresh off an ambush may also have to radically change its course and speed to get to safer waters given how the ambush could have helped the adversary localize the ship against the backdrop of maritime traffic.

Even if forces do not survive their own ambush, they can still have contributed to the broader goals of attriting attacks that were meant for different targets, shaping the behavior of an adversary, and magnifying their uncertainty over the battlespace. The naval picket ambush makes for a high-risk, high-reward tactic that can be considered with respect to broader factors. These factors include the riskworthiness of the picket versus the unit it is defending, the operational opportunities to be gained or foreclosed by launching risky ambushes, the possible depletion and attrition to be inflicted against the adversary, and longer-term force preservation.

However, regardless of the factors, the fundamental choice to use a distributed fleet formation can inherently make some units pickets on behalf of others. The prospect of long-range missiles and aircraft taking a wide variety of flight paths across a theater-wide battlespace means there will be opportunities for some forces to interfere with attacks meant for other forces. Risky picketing and ambushing may become unescapable features of distributed fleet combat. **(Tentative section conclusion)**

Gaps and Corridors

The spread of air defense bubbles posed by a distributed fleet formation dictates many of the options and challenges for attacking that fleet. The disposition of a distributed fleet is likely to be porous, where the gaps between bubbles create seams and corridors that can be exploited by an attacking force. The defense-in-depth of a distributed fleet poses a variety of tradeoffs when attacks must navigate a hiding maze of air defense bubbles.

(These tradeoffs concern volume of fire, weapons depletion, timing, and range. Is **there some kind of table for this**?)

An attacking force can lower the volume of fire it costs to hit a target if it can effectively navigate its missiles around the distributed air defense bubbles that are along the way to the target. However, this can come at the cost of time, both in the extra time it takes to fly non-linear flight paths, and the time it takes to scout the battlespace to identify those favorable flight paths. If a force is willing to accept a higher level of weapons depletion then it could afford to attack sooner, overfly air defense bubbles and suffer attrition, or knock bubbles down to open new corridors for follow-on attack. If a force has to carefully conserve its weapons inventory then its tactical options will be more limited to attacks that require more complexity and scouting to succeed.

One scenario is that a force may have the weapons range to reach a priority target in a linear attack, but not enough volume of fire if that angle of attack is covered by forward defenses. Bypassing those defenses with non-linear paths could make that volume of fire sufficient, but the added distance causes the missiles to burn more time and fuel, or can even put them out of range entirely. These effects can allow distributed air defense bubbles to shape behavior and diminish an adversary's avenues of attack. **(Make a graphic for this)**

….A force that is conserving weapons inventory may be especially susceptible to this effect.

Attacks may be waypointed to bypass bubbles on interior lines or exterior lines. Interior routes may preserve weapons range but run a higher risk of having the volume of fire chipped away on the way to the final target. Attempting to do an end run around bubbles and bypass them on exterior lines may better preserve volume of fire, but come at an additional cost in range. **(Make a graphic for this)**

New corridors can also be created and exploited by closely sequencing operations, where an initial round of mass fires blows a hole in a distributed fleet formation that can then be exploited by a second round of fires.

Gaps and corridors heavily affect the options for massing fires. Tradeoffs between volume of fire, range, and timing….

Aircraft will be needed to cover gaps and corridors, where aircraft can be responsively surged to provide on-demand air defense capability and attrit volumes of fire that are attempting to navigate the seams of a distributed fleet. This depends on aircraft having enough early warning and time to get into position and inflict meaningful attrition against salvos.

The ability to chart the corridors of the adversary’s fleet formation depends on having sufficient intelligence. But attacks may have to be launched before the disposition and composition of a distributed fleet is fully known, allowing the threat of undiscovered air defense traps to persist. Forces may divide their fires across multiple paths toward a target in a bid to avoid undiscovered air defense bubbles and minimize potential losses by exposing only a portion of fires or aircraft to ambush in each flight path. But this will substantially increase the complexity of organizing attacks and combining fires on time.

Tailored Coverage and Mutual Defense

A distributed fleet can pose a multi-layered defense-in-depth on a theater-wide scale. A question is how much will the fleet’s distribution be bounded by the considerations of mutual defense. Even if warships are not physically co-located into a distinct naval formation, distributed warships may be tethered to one another to offer some measure of mutual support. The placing and spacing between distributed warships may be bounded in ways that allow them to provide early warning, launch ambushes, and attrit volumes of fire on each other’s behalf.

If a threat is developing against a high-value unit from a particular direction, a supporting warship may adjust its place in a formation to place itself further along that threat axis and more prominently interpose itself between the threat and the high-value unit. This allows the warship to expand the air defense envelope that a volume of fire may have to force itself through on the way to its priority target. By comparison a tight defensive formation may only pose an air defense gauntlet about 20 or so miles in length – the distance from the target and the horizon – and only begin the defensive engagement after the incoming volume of fire enters its final approach. Extending a formation along a particular threat axis can extend that defensive length and offer major benefits to defenders. Forcing a salvo to spend even one more minute under fire from a defending surface warship can result in many more missiles being shot down, especially in close-range sea-skimming engagements. Extending defensive depth in a particular direction can also result in a more favorable depletion rate. More time and space to shoot down missiles allows for a more efficient defense compared to having to shoot down missiles that are only seconds away from striking, and with possibly multiple warships firing multiple missiles at every incoming threat in an all-out, goal-line defense. An extended defense-in-depth may also be useful in defeating mass fires, where individual contributing fires suffer defeat in detail well before they can merge into a critical mass of overwhelming firepower. **(graphic)**

The tradeoff in extending a formation along a particular axis is that it can create an opportunity for attackers to perform an end-run around the unit that is trying to lengthen the defensive envelope. Successfully bypassing a defense-in-depth affords an attacking volume of fire more opportunity to score hits at lower cost. Using a tighter naval formation attempts to minimize the gaps and shallowness of defensive coverage that could be exploited by sea-skimming missiles in their final approach. Extending a formation means the defender accepts the risk of lowering their defensive density at the core of their formation in exchange for the potentially better rates of attrition and depletion posed by a longer air defense envelope, assuming the threat chooses to fly through it.

(But does this pose a risk of defeat in detail if the attackers shift to focus on the extended defender??? A broad saturation salvo may lose only a handful of missiles to an extended defender/ambusher, whereas a stream can lose much more, since the whole salvo would be traveling through the air defense envelope…..a wide salvo could encounter more ambushers though, depending on how wide it is….)

Whether a threat flies through a lengthened defensive envelope may depend on how advanced its sensors and retargeting capabilities are. A salvo that is not intelligent enough may not be able to sense the opportunity posed by an extended formation and bypass select escorts on the way to a priority target. A more intelligent salvo by comparison could attempt to map out the disposition of a naval formation to devise custom angles of attack that exploit the specific seams and shallows of its defenses.

(Graphics)

This example describes how these dynamics could work for the co-located force package. How can an extended defense-in-depth function at the level of the distributed fleet, where there are large gaps between the defensive coverage of units? (Is this where we start the picket section?...The counter-targeting uncertainty posed by the distributed fleet creates defensive opportunities when an adversary feels pressed to launch attacks before they fully understand the disposition of an opposing fleet….units that have yet to be discovered, or are not co-located with priority targets, may have opportunities to disrupt attacks meant for other units….aircraft and missiles may have to overfly many unknown and civilian contacts on their way to warship targets, it may not be a totally clear maritime space in between them…)

The role of picket, skirmisher, or scout has often been handled by riskworthy light forces that are numerous and whose losses are relatively tolerable. Compared to heavy forces, the attributes and tactics of light forces typically allow them to better avoid decisive entanglements with the enemy. The main role of light forces performing these functions is to be foremost point of contact confronting the fog of war and taking on significant risk to gather critical information on behalf of the broader force. They are useful for helping higher-echelon commanders develop a feel for the battlespace and the adversary's reactions while refraining from decisive engagements. Opposing scouts and skirmishers can encounter one another in the course of their mission, creating opportunities to complicate an adversary's information-gathering.

The traditional logic of light, riskworthy forces taking on the scouting role has been overturned. Instead, the modern maritime scout takes the form of relatively expensive platforms whose losses can be ill-afforded. Whether they be airborne early warning aircraft such as E-2s, maritime patrol aircraft such as P-8s, submarines, satellites, long-endurance drones, or 5th generation fighters, modern maritime scouts are often exquisite platforms whose losses can have outsized consequences for the broader force. Key sensory platforms such as E-2s and P-8s also feature critical battle management capability for coordinating other forces. While this is a natural capability pairing, it further exacerbates the consequences of losing these exquisite platforms and lowers their riskworthiness. As a result of the increasing expense and rarity of the maritime scout, many of these platforms cannot easily take on the forward-most dispositions to penetrate the fog of war as readily as their light force predecessors. To insulate them from risk, these high-end scouts could even warrant scouts and screening forces of their own, adding more layers of complexity to a force's scouting operations.

The closest thing the U.S. Navy has to a numerous and riskworthy scout is the F/A-18 fighter. Yet that platform's scouting utility is considerably limited by its relatively modest range and sensors, and especially the limits imposed by having its operating radius tied to the disposition of the most exquisite platform of all – the carrier. And with the prospect of modern naval attrition, losing small numbers of even these forces may be hardly tolerable (clarify). There is a lack of riskworthy warships that can serve as pickets and scouts, forcing navies to rely heavily aircraft for the role of being the forwardmost line that can provide early warning, defeat opposing scouts, and contest probing attempts.

These aerial picket and scouting roles are chiefly for guarding against air and surface forces. Exquisite warships may have little choice but to continue to serve as the foremost point of contact against undersea threats, especially if maritime patrol aircraft cannot be on station due to survivability and magazine depth considerations….

Marine stand-in force as a picket….not as transient hopefully…..

Pickets….skirmishers…..probing forces…..scouts…. [what does decisive entanglement look like today? Define decisive entanglement]….They are not that survivable if directly engaged…, .the riskworthiness of these kinds of forces stems from their numbers and a deep inventory of assets, that they can be easily replaced or rotated out…..riskworthiness is not the same thing as penetrative capability, just because a force can penetrate deep into heavily defended areas does not mean it is riskworthy….riskworthiness may be more of a function of how much critical capability is lost if the platform is destroyed, than how many defenses it can bypass….riskworthiness may also be a function of strong defenses, that a strongly defended force can be sortied into a contested battlespace and have some measure of confidence that it can withstand attack and survive…..**today,** …a light picket can still have some degree of battle management capabilities like how WWII pickets could be air directors/controllers for CAPs ….submarines are highly penetrative, but are also a low-density, high-demand asset whose losses can be ill afforded..and how much confidence do we have in these platforms' abilities to survive if they do come under direct attack?….. In a large-scale naval environment, it's hard to have numerous assets that can help clear the fog of war because the larger the sensors, the larger the platform, and the less riskworthy it becomes….have to compensate with numbers, having many affordable platforms with good-enough sensory capability…..We don't have riskworthy warships that can serve as pickets, we have to use aircraft for that role….the forwardmost line that can provide early warning, defeat scouting attempts and light forces……..for defense/offense you need a critical mass of forces, but for scouting information, oftentimes only a single witness with a single sighting report can suffice….

Promising Threads

….This dynamic can play out on both the theater-level and force package level…example envisioned so far is for the co-located force package level…..how at the distributed level? Co-located naval formations can be tight, 20 miles at most, to minimize the amount of gaps that can be exploited by sea-skimmers at the final line of defense…..theater-level formation may have more opportunity to exploit high-flying targets?….

tethering effects, having defenders and pickets tethered to other ships on the basis of what?

Fleet formation at the force package level, versus theater-wide disposition….two dimensions of distribution and formation?....difference between formation on the force package level versus the theater wide level, different levels of zoom……YJ-18 can only have some options against the former, not the latter, MST could have theater wide formation reach…..

Air defense bubbles….using the term bubbles for convenience sake, say explicitly why

Effect of sea-skimming flight on bypassing bubbles….makes it easier to bypass at cost of fuel and range……implications of this?....Significant….

ESSM and RIM missile, increasing defensive density (in exchange for depth of fire) for the individual warship or its immediate formation, but less so for the extended defense in depth for a fleet….not as suitable for the ambusher….

How does the formation change when you don’t have a maritime backdrop?

Formations on the basis of offensive range rings/reverse range-rings….like the graphic used in Part Two showing contrasting extent of distributions…

How do you plug holes in blown distributed formations? Shifting the course of hidden surface combatants will make them stand out…..plugging holes with temporary aircraft presence surged may not be enough….

How does your formation allow you to bypass the holes in their formation, or blow holes in theirs?

The interactive dueling nature of fleet formations….and what if your fleets are mixed up together in this busy maritime backdrop? The interposed units become a challenge and priority target perhaps?……

pervasive PRC state-owned shipping could provide early warning to a degree……

the fleet formation is overlayed onto maritime shipping to a degree, and it may change a lot if that shipping decides to take alternative routes and circumvent contested seas.

Bypassing and reacting to unexpected air defense bubbles could be a principal function of in-flight retargeting of salvos……

don't reveal full disposition of forces in first rounds of mass fires (which increases tension with depletion incentives to spread it wide)....let them perceive gaps in distribution and air defense coverage to channel their fires toward hidden strong points….canalizing effect, give the false appearance of open corridors toward high value targets and objectives…….nature of defense-in-depth for a distributed fleet?

The orientation of the distributed fleet relative to what? Offense or defense…..guarding a beachhead? Attacking another fleet? Protecting allied territory? SLOC defense? The general disposition of the fleet will be tethered to an objective, some offer more freedom and flexibility of force posture and maneuver than others….

Lone unit distribution….is every unit's defense a goal line defense, or can we structure it in such a way that we still have some mutual support defensively? (picket defense)

framework of assessing formations? (Tough one) What are the key dimensions to weigh? C2, massing fires, ISR, counter ISR implications, combined arms relations….ASW/AAW/ASUW optimization…..logistics…..

.....tactics of deception, let them see a target at range, and then when they try to strike it, use hidden forces interposed between the revealed target and the enemy to ambush the salvos and the aircraft….depth of defense and breadth of defense is expanded with distributed fleet formation, at the cost of defensive density on a force-wide level, how do you balance this, distribution is a form of naval defense-in depth, but are you running the risk of defeat in detail and being gradually reduced?……..

how exactly do you get into DMO battle formation? Very key question, adversary may want to preempt this, fight to get to the fight, the formation a fleet uses to travel to a battlespace can be more concentrated than the formation it uses to persist within it, how do you mark the transition….do you trickle in slowly, merge with maritime traffic in small increments beyond the scope of their sensors?...

Quote from Sandy Woodward book on bottom of page 204, on haphazard appearance of fleet formations….

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Threads

How to best structure a fleet formation for air defense traps?

Considerations of distributed formations on salvo warfare in particular…..defense in depth….midcourse intercept of ASBMs…

….This supposes a degree of target prioritization, where a force wants to target a more important target and ignore others….they could just gradually reduce targets at the edges and work your way inward….defeat in detail…..

……Offensive/defensive elements happening at the same time…..leave some bubbles unrevealed during the course of mass fires so adversaries may perceive a corridor, and some contributing fires should be deceptive fires…..

Aircraft could be lured toward certain targets whose various approach vectors could align with the positions of waiting surface warships, who intend to ambush aircraft well before they are in position to fire.

Part on kamikazes fearing the picket tripwire….consider rewriting to pose that as a hypothesis rather than an assertion…..

Disposition of the scouting force relative to the main force…..are they tethered, does tethering create liabilities….

Distribution conceals total strength…..Yamamato's Midway dilemma between mutual support versus deception for the sake of enticement…..

Distributed warship, unlike in a formation, can somewhat choose its own bearing and speed…what does this imply?

Skillful maneuver can earn kills at lower volume of fire…but skilled maneuver has to be enabled by ISR….may have to majorly reinforce volume of fire to hedge against the risk of overflying unidentified surface warships….or instead of multiple rounds of fires, a very large volume of fire that can immediately press on to the next target (can't be fully saturation pattern in this case, to minimize volume of fire lost to overkill, could be split into separate but closely sequences volumes of fire at different altitudes…..)

Offensive considerations…..consider geographic delivery density and WEZ overlap, having redundancy and reinforceability of fire, at what point does it reach overwhelming volume of fire, as well as timing options, and minimizing lead times of necessary maneuver to set up strikes…

Active emissions can push or pull contacts away from bubbles….

Include graphics of WWII ring formation…..WW I column formation….both real-life images and chart graphics? CVBG formations…..

Fleet formations are closely related to the force packaging of a Navy and how it structures its units. A set of fleet formations can translate into different tables of organization and unit composition, allowing a standing fleet-level force package to regularly operate in its expected wartime formations, rather than grouping separate units together in ad hoc fashion to operate in large formations they have hardly practiced together.

Combined arms relationships graphic and section here?

Look at a formation and be able to discern the gaps and seams, the overlaps in capability….and the corridors that could be created, the paths that could be cleared, if adversaries focused effort upon specific parts of the formation……..

What if you deplete the ships farthest forward, what does that imply versus depleting the ships further back?

Aircraft can fall back upon air defense umbrella of surface combatants, but lowers the amount of time to chip away at the volume of fire….

How much maneuver room do you really have when mimicking a commercial vessel track, sticking to a single course for prolonged periods? You need deceptive ship contacts that can add a layer of ambiguity there….

Unsure/Unused

Force package-level formation can have biased sector coverage rather than 360 coverage…360 degree coverage at a sea-skimming level basically means a highly concentrated formation of warships only within several miles of one another ….

These factors, along with the poor last-ditch firing opportunities of naval ambushes, encourage warships in these roles to heavily emphasize anti-air weaponry in their loadouts.

some may have to forgo the opportunity to preserve a later opportunity to ambush….

Placing and spacing of platforms to create relationships between capability

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ASW and Naval Salvo Warfare

Introduction

Fleet Dispositions

One of the most profound effects ASW has on the distributed fleet is its disposition across the battlespace. Distributing a fleet into smaller force packages and lone units is incentivized by the desire to complicate an adversary's targeting, blend in with the busy maritime environment, and creating more angles for mass fires to come together. By comparison, ASW creates strong incentives for naval formations to concentrate for the sake of mutual support because ASW is extraordinarily close-range work for warships. Having multiple ASW escorts and pickets expands the scope of undersea sensor coverage that could detect a submarine, complicates the submarine's ability to circumvent escorts to attack a priority target, and intensifies the submarine's challenge of breaking contact even if its priority attack is successful. By comparison, a fleet that distributes into small force packages and lone units will substantially increase its vulnerability to submarine attack. A lone warship poses a much more comfortable target to a submarine compared to a tightly integrated formation with many layers of overlapping capability. As Admiral Sandy Woodward noted, "as a breed, they prefer lone targets, quote in early parts of *100 Days* book."

These factors create a major tension for naval distribution. Concentration improves survivability against undersea attack, but it creates a distinct center of gravity that can be more inviting for missile attack. Spreading warships out for the sake of counter-targeting against missile attack could result in exposing them to defeat in detail by submarines. A fleet disposition that is optimized against missile attack could be significantly different than a disposition optimized for theater ASW.

Putting submarines in position for torpedo attack, very different set of dispositions than optimizing for salvo attack….can there be overlap? modern subs can cue fires now against warships

Air Superiority and ASW

Maritime patrol and reconnaissance aircraft (MPRA) such as P-8s are at the forefront of the anti-submarine warfare mission, and are the only platform that can contribute to ASW over a wide expanse in a short timeframe. Other ASW platforms such as destroyers, submariners, and helicopters are relatively confined to performing ASW in their immediate surroundings. The P-8's combination of range, speed, and land-based airfields enables it to conduct far-reaching ASW operations. However, despite the seemingly independent appearance of their ASW mission, the operations of these platforms are still heavily shaped by broader fleet combat considerations. P-8s have little in the way of defensive capability and will have poor survivability in a contested air environment.

Naval air superiority is therefore a critical enabler of undersea superiority. Air superiority expands the geographic scope of survivable aerial ASW operations and increases the number of ASW aircraft – both MPRA and helicopters – that can be committed to ASW operations to improve coverage and responsiveness.

The low survivability of these platforms against anti-air threats requires a great degree of permissiveness in the air domain to conduct their operations. Aerial ASW operations are especially dependent on the ability of the platform to persist and endure in the battlespace. Aerial ASW platforms that have their operations frequently disrupted by anti-air threats will struggle to 1) remain on station to meticulously investigate contacts 2) lay down and maintain specific patterns of sonobuoy dispositions, and 3) maintain contact with undersea threats for the sake of coordinating combined ASW responses. The methodical and diligent pacing required of aerial ASW operations makes them easily disrupted by anti-air threats, creating a strong need for a relatively permissive and predictable air environment.

The theater anti-submarine warfare campaign of a navy may heavily depend upon the ability to carve out sufficient air superiority in select times and places so MPRA can effectively hunt submarines and deploy sensor coverage over key geography.

These factors demand a combined arms relationship between the MPRA community and the naval strike fighter community. Fighters may be needed to escort P-8s and secure enough air superiority to allow the ASW mission to proceed smoothly. A combined arms bounding effect can govern these operations, where P-8s may only operate as far out as they can be guaranteed a certain degree of fighter screening and escort.

The relationship between naval air superiority and ASW will of course directly impact the submarines themselves. The more air superiority a navy earns, the more permissive the undersea operating environment will become for friendly submarines, to an extent. If an adversary is forced to curtail MPRA or helicopter operations in the face of a persistent anti-air threat, then friendly submarines will subsequently gain more options and survivability.

P-8s can carry anti-ship missiles in addition to their torpedo loadouts, creating new options and challenges for their roles in fleet combat. These aircraft have relatively low magazine depth, being able to only carry several torpedoes and anti-ship missiles each. This low magazine depth strongly affects the platform's ability to persist and provide longer-term sensor overage. A multi-mission loadout may also lead to one mission overriding another. Depleting one type of weapon may compel the platform to leave station to reload without using the other type, such as if contributing anti-ship fires takes strong precedence over hunting submarines. These two missions also have a major difference in what constitutes a sufficient volume of fire. A P-8's anti-ship missile loadout may only contribute a small fraction of the mass fires necessary to sink a modern naval formation. But the P-8s loadout of several torpedoes can be sufficient to allow that platform to muster enough weapons on its own to sink a submarine. The highly time-sensitive nature of attacking an evasive undersea contact and the ability of ASW aircraft to muster enough volume of torpedoes by themselves will encourage these platforms to conduct ASW under a much greater degree of independence and initiative compared to contributing to mass fires. The multi-mission loadouts and operations of MPRA aircraft can be strongly influenced by these factors.

Threads

ASW formations….find pictures and graphics of them

P-8 is land-based air that can be useful for sensing and battle management….long-endurance, and land-based are key enabling capabilities

Other effect of low torpedo magazine depth of P-8s….they only have enough to sink maybe a submarine or two….their key contribution in providing enduring sensor coverage could be diminished by this….

ASW is combined arms warfighting in its own right….they understand it's a team sport to kill the submarines, but need to understand how broad fleet combat interfaces with ASW, and how they shape one another.

Unsure/Unclear/Unused

Contrasting ASW posture between USN and PLAN?....WWII, lone merchant ships suffered worse losses than convoying…….

Massing Fires with Aviation

Meta/structural: Consider splitting this off into a separate chapter on massing fires with aviation….some of this stuff may be more appropriate in Part Two section on Harpoon….pull in content from the N98 Carrier CONOPs briefing…

Threads

Is sortie generation rate the new weight of broadside metric? What is the proper metric for outgoing firepower? Not just range and payload, but speed of delivery?

…….A single destroyer's VLS can match the volume of fire of half an air wing….

These new long-range vls compatible weapons….will allow the carrier air wing to contribute smaller volumes of fire….rather than take up most of the burden, making the anti-surface mission more feasible…..

Sortie generation rate of 125 per day (cite Paparo)....assume how many missiles carried per sortie, how fast could a destroyer launch that off? That equivalent firepower? You are comparing the rate of fire of VLS, plus spin up time of missiles….with the time it takes to prep, launch, and assemble aircraft for strikes…..not assuming mission planning differences of course, but probably a lot simpler given how missiles are taking a one way trip……

Can pilots do sea-skimming flight at night and in poor visibility? Can missiles? Is it too risky?

While the air wing has a lot of flexibility, it cannot pivot between mission sets as quickly as surface warships can, because of the time cost of swapping loadouts…..swapping loadouts and reconfiguring the air wing has a cost and there will be situations and tactics that will want to bypass that cost….

What is the signature of air wing operations look like to space-based infrared sensors? Like SBIRS? Does China have something like that? Learn more about SBIRS and this type of capability….

Air Force considerations? Air bases….heavy bombers……tanking…what factors are unique to them?

Launching and recovering aircraft from an unknown surface contact makes it easier to detect….

Interwar period scripting to guarantee battleship kill chains, modern equivalent? Carrier argument problems with it just being attributes, mission areas, mobility (top speed of warships has not changed in 80 years)....

Amount of time it takes to launch firepower via warship launch cells versus aircraft carrier….probably a lot less for VLS based firepower….meaning far less information demands……lessening the need to hold target track quality while an air wing is armed launched and assembled and sent to target…..the differences could be minutes versus hours (VLS versus carrier)...after making a decision to attack, what kind of track quality do you have to maintain for how long before you can launch fires? How flimsy is that killchain, how easily disrupted?

The time it takes to prepare, launch, and assemble a full deckload of aircraft could often prove too long in the compressed timeframes of salvo warfare

Long process of assembling air wing strikes imposes a concurrent demand on the ISR guiding the strike….because it takes so much time to assemble the strike, the information demands are much stronger….what kind of firepower coverage do we have ready and in place, all we have to do now is find and discriminate targets…. versus discriminating targets, and then having to maneuver launch platforms into place, and then firing……the latter is more time consuming, and has stricter information demands, because you want to maintain information clarity as you are maneuvering forces into firing positions…..

Sortie generation rate of carrier is not that impressive of a metric when you compare it to the rate of fire of vertical launch systems….

The time difference between deciding to kill a target and then actually firing missiles at it…..it's a combination of weight of broadside, plus range, plus time……..calculate this……if I need to put 100 missiles into a naval formation, how quickly can I do that with a carrier versus VLS?

The time difference between committing to an attack, and actually being able to begin the attack, and initiating a mass firing sequence…..a key difference between VLS and the air wing……

How many rounds of large-scale air wing strikes can happen in a single day? Two or three? How many rounds of large-scale strikes could you do from VLS? Probably a lot more….in the span of a single large naval battle, you can have a lot more firepower, a lot more rounds of fires, delivered through VLS……

Bombers for maritime strike….Soviets expected up to 50% losses, meaning the tactic was only good for 2-3 uses on large scale, and that was mainly against outer air battle attrition, not losses suffered at the hands of surface combatants…..also concern of losing too many of these bomber aircraft since they form an important part of a nuclear deterrent and power projection capability, attrition would not be allowed to zero out the inventory of course….large-scale air raid gone wrong is very hard to recover from, hence the incentive to assemble fires in a combined arms fashion rather than solely from aircraft-based strike packages…..perhaps bring up the challenges of overflying a bustling maritime traffic space with hidden surface combatants that could launch surprise air traps and kill a lot of aircraft in short order (maybe reference how this will be discussed more deeply in the distributed formations chapter)

Consider the long lead times to simply set up strikes, how long before you've got all your missiles in the air? But also consider how aircraft toward the end of the engagement could better satisfy terminal information demands than missiles….

Metrics….two different graphs….it's not just range of missiles on platform in a range ring, **it's the flight time, it's the rate of fire time, it's the lead time…..**

· Two broad situations….what kind of firepower coverage do we have ready and in place, all we have to do now is find and discriminate targets…. versus discriminating targets, and then having to maneuver launch platforms into place, and then firing……the latter is more time consuming, and has stricter information demands, because you want to maintain information clarity as you are maneuvering forces into firing positions…..

Shifting burden of maneuver between platform and weapon….VLS versus the carrier….time it takes to set up strikes as it relates to that burden of maneuver. If I want to hit something 600 miles away with a carrier, I have to get an aircraft ready, get that aircraft to a launch point hundreds of miles in, and release the weapon which covers the final distance….with a Tomahawk, I can just launch, and it will cover 99% of the distance on its own…..shifting more burden of maneuver from the platform to the weapon, lowers the amount of set up time required for the strike…..

Mobility of a warship becomes more of a complicating factor the more lead-time you require to set up your attack…..warship mobility can make a big difference in the timeframe of setting up a mass aerial attack

Modularity and flexibility cost time, like maneuvering aircraft or shifting their loadouts….and in a short enough time span, the time cost of leveraging that modularity is actually a liability……

Timing challenge….force VLS platforms to be beholden to the lead time of setting up carrier air wing's strike?

Lead-time of setting up attacks…..the hours-long lead time to set up and deploy large aerial strike packages can afford surface forces enough opportunity to make maneuver matter tactically, where they could open the range and cover enough distance to perhaps complicate the consummation of an inbound strike…..Covering an extra 100 miles in three hours for a surface warship could make a meaningful tactical difference in some scenarios…

Unsure/Unused

And despite this being the U.S. military's primary tactic for sinking warships at range, the tactic of massed airborne anti-ship strikes has received relatively little attention in combat training from the strike fighter community after mainly focusing on anti-air and War on Terror skillsets for 20 years. (Source Graham piece and Stephen Walsh's piece).....one carrier captain stating that it's the first time he's seen it?

Sardiello quote: "We did some long-range strikes out there – at one point we had a wall of 14 fighters, each with two Harpoons apiece, going way beyond the horizon and striking against potential surface adversaries. That, I don't think that's been done in recent history, we were in the middle of nowhere and then we had to recover these aircraft, all of them, after this long-range strike."

Massing Fires with Aviation (Excerpt from Part 3)

These frameworks for assembling massed fires presume a relatively static laydown of forces from the start to finish of a firing sequence. This is a fairly reasonable assumption when missiles can travel hundreds and even thousands of miles within timeframes that a ship or land vehicle can travel only tens of miles. Most launch platforms will have to rely on the speed and range of their missiles to compensate for their platform's lack of near-term maneuver in a missile exchange.

Aviation is a critical exception to this. Aviation is the only launch asset whose speed can approach and even exceed that of cruise missiles. The scope of a weapon's reach can be greatly enhanced by the speed and range of aerial launch platforms, where aviation can put fires in many more places than warships can with similar-ranged weapons in similar timeframes. Through speed and maneuver, aviation can be dynamically repositioned to bolster aggregated salvos in tactically meaningful timeframes. This ability to add flexible on-demand fires makes aviation an especially potent force multiplier for distribution and aggregation. But leveraging aviation poses challenges for assembling massed fires.

First, an important contrast has to be drawn between the availability of fires from carrier air wings, warships, and bombers. One critical advantage carrier aviation has over warships in launching anti-ship strikes is logistics. Carriers have especially deep magazines, and air wings can be rearmed in a matter of hours compared to the days or weeks it can take to rearm warships exiting the theater. But it is quite possible that air wings cannot be armed and sortied quickly enough to satisfy pressing operational demands in a shorter timeframe, such as fitting into a tight firing sequence. It can take a considerable amount of time to finalize mission planning for a large airborne strike, arm dozens of aircraft with specific weapon loadouts, launch those aircraft, assemble the air wing in flight, and then prosecute the strike.[7] Aviation-based fires cannot be contributed until planes are loaded and made airborne.

While warships cannot rearm cruise missiles at sea like an air wing can, aviation cannot always match the promptness of warship-launched fires. By fielding weapons within launch cells, warships can fire salvos relatively soon after the decision is made to strike, essentially bypassing some of the steps it would take to deliver similar firepower through aviation.[8] Commanders attempting to combine fires from carrier aviation and warships may find the near-term time demands of setting up aviation are constraining quicker options for massing fires. Commanders in need of rapidly deployed firepower may very well opt for warship-based fires over aviation-based ones, and be willing to pay the steeper logistical price of depleting warships in exchange for the earlier application of firepower.

It may be too logistically taxing to keep most of a carrier air wing airborne and on station for the sake of maintaining quicker options for fires. Instead, it is more likely that a carrier air wing would be armed and launched once targets have been definitively selected and the strikes ordered. If enough anti-ship firepower is widely fielded to the point that entire air wings are not necessary to achieve volume of fire, then smaller numbers of carrier aircraft can contribute a fraction of the contributing fires and reduce the time required to prepare aerial strikes. But compared to carrier aircraft, bombers offer a much more stable and enduring source of on-station aerial firepower by virtue of their longer endurance. This on-station endurance can allow bombers to provide options for fires that are more quickly deployed than air wings that need time to prepare and get airborne for massed strikes. The following schemes of assembling massed fires with aviation are more feasible with heavy bombers than full carrier air wings.

Combining fires between ships and aircraft will often depend on how much repositioning aviation needs to set up its contributing fires. But repositioning costs time, where taking advantage of aviation's high speed to bolster salvos on demand will cost the time it takes to use that speed. That time is also needed to use speed to compensate for how U.S. aircraft are often limited to carrying smaller and shorter-ranged cruise missiles than the ship-launched weapons they can be combining fires with.

The time it costs to reposition aviation can delay massed fires, put aviation later in the firing sequence, and force other platforms to wait on aircraft to move. Flexible repositioning is one of aviation's greatest potential contributions to massed fires, yet the time it costs to reposition can complicate aggregation and firing sequences. A critical question is how to position aviation in advance to create options for quick and flexible fires.

The extent to which warships are forced to wait on aviation depends on aviation's position relative to the target and to the friendly warships they are combining fires with. The extent to which aviation will need to reposition after warships initiate the firing sequence mainly depends on aviation's proximity to the target. Simply put, how do things change if aviation is kept on station in the space between opposing fleets, or when aviation is kept behind friendly fleets?

If aviation is kept behind friendly warships, then warships will often have to wait until enough aviation is assembled and then maneuvered across lines of departure before the warships can initiate the firing sequence with their longer-ranged weapons. Those aircraft may then have much of their ability to maneuver on the way to the target tightly constrained by the need to adhere to the timing of the firing sequence while still having to travel hundreds of miles forward to their launch points.

If aviation is maintained in the space between opposing fleets, then warships can initiate massed fires without having to wait as much for aviation to reposition. In this scheme, the need to reposition aviation can be deferred to the point of it not being a hard prerequisite for initiating the firing sequence. Aviation would have more flexibility to maneuver as needed while the firing sequence is in progress, rather than be locked into a more constrained flight path from the outset and across a longer distance.

Maintaining aviation in the space between opposing fleets will allow massed fires to be initiated earlier. But aviation positioned in this space may be deprived of the valuable air defense and sensing support that friendly warships can provide. It can also be more risky to maintain an aloft presence with aerial tanking in such a forward position, and protecting strike aircraft in a forward position could create substantial air defense requirements for carrier air wings and other aircraft. But unless aviation has missiles with similar ranges and flight times as the larger warship-based weapons, a force that wants quicker options for massing firepower will accept more risk to aviation by maintaining aerial presence in the space between opposing fleets.

Regardless of where they are maintained in the battlespace, once strikes are ordered, aviation will often need to go far beyond the protections of friendly warships that can fire from much longer standoff ranges. If a bomber with LRASM needs to combine fires with a nearby warship's 800-mile-long Tomahawk strike, that bomber could have to travel 500 or more miles deeper into the contested battlespace before it can launch its own weapons. While other contributing salvos are in flight, aviation will have to be traveling deeper into the battlespace until the necessary time factors overlap so they can add their own fires. This challenge can be greatly mitigated by fielding larger or more capable cruise missiles that can shift more burden of maneuver from the platform to the payload, such as by equipping bombers with Tomahawks or extreme-range JASSMs. This would allow aviation to fire from more flexible standoffs ranges that are comparable to that of warships.

The disposition of aviation would be constrained by the relationship between the speed of the aircraft and the speed of the missiles they are combining fires with. In the U.S. military, many of the bombers and cruise missiles have similar subsonic speeds. Subsonic bombers like the B-52, B-2, and B-21 have fewer options for aggregating with subsonic salvos than faster aircraft. Aircraft that can outpace subsonic missiles, such as strike fighters and B-1 bombers, could be held further back and across wider distributions. If commanders are willing to pay the logistical price, they can use supersonic flight to surge these aircraft forward in time to combine fires with slower subsonic salvos.

Attack Waves/Multiple Rounds of Fires

Threads

Do you wait to process the results of an attack before launching another, or do you go ahead and launch another attack regardless to have a faster tempo and stay ahead? How much faith do you put in retargeting support to make major in-stride adjustments if you fire on shorter timeframes like that?

Volume of fire that is required to overwhelm targets may become less and less as the battle goes on….due to losses and depletion….tracking enemy depletion is important so you can have a sense of whether you can kill them for a bargain….the balance of the remaining offensive and defensive firepower and who still has the advantage after each successive round of fires…..how do you make sense of this evolution of depletion, attrition, advantage, and opportunity??

.....tension between multiple rounds of fires though, and letting loose with everything you have…what is to stop you from doing the latter? With keeping firepower in reserve? You may have enough firepower to kill the target and still have some left over….you may want to await lessons learned from the engagement….you may be targeting a specific force for operational effect even though other targets are available….

Similar to logic of how missiles that get destroyed in a salvo buy more striking opportunity for those behind it….earlier rounds can buy more striking opportunity for later rounds? How so? Is multiple rounds not an inefficient dilution of firepower? Wouldn't it just be better to do it all at once? How may multiple rounds transpire and it what circumstances could it be desirable?

First wave of fires can map out corridors for subsequent waves to traverse…..a distributed fleet can react by changing the courses and dispositions of its forces in such a way as to close these corridors in time for the next attack…. **(Graphic)**

If problems arise with coordination of fires and timing of launches, late launches could be organized into a second attack wave to have some semblance of cohesion, rather than devolve into a piecemeal fashion….so adjust the timing to a new firing sequence

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Operational-level of war chapter

Threads

Define and delineate operational level first……what is it?

How to align these operations in service of strategic objectives? How to win tactical engagements that matter to the larger context…..

Air superiority, securing it in relation to mass fires? As a hard prerequisite? In reality it may be more of a matter of gradual envelopes, degrees of superiority, limited in time…..but as aircraft attrition accumulates, it may tilt the balance in the later phases of the fight

Fundamental tensions between massing forces and massing fires as described in Kaigun pg. 333 on carrier doctrine…..and also bear in mind line from AC DMO project, distributed forces ostensibly less clear to target although at lower cost of weapons expenditure…..

The battle after the mass firings…..once the dust has settled?

The battle after the missiles have run out……what do we do then?

What is the mass firing warfighting concept if SM-6 and LRASM are the only weapons we have some of?

How do you take the initiative in naval salvo warfare?....Simply by firing first? Winning the scouting battle? Securing air superiority?.....Taking the initiative, faster tempo, who is reacting to who…..both sides are trying to fire effectively first…the side that fires first may apply major pressure on the killchain of the other, such as by triggering last ditch salvos fired on incomplete information……But if you fire first and your salvos are easily shot down without effect, you have not fired effectively first…..

Tempo and going faster than the adversary……faster killchains…..like faster missiles, consider the graphic that shows how multiple SM-6 salvos can be fired within the time it takes to fire a single MST salvo……

Is having enough volume of fire a necessary pre-requisite to taking the initiative to fire? Not necessarily….you can still shape adversary behavior and perceptions, and also inflict weapons depletion….

defeat in detail leads to cascading risk possibly and losing the initiative? Defeating the individual elements of a distributed force at economic weapons expenditure, could that force the hand at the fleet-wide level?

Options and flexibility…..you want to be able to take losses and still be able to muster volumes of fire that have a large enough margin to be confident……you don't want to feel like you are on the edge of barely having enough firepower…..

Descend into melee, fracturing of the force, what does it devolve into…..

Include section on surface fleet being outranged dynamic here?

Command of the sea is not one-dimensional, it is three-dimensional, air, surface, undersea… (from Kaigun)......temporal superiority in some domains….

Operational pauses….rounds of reconstitution….with lots of defaulting to steady state attrition in between (via submarine and air attack?)......what are the implications of these cycles and tempos?

Distribution of fire: The distribution of fires across targets, and the distribution of launch platforms……two ships shooting 100 missiles at five targets, versus five ships shooting 100 missiles at two targets……two elements of distribution….this is why they they think small combatants are such a good bet, the wide distribution of fire problem….Distribution of launch platforms for sourcing the firepower, and the distribution of targets to spread that firepower across….. How are fires distributed across the target set….multiple concurrent aggregated salvos…..

How do you exploit victory in the near-term, when that victory depleted you heavily and you have to leave a victorious battle to reload rather than press the advantage? Maybe you deplete your ASCMs and AAW weapons to create opportunities to project power with LACMs? (Like defeating barrier forces guarding Taiwan?) By temporarily earning superiority in certain domains, you earn opportunity to project power into others? Bear in mind what objectives and what opposition your forces are interposed between….what forces are between you and your objective….and bear in mind the operationa-llevel dimension of pressing the advantage, yes you have to leave to reload after a victorious battle, but now you've gained new and better options for the next battle, you've increased the military balance and preponderance of force in your favor, and may have even seized the initiative at the campaign/operational level…..

Does the wait-and-see IJN strategy of decisive battles plus steady state attrition map onto China's situation? Expecting deep westward thrust of USN at outset?

Much of the challenge has been about luring an enemy fleet out to see so it can be destroyed in a decisive engagement…..fleet can be lost in an afternoon….fleets are very picky as to when they sortie for decisive fleet combat operations…..you can lure them, or you can compel them….in the case of China's Navy, assuming they feel weaker…..how do you get them to leave a protective umbrella of land-based air defense cover………. Fleets and anti-ship assets may be forced to sortie to kill enemy fleets because achieving sea control is not a hard prerequisite for project power onto land, like launching Tomahawks, may feel compelled to attack enemy fleet lest they launch land-attack missiles, and in that case, they may be forced to simply absorb the firepower as best they can…..

How to exploit success in tactical engagement? What objective or opportunity lays beyond it? Can you do it immediately, or does exploitation lay on the other side of an operational pause?

Operational art is partly the art of knowing how to pick battles, knowing when to take them and when to decline them, and knowing how to set broader conditions that allow you to choose battles on more favorable terms….

What would be the strategic benefits of destroying the Chinese surface force? Creates opportunities for better delivery of missile firepower and submarines…..it would shift what kinds of forces they would need to protect their outer layers, shift their base of fire…..strategic implications of destroying the U.S. surface force?

Shattered Sword pg. 421 “Demands made on resources by time and distance….”....in a local sense but also in a broader sense….easier for China to mass 100 anti-ship missiles in the Philippine Sea than the U.S. in some ways? Expeditionary power projection versus A2/AD in a near sea

Tempo of operations…..trying to maintain a high tempo can be possibly accomplished through tight timetables and heavy scripting…..or through lots of delegated initiative that can maintain tempo despite things not going according to plan…..how does this apply to this specific context?

Force allocations….. “policy of fighting fewer battles, but bringing a bigger stick to each….”....critical mass of platforms for achieving critical masses of fires…..

Multiple Rounds of fires….how much depletion is enough to trigger an operational pause? Tension between that, and perhaps trying to squeeze in more blows, believing the enemy to be even more depleted…..

During the operational pauses between major actions, what else is happening? Consider Russia-Ukraine and how things default to attritional artillery and drone strikes when maneuver operations are not possible for the moment…..maybe it defaults to attritional air and undersea strikes, and perhaps small-scale surface actions….but most warships will be preserved for massing forces perhaps, building combat power during operational pauses…..

Geometry of distribution: Setting up the geometry of distribution that is the foundation for distributed attacks, that will determine what your firing options are…….and what exactly could this geometry look like?...and being able to flex the geometry on a theater-wide basis…..the geometry of possible options and mass firing sequences will change depending on a variety of circumstances, including the spread of depletion across platforms, the operational cycles of aircraft, and attrition…...interfering with the deployment of this geometry of an opponent is critical…..and once it is deployed, where do you focus your efforts? How can you best undermine an opponents' geometry? The true geometry is hard to know of course because of the fog of war, distribution, and scouting efforts….the geometry of land-based flight operations are well-known because of the fixed location of bases….the geometry of mobile centers of fires like warships introduces more flexibility for oneself and uncertainty for the adversary…..how does the concept of attrition/maneuver fire/maneuver apply here? "You maneuver to improve opportunity to fire, you fire to improve opportunity to maneuver".....if a naval formation is sunk, aircraft are your maneuver forces that can now quickly exploit that air defense gap that is opened up by the destroyed warships, that new position may offer new angles for growing the volume of fire…..

How closely to sequence mass fires? A couple sequential fires in the span of a single attack….versus a second whole new wave…..how do we set ourselves up to be well postured for the immediate next round of attack….and what are we waiting on before starting the second wave? Awaiting BDA and effects before recalibrating our next attack?....and like chess, trying to see several steps ahead……the targeting picture may resolve itself in crucial ways during the course of mass fires, and especially due to enemy reactions to incoming mass fires, it makes sense to have reserve firepower ready to launch to augment mass fires in real time in prompt reaction to the changing sensor picture……

Battle of Leyte Gulf….forces within the individual battles were stretched thin tactically, but were mutually supporting operationally….

Depletion as a major source of operational pauses and tempo, ceding the initiative….a form of victory, what do you do with it…..

Crossing the T principle….some kind of positional or informational advantage that allows you to maximize massing of fires while simultaneously minimizing the adversaries?

Luring with bait…..offering a juicy yet manageable portion of a fleet to entice the enemy into attempting defeat in detail, and then pouncing on their larger force with your main body….like at Jutland…how does this work in salvo warfare?

Giving them progressively worse scenarios…..after Battle of Midway…..then Battle of Philippine Sea….then Leyte Gulf…..then Operation Ten Go…..

Systems confrontation warfare….how does that apply to naval warfare, salvo warfare? What are the key nodes and lynchpins to target?

Temptations to plan one large attack to kill the enemy fleet in one fell swoop…..natural inclination, but may be tempered by multiple factors, including…..collecting data on the offensive/defensive balance, weapon interactions….depletion, shaping behavior as a result of inflicting partial losses, maintaining some presence of forces…….is this a sprint or a marathon? The tensions between the two…….

Operational pauses to assemble a critical mass of forces to relaunch meaningful attempts….otherwise feeding piecemeal forces into the fight as soon as they become ready, risking defeat in detail…in a pointless fight for initiative, thinking it barely hangs in the balance…..have to be able to accurately perceive this and know when to pause…..

Being able to perceive degree of coordination and crispness of enemy fires coordination….are they crisp or are they fighting ruggedly? What does that look like, what could it mean, and how to take advantage?

Not just preparing for battle, but for war….having a longer term perspective, knowing how to structure a series of battles, a series of campaigns….long term material and personnel preparation……

If distribution of the fleet is so wide as to threaten being stretched thin…..where assets could be sucked into other types of engagements that diminish the cohesiveness of the broader fleet……what if surface forces get sucked into air defense missions of protecting allied territories? Air defense is heavily depleting and emissions intensive, could threaten the ASUW capability of the broader fleet…..

Commander should be able to take stock of the missile firepower of opposing formations, envision the tactical possibilities, and decide whether the force is worth sortieing…..when major fleet battles are possible, fleet have not often sortied when they cannot guarantee a preponderance of force, and instead opt to be fleets-in-being…they can be compelled to come out by threatening strategic objectives…..but a good commander understands the balance of force, the balance of advantage, and doesn't commit forces to decisive actions when an advantage is not apparent…..how apparent is the advantage really in salvo warfare?

Scouting fires

Threads

Reconnaissance by fire, a known Army tactic

Faster missiles have a smaller area of uncertainty than slower missiles, scout on behalf of them….?

Salvos as critical sources of information….pull excerpt from N98 brief?

Battle of nerves

If it all it takes is a few missiles to get a battlegroup to light off its sensors, then that tiny volume of fire will have more than paid for itself

Scouting fires from what platform? Submarines could be interesting…

Scouting fires better to be shot down by aircraft? To minimize how much those fires discovered/stimulated…..

Fictional Narrative

A fleshed out illustrative narrative of fleets engaging each other with mass fires.

Tactical Factors

- depletion
- timing
- reinforced volume of fire
- spread of capability across weapons and platform types
- last-ditch salvos
- Air defense ambushes
- combined arms relations
- contested aerial battlespace
- salvo patterns, smart missile behaviors
- waypointing and feinting attacks
- Joint fires Integrators
- Deception, seekers discriminating against traffic
- Chinese forces hiding within traffic
- Rapid overkill

Specific Vignettes

- Aircraft pilot participates in ship self-defense mission, ship gets destroyed shortly after discharging last-ditch salvo, pilot subsequently guides the salvo with retargeting and datalinking as revenge….LACMs and ASCMs part of the salvo, pilot arranges the attack pattern in a certain way……has to contend with defending fighters, who shoot him down (ejects?), but he successfully destroys the Chinese formation, which launches a last-ditch salvo of their own, watches PLA fighters escort the last-ditch salvo as he parachutes down….

- DDG captain makes decision to fire last-ditch salvo
- Saying screw it to the firing sequence and launching immediately….small volume of fire easily batted away….
- Smart missile….internal dialogue of an LRASM….
- Consulting with a highly classified fleet-level AI to design mass firing sequences, choosing among options
- Sailor crumbling from psychological stress
- Someone losing the battle of nerves in salvo warfare
-

Other elements:

- Names and people, including first person perspective from the PLAN, and personal reactions to things like last ditch pressures
- Both sides dying plenty
- Realistic force sizing
- Realistic objectives
- Feature all major warfare communities (Surface, submarine, aviation, IWC, and SOF)
- Joint and allied components, to what extent…..
- Something personal and visceral, the smell of burnt flesh, vomit, torn open bodies….
- Use abundant names, don't treat things as just planes or ships, bring the human element to the forefront….
- Being forced to engage in boring or tedious duty…..missions they don't want to do, or that match the valorous ideal….
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<u>Other Ideas</u>

Maybe make a wargaming demonstration out of it and link to the video….

Consider republishing during a fiction week?

For examples: See Wayne Hughes and Jeff Vandengel's narrative chapters, Dave Poyer

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