Airman secures Joint Air to Surface Standoff Missiles on flatbed truck at munitions storage area on Ellsworth Air Force Base, South Dakota, October 2019, as part of U.S. Strategic Command's exercise Global Thunder 20 (U.S. Air Force/Christina Bennett)

The Challenge of Dis-Integrating A2/AD Zone

How Emerging Technologies Are Shifting the Balance Back to the Defense

By Alex Vershinin

Today, America's adversaries are building antiaccess/area-denial (A2/AD) zones to keep the U.S. military out of key strategic regions. A2/AD is a series of sensors; antiship, antiaircraft, and ground defenses; and long-range fires utilized by U.S. competitors and designed to prevent the United States from entering into a close fight.[1] We see Chinese A2/AD zones set up to deny U.S. access to Taiwan and the South China Sea. Russia uses A2/AD zones in Kaliningrad, Crimea, the Kola Peninsula, and the Kuril Islands to block key maritime avenues of approach. In the past, the weakness of these zones were the command and control nodes, which formed a

Lieutenant Colonel Alex Vershinin, USA, is Director of Technical Integration at the Army Futures Command Studies Group.

single point of failure. Utilizing precision-guided technology, the United States would wage a short, inexpensive decapitation campaign aimed at these nodes. Their destruction would break up integration of enemy defenses, also called *dis-integration*. For decades, the offense-defense balance was firmly on the offense. Emerging technologies in the fields of network, artificial intelligence, and space are shifting the balance back to defense, making these zones more dangerous. At the same time, the United States may have overestimated the effects of long-range strike capabilities after three decades of fighting nonpeer competitors. Unable to fight a short decapitation campaign, the United States may be forced into a prolonged attrition campaign, at unacceptable political costs.

What Is A2/AD?

A2/AD zones are composed of intelligence, surveillance, reconnaissance (ISR), and defensive and offensive strike systems. ISR systems are utilized to spot incoming threats for engagement by defensive strike systems. Offensive strike systems attack enemy bases, logistics, and command and control (C2) infrastructure seeking to delay the buildup of U.S. forces. Adding to the effectiveness of the A2/AD zones are the decoy and deception operations that favor ground-based defenders and increase the defender's survivability. Combinations of these techniques with emerging technologies are making defense the stronger form of warfare for the foreseeable future. The key strategic objective of the defender is not to defeat the United States in battle, but to increase the costs to the United States until the potential political gain is outweighed by the loss.

Current: Advantage Offense (United States)

Traditionally, the defender has relied on combinations of ground-based radars, human intelligence, and ground reconnaissance to gain an operational picture. Wealthier states could afford to augment these sensors with an Airborne Warning and Control System (AWACS), consisting of powerful radars mounted on large passenger planes, unmanned aerial vehicles, and space assets. The augmenting assets are expensive and available only in small numbers. This makes them early high-value targets, unlikely to survive prolonged conflict. Within a month of conflict, the United States would destroy most of them, forcing the defender to rely on his primary systems for early warning and targeting.

For the U.S. military, the main strike capability has always been land- and sea-based airpower. U.S. adversaries' solutions were ground-based air defense. These air defenses are relying on ground-based search radar to identify incoming strikes and attack radar, which paints the targets for the defending missile. The search radar has numerous weaknesses. It is stationary; thus, its coverage is limited and can be bypassed. Once turned on, electronic warfare (EW) aircraft can identify its location and destroy it with standoff antiradiation missiles that home in on radar emissions. Historically, an attacking air force can suppress air defenses after a month-long air campaign.[2] Ground search radars can be augmented with AWACS. These aircraft are more survivable than ground-based radars due to their mobility, but the introduction of long-range and very long-range air-to-air missiles, together with low observable aircraft, are rapidly negating the effects of AWACS, retaining advantage for offense.

Reliance on ground-based search radar forces the defender to centralize the C2 structure. Passing targeting data between batteries requires a single central control node. This weakness is exacerbated by the effectiveness of suppression of enemy air defense missions using antiradiation missiles. Unable to continuously emit, defenders must rely on rolling emissions by several radars to gain a picture of their airspace. It is a process where several radars cover the same area and turn on and off for short durations before moving. Only a centralized headquarters can coordinate that effort and tie it in with defending fighters. This gives the attacker few key nodes for targeting. Destruction of these nodes will rapidly dis-integrate the enemy's A2/AD defense. The missile launchers will still be there, but they will not be able to engage without warning and targeting data telling them where to shoot. So far, the balance is in favor of the offense.

Next 10 Years: Advantage Defense (Adversary)

Emerging technologies are changing this 10-year prediction. One key technology is the miniaturization of cameras and satellites. New microsatellites are cheap, small, and effective. A single rocket can deliver 80 small photo reconnaissance satellites into orbit.[3] This technology has allowed the U.S. firm Planet to photograph any corner of the Earth with one of its 200 satellites, updating images every day with 2-meter resolution.[4] The defender does not need to cover all the Earth; he just needs to cover the conflict zone. He can accomplish this by seeding the orbit over the conflict zone with 300 to 500 microsatellites, especially if these satellites are able to generate imagery of 1-meter resolution and transmit data every 5 to 10 minutes. This satellite constellation will have complete photo coverage of the battlespace and be able to spot any aircraft or ship coming into the conflict zone. This system is even more dangerous because antisatellite weaponry is extremely expensive. For example, both antiballistic and antisatellite (Standard Missile 3, or SM-3) missiles cost between $15 and $18 million each. To make matters worse, in 2018 the Department of Defense planned to buy only 40 of them.[5] There may simply not be enough antisatellite missiles to destroy an enemy constellation. There are direct energy weapons coming online, and the Russians recently claimed to have operationalized one.[6] Yet even those systems are few in number and may not be able to attrit a satellite constellation faster than the enemy can reseed it. In short, this constellation may be extremely survivable to the point where an attacker might not be able to neutralize it due to the large number of targets.

Space-based ISR will be augmented by aerostats. These are high-altitude balloons or blimps. They can maintain a position at 70,000 feet above sea level and have visual coverage of up to 775 miles.[7] Aerostats vary in cost but are far cheaper than interceptor missiles and can be easily replaced. Functionally, they are like microsatellites—a cheap and resilient, wide-area ISR system.

More powerful high-speed computers allow algorithms to rapidly process thousands of surveillance images, identifying incoming aircraft or ships based on preprogrammed image recognition. It also allows prediction of trajectories based on several images collected with the ability to pass that data across the battle network. The United States has been working on a similar capability in Project Maven.[8] This data will not be enough for targeting, but it will generate an early warning system robust enough to replace ground-based radar systems without any of their weaknesses. As computers get smaller, they can be mounted on the microsatellite. This allows data processing to be done in space and only targeting data to be passed across the network. This reduces the bandwidth requirements and speeds up the time to identify targets. Instead of updating target location every 5 minutes, it can be done every minute, resulting in greatly increased effectiveness of early warning systems.

Where an attacker can gain an advantage is in the defender's logistics. Once enemy air defense artillery fires, it requires resupply. An attacker can use the same space-based ISR combined with high-speed computing power to develop algorithms to track resupply vehicles traveling to locations from which missile launches have been detected. This method will give the attacker a general idea where the enemy defenses are; unfortunately, the defender must start shooting before it can be utilized.

Another defensive advantage is electronic warfare. The increased bandwidth and processing power of computers allow U.S. adversaries to network their electronic reconnaissance. By networking all his EW reconnaissance assets with analytical systems, the defender can analyze the emissions of attackers in real time and determine which targets are real and which are decoys. It can rapidly identify incoming threats that generate emissions that may have been missed by other systems. Russia has this capability in its Moskva-1 system.[9]

Standard Missile-3 Block 1B interceptor missile launches from USS *Lake Erie* during Missile Defense Agency and U.S. Navy test in mid-Pacific, May 2013 (U.S. Navy)

Underpinning the enemy system is the network. For any data to be relevant, it must be easily passed from one system to another. The network must be robust and secure. Quantum computing technology introduces communications that are long range, difficult to locate, and nearly impossible to break into.[10] This network allows data to be rapidly passed between early warning satellites and ground-based defense systems. In addition, the defender owns terrain and will have time to lay fiber cable between his battle positions, reducing emissions and defending its network against jamming.

It will be difficult to isolate specific portions of the battlefield. We know that our adversaries are looking to develop such networks and technologies, and it is only a matter of time before they succeed.[11]

How the New ISR Comes Together

The defender will retain ground-based search radars but keep them off and rely on satellites and aerostats to provide early warning and to cue attack radars. Without emissions by the ground-based radars, the attacker will be unable to locate enemy antiaircraft and antiship missile batteries before they fire. The ground search radars will only be activated if the network fails, giving the A2/AD complex redundancy should it be temporarily dis-integrated. Neutralizing them will become far more time-consuming and costly in terms of munitions expended and aircraft lost. The penetration of a robust A2/AD system requires the attacker to converge complementary capabilities from multiple units and services. The challenge is the amount of time needed to plan such a deliberate operation and the availability of key capabilities. If any capability such as EW aircraft is not available, then the entire mission must be canceled.

The digital network that passes data directly from satellite and aerostat early warning systems to the ground-based shooters allows the defender to decentralize command and control. Data carried across the network is generated by each reconnaissance node and is seen by all shooting nodes. For example, when a satellite constellation picks up a target, it automatically puts the data out on the network so that every shooting battery sees it without headquarters in the loop. Even fighter aircraft can operate independently based on priorities published prior to conflict. This system removes headquarters as a single point of failure in a defender's A2/AD zone, making the task of dis-integrating more challenging. A recent speech by General Valery Gerasimov, chief of the Russian general staff, indicates that this is the direction Russia is planning to go.[12]

Survivability

The next key topic is the survivability of adversary A2/AD systems. There are two issues. The first is the effects that munitions have on targets and the number of strikes needed to fully neutralize enemy defenses. The second is the increased effectiveness of modern decoys and camouflage.

Decreasing Effects of Long-Range Fires

The most common long-range fire systems employed by U.S. forces are Tomahawks and Joint Air-to-Surface Standoff Missile–Extended Range (JASSM-ER) long-range missiles. Their key advantages are their long range (over 1,000 kilometers), precision, and the absence of danger to human pilots. They can be delivered by aircraft, submarines, and surface ships. In the past, these weapons were fired early in a conflict to destroy search radars, degrade airbases, and neutralize key nodes in an enemy's A2/AD system. The effectiveness of these weapons may be overestimated because we have fought nonpeer enemies. During the conflict in Syria, the United States employed massive cruise missile strikes on two occasions; in both cases, the damage inflicted was in no way proportional to the amount of munitions used.

During the strike on Shayrat Airbase on April 7, 2017, the United States fired 59 missiles. Satellite imagery shows only 44 targets hit, although some may have been hit twice.[13] It is possible that Russian jamming may have diverted some missiles off target, although there is no way to be certain without access to classified information. Russia's Krasukha, an electronic warfare jamming system, was reported in the area at the time of the strike.[14] Regardless, the airbase was launching airstrikes less than 24 hours after the attack.[15] While the base was warned an hour ahead of the strike, it was not equipped or postured to endure a conventional precision strike.

The second strike took place on April 14, 2018. A combination of 109 JASSM-ERs, Tomahawks, and SCALPs (a European cruise missile) was fired at six buildings. The second strike was purely political in nature and is harder to assess for weapon effectiveness. There are indications that some of the incoming missiles (Tomahawks and SCALPs) were intercepted. The Russian government has presented missile remnants showing clear damage from air defense artillery (ADA) fragmentation impacts.[16] In addition, there is video evidence from Damascus showing incoming missiles intercepted by defensive missiles.[17]

At sea, the situation has been even more difficult. An attacker's surface ships entering A2/AD zones are vulnerable to antiship missiles, especially new hypersonic systems such as the Chinese DF-26 and Russian Zircons. Even submarine launches are becoming a challenge as defending diesel submarines are becoming quieter and increasing their submerged time thanks to independent air propulsion. During an April 2018 North Atlantic Treaty Organization (NATO) missile strike, a state-of-the-art British *Astute*-class nuclear submarine was located and harassed by a pair of Russian *Kilo*-class diesel submarines. It is suspected that it failed to participate in the attack because of the harassment.[18] The combination of antiship missiles and cheap diesel submarines can be used to keep attacker's ships away from an A2/AD zone. It is possible that in the future, aircraft will be the only means of reliably launching cruise missiles.

The number of missiles required to destroy a target is another issue, and there may not be enough missiles in U.S. inventories. Official reports indicate that approximately 100 to 150 missiles are purchased every year.[19] Quick math shows that missiles introduced in 1983 would result in 4,500 missiles in stock, at 125 missiles purchased for 36 years. About 2,000 have been expended in combat.[20] That leaves an inventory of 2,500. At 100 missiles per major target, the U.S. stockpile is empty after 25 targets. Even then, the damage is rapidly repairable as the Shayrat Airbase strike demonstrated. Once the stockpile is depleted, the United States will be reliant on replacing hundreds of Tomahawks and JASSM-ERs a year. As enemy EW and ADA continue to improve, the required expenditure of missiles per target will only go up. Traditionally, the United States could rely on its industrial base to ramp up prior to conflict. This may not be possible. A recent report by an interagency task force points to a decline in U.S. industrial bases' potential. A decrease of skilled labor, combined with foreign parts in the supply chains, suggest that the United States may not be able to ramp up production prior to conflict. Instead, America may suffer temporary disruption of production.[21]

Once standoff weapons are expended, the attacker will be forced to rely on manned aircraft to penetrate the A2/AD zone. This will immediately drive up the cost—in lives, aircraft, finances, and political capital for the attacker. Manned aircraft can generate far more strikes but are vulnerable to the same ADA as a cruise missile. In addition, there is a human factor. Faced with incoming fire, pilots may choose to drop their munitions and abort. Cruise missiles will press on, no matter the odds.

A2/AD zones are able to soak up tremendous amounts of conventional fire power without long-term effects, especially those of near-peer competitors whose industrial base will replace losses and restore the effectiveness of A2/AD zones after repeated strikes.

One of the best examples of A2/AD zone resilience is the Siege of Malta, which took place from June 1940 to November 1942. The island, sitting in the middle of the Mediterranean Sea, was able to conduct air and sea denial against Axis shipping for the duration of the North African campaign. Despite committing over 2,000 aircraft during the campaign, German and Italian forces failed to neutralize the island for any length of time. When the battle was over, Malta-based forces had sunk 23 percent of total European Axis shipping. The key to the island's defenses was heavy ADA, distribution of aircraft across numerous small airfields, and a constant air patrol. Logistics were distributed across numerous small caches rather than one large supply point. The airfields were rapidly repaired and put back into action. The key takeaway from that battle is that most damage inflicted on an A2/AD zone is temporary and will be repaired given even a short respite.[22]

USS *Monterey* fires Tomahawk land attack missile in U.S. Fifth Fleet area of operations, April 2018 (U.S. Navy/Matthew Daniels)

Defenders can use many of the same techniques today. Dispersing aircraft across multiple airfields, always keeping a combat air patrol airborne, and using highway segments as runways can serve to make fixed-wing aircraft more survivable and allow them to enhance the A2/AD zone. Strikes at airbases work only if aircraft are on the ground. This system's point of failure is sustainment. Using highway segments increases survivability, but someone must fuel, rearm, and then park the aircraft. Maintenance is a major issue, especially for fifth-generation aircraft. During Operation *Desert Storm*, U.S. F-15s and F-16s generated one sortie a day. In 2018, F-35s generated only 0.33 sorties per day while flying from USS *Essex* against the Taliban.[23] Providing maintenance assets at dispersed locations requires considerable coordination. Although both sides have to contend with long-range fires, the defender has the advantage because he had years to plan and rehearse dispersed operations on familiar terrain.

It is important to note that munition effects cut both ways. There is an assumption that Russian missiles will destroy NATO infrastructure and prevent use of NATO airbases in range of Russian A2/AD zones. This is highly unlikely. Russian missiles are newer, and the country has not had time to build large stockpiles. As noted above, it takes almost 100 missiles to close an airfield to operations, and the effect is only temporary. The U.S. Air Force adaptive bases concept adds to resilience by further spreading out aviation assets and increasing the Russian target list. The Russians are far more likely to concentrate their limited missile inventory on key targets such as C2 nodes and logistic support areas, including forward fuel storage facilities.

Decoys and Deception

The capacity of the defense is further increased by decoys and deception countermeasures. These can work both ways but usually favor the defender. Decoys are used to absorb fire power and divert from real targets. Attackers can use decoys to mislead a defender and overwhelm the ADA with targets, but with aircraft being the main striking platform, this becomes more difficult. In theory, airborne decoys are possible, but they must fool radar, EW, and the visible spectrum from space-borne ISR assets, all while maneuvering at Mach 2. The price tag of this decoy will rapidly approach the cost of an actual combat aircraft. Ground systems are much easier to hide using underpasses and vegetation, while ground decoys are cheaper since they can be stationary. The defender has a major advantage when it comes to camouflage and deception operations.

During the 1999 conflict in Kosovo, the Serbian army made extensive use of decoys to absorb NATO airstrikes. According to one report filed by the U.S. Air Force Munitions Effectiveness Assessment Team, 90 percent of reported hits were on decoys. In an extreme case, the Serbs even managed to protect a bridge by constructing a decoy 300 meters downriver. The decoy bridge was designed to be seen from the air and was struck multiple times by NATO aircraft.[24] The spoofing did not end in visual range. Serbian air defenses also used extensive radar decoys to divert NATO suppression of enemy air defense missions away from actual radars. Serbian Colonel Zoltán Dani, commander of the 250th Air Defense Missile Brigade, used old radar sets pulled from obsolete fighters to divert NATO strikes away from search and attack radars. During the war, his brigade was engaged more than 20 times with NATO antiradiation missiles without any effect. The decoys absorbed all the damage. Using such innovative techniques, his brigade was credited with shooting down two NATO aircraft, including a stealth F-117, and damaging another.[25]

The lessons of the Kosovo War were not lost on our adversaries; the Russian army has institutionalized Serbian techniques. While Serbian weaponry was a quarter-century behind, the state-of-the-art A2/AD zones in Russia and China are equipped with modern systems. To provide concealment and deception, the Russian army has created the 45th Engineer-Camouflage Regiment. This formation is tasked with camouflaging targets so they cannot be found and creating dummy targets that divert an attacker's fire power.[26] The Russians make extensive use of inflatable decoys. Their dummy tanks can be transported in two duffel bags, resist minor shrapnel damage, and incorporate radar-reflective coating.[27] It is suspected that a battery-powered heater can be used to generate a heat signature. It appears that this technology was tested in Syria with satisfactory effects.[28] The regiment not only hides formations; it can also disguise an installation and build a fake airfield in 24 hours.[29] In addition to setting up decoys and disguising physical targets, the formation has capabilities to simulate radio and radar emissions for full-spectrum deception operations. When combined with constant shifting of forces around the battlefield such as moving aircraft between airfields and patches of highways, these tools can be highly effective.

Systems deployed by formations such as the 45th regiment are not capable of complete deception, especially against higher end space platforms, but they do not have to be. They are designed to defeat tactical-level collection platforms such as the microsatellite ISR described earlier. The problem with national-level collection platforms is that there are few of them and they are tasked to support national- and strategic-level targets, not tactical operations. The small number leaves them vulnerable to enemy antisatellite systems.

Another technique is to make all systems look alike. The proliferation of standardized containers for international shipping is making the camouflage of weaponry even easier. Recently, both Russia and China have introduced antiship missile launchers that are disguised as containers.[30] Northrop Grumman has also investigated this technology.[31] As space-based ISR becomes more resilient and robust, we can expect all vehicles to start looking the same. The attackers will have no way of knowing if the observed truck is carrying a deadly antiship missile or hauling humanitarian supplies to a refugee camp. By making all targets look the same, the defender can degrade the effects of enemy fire power and protect his key defense systems.

A defender's techniques are not all powerful and will not prevent an attacker's penetration of the A2/AD zone. Once key U.S. systems are converged, penetration of the A2/AD zone is possible. A strike package would consist of EW protection and attack aircraft to jam radars and incoming missiles, cyber attack to disrupt the enemy network, and ground- and sea-based long-range fires to disrupt enemy ADA and airbases, all timed to allow strike aircraft to penetrate the A2/AD zone. A defender's deception operations and the survivability of his formations will degrade the effects that the penetrating strike force has, while attacking platforms are engaged by state-of-the-art air defenses. The attacker will penetrate the A2/AD zone and destroy targets but at much higher cost and increased duration of the conflict.

Conclusion

Attempts to penetrate an A2/AD zone of a near-peer competitor are possible, but at high cost and over a prolonged conflict. By utilizing space- and aerostat-based ISR, a defender gains a nearly indestructible early warning system. It can protect his ground-based search radars while maintaining situational awareness. EW reconnaissance systems and high-power computers can distinguish decoys from real aircraft. This degrades the attacker's situational awareness because the defending battery no longer emits until it is ready to engage real targets. The real defenses are camouflaged, and realistic decoys are set up to draw fire away from defensive systems. The attacker is then engaged from unexpected locations by modern air defenses, including long-range surface-to-air missiles and fixed-wing fighter aircraft.

The defenders will fight in a decentralized manner. Also, a defender's higher headquarters will allocate ADA and antiship assets and allow them to fight on their own with direct access to early warning networks. The higher headquarters will likely retain control of defending air assets and allocate targets for their own long-range fires, but the bulk of the fight will be in a decentralized manner. This will make dis-integrating enemy defenses difficult because C2 centers will not affect the fight to the degree seen in previous conflicts. Destroying the defender's C2 nodes will degrade but not dis-integrate the defense. Furthermore, the enemy will likely regenerate damaged C2 nodes, while networked communications will continue to function unabated due to multiple connections and non-C2 nodes that carry the same traffic.

Penetration and degradation of an A2/AD zone is possible through converging key systems across all domains. The real challenge lies in dis-integration of the A2/AD zone. It is important not to underestimate the resilience of enemy networks and their ability to reconstitute damage inflicted by U.S. fire power. At the strategic level, failure to gain quick victory via dis-integration of A2/AD zones will result in a war of attrition, a contest that may not be won at a politically acceptable cost, ending the conflict in a peace settlement favorable to the adversary. **JFQ**

Notes

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