



Maintaining America's Edge

Overcoming Advanced Air Defenses



American Security Project



Perspective

Matthew Wallin

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In this Report:

The return to great power competition highlights a need for the United States to develop and invest in technologies capable of overcoming advanced air defense systems. The capabilities of modern Russian and Chinese-produced air defense systems will limit US abilities to destroy targets on the battlefield, especially as these systems proliferate around the globe. This report presents an overview of the threats posed by these systems and considerations the US must make for investments in the precision guided munitions necessary to ensure continued mission effectiveness.

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IN BRIEF

- America's technological dominance in precision guided weapons is shrinking.
- Newer advanced air defense systems developed and deployed by America's adversaries threaten the ability of the U.S. military to destroy targets and achieve missions.
- An inability to destroy a target with minimal munitions has a negative impact on cost, lives, equipment, and a mission's time frame.
- The U.S. should invest quantitatively and qualitatively in more precision guided weaponry that spans a variety of survivability methods.
- Mission commanders must have options on the table to deal with different threats.

About the Author

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The Strategic Need: A Return to Great Power Competition

The 2018 National Defense Strategy signaled a major shift in US defense priorities: “Inter-state strategic competition, not terrorism, is now the primary concern in U.S. national security.”¹

For the course of the Afghanistan and Iraq wars, a primary challenge facing our military was the threat of relatively low-tech weaponry. The proliferation of IEDs resulted in completely new equipment, vehicles, and technologies to counter this tactic. But the course of these wars also demonstrated in stark detail the capabilities and tactics of Americans in combat, all to the closely watching eyes of Russia and China.

In this new age of great power competition, the premise is that the US is no longer fighting vastly inferior forces in pickup trucks, but rather peer or near-peer competitors. For years, the Russians and Chinese have been developing systems intended to counter the American technological advantage—an advantage that is waning as these countries have developed their own advanced technology. While non-state actors had access to anti-aircraft guns and/or manned portable air defense systems in Afghanistan, Iraq, and Libya, nothing in those arsenals compares to the modern anti-access/area denial capability of Russia or China.

These modern anti-aircraft systems not only pose a threat to the aircraft of America and her allies, but to the very munitions dropped or fired by these aircraft and naval vessels. What good are American precision weapons if they can be destroyed, disabled, or diverted before they can hit their targets?

Beyond the challenging issue of air defense, great power competition greatly affects the scale of conflict in which the US could be operating. Illustrating the challenge, in 2011, NATO allies engaged in the bombing of Libya began to run short on guided munitions such as laser guided bombs.² A conflict against Russia, China, or even North Korea would be significantly more taxing on the quantity of precision guided munitions required—especially due to the greater number of targets on the battlefield. Further complicating the matter in Libya, the US could not resupply these allies due to incompatibility between the American stockpile and the foreign aircraft of its NATO allies. Much as NATO standardized the ammunition for small arms across the alliance in order to satisfy logistical and resupply needs, the US should encourage the adoption of cross-compatible advanced munitions and hardware across the alliance. This should include full compatibility with delivery platforms like the F-35.

The Problem: Air Defense

Russia and China are increasingly bolstering their ability to threaten or deny airspace to potentially hostile (i.e. American) aircraft. Long range anti-aircraft missiles compromise the ability of military aircraft to approach and attack a target. To protect American or allied aircraft and pilots, the military relies on technology including stealth aircraft or stand-off weaponry like cruise missiles to reach inside the contested airspace and destroy those systems, thereby shrinking the size of an adversary’s defense envelope. However, stealth aircraft and their human pilots can still be still vulnerable to advanced detection systems. Some current and legacy stand-off cruise missiles are also not always guaranteed to reach their targets due to multiple layers of defenses, including surface to air missiles and close-in weapons systems.

The threat to America’s technological dominance and its ability to destroy a target is increasing.

Russian propaganda outlets such as RT and Sputnik have repeatedly touted the effectiveness of Russian-made air defense systems, claiming that many of the cruise missiles fired into Syria in 2018 were intercepted or otherwise shot down without presenting any credible evidence.³ While there is no independent information that supports this claim, the premise is plausible.

A properly operated and fully armed advanced air defense system can destroy incoming precision guided weapons. Even “dumb” gravity bombs, or those modified into precision weaponry like the Joint Direct Attack Munition (JDAM), are potentially vulnerable to an effective air defense system.

The S-400, an advanced long-range surface-to-air missile system exported by Russia, has been deployed to countries like Syria and China.⁴ The export of systems like the S-400 to middle powers around the world significantly raises the threat to America’s ability to conduct military operations in these areas. Perhaps just as concerning, as a NATO ally and potential F-35 operator, Turkey’s interest in the S-400 system risks the stealth effectiveness of the entire F-35 system,⁵ as it could potentially be used to spy on the F-35’s characteristics in flight. By the end of 2020, Russia estimates it will field the new S-500 system.⁶

A number of other Russian systems include the Pantsir S1 and S2, a truck-based short range anti-air system combining guns and missiles; and the AK-630M2, a ship-based twin-30mm close-in weapons system (CIWS) that fires 30mm projectiles at a rate of 10,000 rounds per minute.⁷ A Chinese CIWS, the type 1130, also has a rate of fire of 10,000 rounds per minute and has been equipped on Chinese naval vessels.⁸ These systems are specifically designed to destroy incoming munitions in the final moments before impact.

As more advanced weapons systems are introduced to the battlefield, the US will need to be prepared overcome these defenses, noting that technology will need continuous improvement and innovation.⁹ These weapons will begin to saturate the battlefield as the technology becomes cheaper and more readily available.

In areas like the South China Sea, where naval forces are most likely to clash, precision guided weaponry capable of overcoming air defense systems in a crowded battlefield can potentially determine the victor in any clash of arms.

Without proper technology to overcome these integrated air defense systems in a conflict, the cost in terms of lives and treasure is likely to increase. Currently, the US military often fires multiple munitions at a single target in order to ensure its destruction, as not every weapon is guaranteed to hit the target. However, as future conflict may include larger target sets that are better defended and over a wider area than the U.S. has attacked before, the number of precision guided munitions required to kill a target will increase significantly,¹⁰ thereby raising the total cost.



A missile transporter erector launcher of the S-400 system. Photo credit: Vitaly V. Kuzman / Wikimedia Commons.

The U.S. and its allies need to ensure their ability to destroy ground and sea targets, while protecting their pilots and keeping total costs and munitions at a minimum. A failure to do this will negatively impact a commander's ability to accomplish the overall mission, as surviving targets may pose threats to friendly forces, and supply line capacities are strained by the number of munitions required to complete the mission.

The Solution: Increasing Survivability

The United States needs more long-range precision guided weapons.¹¹ These weapons need to be both affordable and capable of hitting the target—that means they must be able to survive until the point of impact.

There are several means to overcome the challenges posed by advanced air defense systems:

- **Overwhelm:** This can be accomplished by deploying more munitions, or submunitions, than the network or installation is capable of engaging. The larger the network, the more munitions must be expended as multiple overlapping defenses increase effectiveness. By its nature, this can be incredibly expensive, especially if the primary munition is a \$1.4 million cruise missile.¹² Additionally, to increase the effectiveness of this type of mass or swarm attack, an optimal number of missiles need to arrive on target simultaneously, thereby limiting the ability of a defense system to engage multiple targets with sufficient time to track and engage the next.
- **Expend:** Forcing enemy air defenses to wastefully expend ammunition can pave the way for other attacks. This too can be accomplished using multiple munitions, which in theory should force the air defense system to engage and run out of ammunition by means of the sheer number of incoming targets. As indicated by a recent Israeli strike in Syria, forcing an air defense system to expend its ammunition can be effective.¹³ However, in a conflict against a more capable adversary like Russia or China, training, logistics, and supply lines may be sufficiently robust to minimize the downtime caused by over-expenditure of ammunition.
- **Evade:** Evading enemy air defenses can be accomplished by a variety of means. One technique is to fly low, thereby using terrain features and man-made structures to hide from radar signals. The effectiveness of this technique is minimized over open ocean. Another method is to reduce radar cross section (essentially visibility to radar), which can be accomplished through a combination of size, shape, and “stealth” radar-absorptive technology. Maneuverability, and thus the ability to dodge projectiles or missiles is another desirable trait. Speed can reduce the time a defense system has to track a target, or the time that target has to avoid an incoming attack. As air defense systems often fire high speed defensive missiles, outrunning these defense systems is extremely difficult.
- **Confuse:** Electronic warfare can be used to confuse an enemy air defense system. This could come in the form of radar jamming, disruption of communications, or other methods. The potential result is an inability to properly track or engage an incoming missile or aircraft.
- **Distract:** Decoys can be deployed to either overwhelm an air defense system, divert its attention, or force it to wastefully expend ammunition. Some decoys can use electronic warfare methods to confuse or simulate the appearance of specific munitions or aircraft on an enemy weapon system.¹⁴ Additionally, cheaper munitions or low-cost drones could be used to distract a defense system from targeting the primary delivery munition.

Each of these features and tactics has advantages and disadvantages.

For example, both overwhelming and wasteful expending can lead to a defense system running out of ammunition. Overwhelming a target typically requires multiple sacrificial munitions, many of which will prove redundant or be destroyed. Forcing the defense system to engage these sacrificial munitions and run out of ammunition in doing so inherently assumes a certain degree of “waste” on the part of the attacker as well. A key question to answer is how to increase the likelihood of hitting a target without requiring so many munitions and the potentially higher cost that comes with that.

Alternatively, stealth comes with its own set of limitations, like the total payload that can be delivered to a target. Illustrating this, in order to maintain its stealth attributes, an aircraft like the F-35 must carry its weapons in an internal bay instead of on the wings.¹⁵ This conceals the weapon and preserves the stealth shape of the aircraft.



An F-35 displays its internal weapons bay. Carrying weapons internally preserves the stealth shape of the aircraft. USAF photo.

Munitions carried externally create additional surfaces which reflect radar signals and significantly impact an aircraft’s undetectability.

To overcome some of the drawbacks mentioned above, the U.S. should focus on increasing the survivability of the precision guided weapons themselves. Upgrading the survivability of America’s smart arsenal accomplishes several things. First, it increases the likelihood of the target being destroyed. Second, it decreases the number of weapons deployed to destroy said target, thereby potentially decreasing cost. Third, it increases the operational tempo of military action, thereby increasing the likelihood the US will prevail in its objectives.

Yet as new countermeasures are developed against U.S. advanced weaponry, variety may outweigh perceived superiority. Having a variety of attack methods with varying survivability features, possibly deployed simultaneously against a target, reduces the chance that target can be successfully defended. Should stealth technology be overcome by advanced tracking and detection systems, another feature, such as maneuverability or speed may become more vital.

Options on the Table

Rather than seeking a one-size-fits all weapon, it may be advantageous to have a variety of weapons in the arsenal from which to choose. This variety may provide for a better overall response to a specific threat.

As adversaries develop defenses that could be effective against a particular system, the US should avoid putting all our eggs in one basket. It is better to have a small portion of America’s smart weapons rendered obsolete, than the entirety of the arsenal. For instance, if the US invests heavily in weapons that rely on speed over maneuverability or stealth, a Chinese or Russian ability to track and destroy that high-speed weapon would render most of them useless.

Similarly, a weapon relying entirely on stealth may be compromised as detection technologies improve. A missile relying solely on GPS may have its ability to fly a course compromised if the military GPS system is jammed, spoofed, or otherwise made unreliable. Having a backup weapon that retains other traits or abilities is therefore desirable. Additionally, it may be cost-effective and desirable to have the ability to upgrade components and software to counter new defense capabilities.

The United States already operates several types of cruise missiles, both air- and sea-launched. With the dissolution of the INF treaty, the development of land-based cruise missiles is possible, but likely unnecessary, as both the air- and sea-launched weapons may be sufficient for America's defense needs. The U.S. should



The Tomahawk cruise missile has been the backbone of America's stand off arsenal for decades. DoD photo.

invest in increasing both the types and numbers of these missiles in its arsenal, as they already have the ability to strike targets deep inside enemy territory,¹⁶ and are more mobile in nature than a land-based counterpart.

One option for increasing the inventory is the Joint Air to Surface Standoff Missile (JASSM), which saw its first combat use in 2018 when the U.S. deployed the weapon against Syrian targets.¹⁷ The upcoming XR version of the missile promises a 1,000 lb warhead and 1,000 mile range,¹⁸ thereby giving pilots an added measure of safety. This latest-generation cruise missile is compatible with various types of US bomber and fighter aircraft.¹⁹

Another option, the Joint Strike Missile (JSM), offers several unique capabilities not available in the other options currently employed by the United States Air Force. The JSM, designed in NATO ally Norway, offers a combination of high maneuverability, an extremely low flight path, and the ability to be stored internally in the F-35A/C's weapons bay²⁰—thereby preserving the aircraft's stealth features. That stealth capability is especially important for the initial stages of a conflict, when enemy air defenses need to be destroyed. The U.S. needs a missile capable of allowing the F-35 to fulfill this mission.

The U.S. has also been investing in developing hypersonic technologies. These weapons travel at speeds exceeding Mach 5. There are two varieties:

- Hypersonic cruise missiles: These are faster versions of what we currently call cruise missiles and are powered throughout their flight
- Hypersonic boost glide vehicles: these are launched into the upper atmosphere or space in similar fashion to a ballistic missile, with a separating glide vehicle that guides the warhead to its target unpowered.

Hypersonics are capable of evading modern air defenses by means of sheer speed and maneuverability.²¹ However, as the launch profile of a boost glide vehicle can be easily mistaken for an ICBM, these weapons could accidentally trigger a nuclear conflict.²² Due to this risk, it makes more sense for the U.S. to make further investments in hypersonic cruise missiles, but these weapons are unlikely to fit within the F-35 weapons bay. If stealth is necessary to a mission, these weapons would likely be limited to the B-2 or future B-21 bombers due to their large internal weapons bays. However, these aircraft will be relatively few in numbers and short on availability compared to the F-35.²³

Considerations

Regardless of the advantages of specific options, a critical consideration of any option needs to include an examination of the cost in destroying a target vs its ability to do so. This is a tricky thing to assess. For example, a target may be destroyable via several options:

- (1) A precision strike by one or multiple JDAMs;
- (2) A single \$2 million cruise missile with a high probability of hitting the target;
- (3) Multiple \$800,000 cruise missiles with a lower chance of hitting the target individually;
- (4) A combination of lower cost munitions, decoys, jamming aircraft, etc.

Choosing which option is best is a balance against the monetary and combat value of the target, the threat posed by the assets employed against it, and the value of eliminating that target to the mission (and potential cost in lives). For instance, it would not make financial sense to use a \$2 million cruise missile to destroy a pickup truck in an area with no air defenses. Additionally, the explosive yield of the munition used to destroy a target may be a factor in areas where civilian casualties are possible, or the destruction of the target may release deadly chemicals.

The bottom line is that the United States must have options. A variety of advanced missiles, decoys, and aircraft are needed to maintain an effective military edge over Russian and Chinese air defense technology. Lower-cost munitions are desirable for less-risky environments that do not require advanced evasive technology. The different defense characteristics of the targets US forces may face in-theater require a variety of tools to overcome those characteristics.

Final Recommendations

To maintain America's ability to fight and win wars against adversaries with advanced air defense capabilities, the U.S should:

- Invest quantitatively and qualitatively in more precision guided weaponry that spans a variety of survivability methods.
- Invest in low-cost, high volume systems that help enable the survivability of more expensive/destructive precision guided weapons.
- Ensure new munitions are upgradable if appropriate, in order to cost-effectively improve existing weapons to overcome air defense advances.
- Perform regular cost-per-kill analyses on weapon systems, delivery vehicles, and targets.
- Expand alliance interoperability, ensuring allies are capable of filling in supply chain gaps, carrying compatible munitions, communicating, and supplementing logistical capabilities.

In the era of great power competition, the conflicts may be simpler than the insurgencies and terror groups that America has been fighting in recent decades, but the consequences are potentially much greater. No one should want to fight a war against Russia or China, especially with the nuclear implications. But the export of advanced Russian and Chinese tech to other powers raises the stakes for American military operations around the world—and the U.S. must maintain its technological edge to ensure military effectiveness and deterrence. Conventional deterrence against these powers can be demonstrated by the ability to hit targets in contested air space. If Syria has taught us anything, it's that operating in close proximity to other great powers will require both careful diplomacy and a contingency plan in case things go awry.

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The American Security Project (ASP) is a nonpartisan organization created to educate the American public and the world about the changing nature of national security in the 21st Century.

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