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MAKING THE WEASELS WILD AGAIN:

ENSURING FUTURE AIR DOMINANCE THROUGH EFFECTIVE SEAD TRAINING

by

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ABSTRACT

The US military's dominance in the aerial warfare arena is well established, as no US aircraft has been lost to an air-to-air engagement since 1991. All US combat aircraft losses since *Operation Desert Storm* (ODS) have been to enemy integrated air defense systems (IADS), and it is predicted that most countries will use surface-based IADS to challenge US air superiority in the future. Over the past decade, the US has been focused on close air support (CAS) missions in the CENTCOM area of responsibility (AOR) with a permissive air environment and a minimal surface-to-air threat. This has resulted in a generation of military aviators ill-versed in the suppression of enemy air defenses (SEAD) mission and unequipped to deal with a significant IADS threat as training efforts have largely ignored SEAD.

Current SEAD training is insufficient, as it does not adequately prepare US forces to face the advanced long-range and mobile SAM threat in existence today. The USAF must increase both multi-mission design series (MMDS) and joint SEAD training as well as improve the capabilities of its electronic warfare (EW) ranges in order to correct SEAD training deficiencies. This paper will use the scenario-planning framework to postulate future SEAD requirements and analyze current SEAD training deficiencies that may preclude successful SEAD operations.

Introduction

The year is 2025, and the US is preparing to invade the country of Qumar after continued violations of a nuclear agreement. The nation signed a deal with the US in 2018 regarding its nuclear program that included inspections similar to those the United Nations attempted with Saddam Hussein. Initially, the government of Qumar complied, but over the past few years, Qumar has pushed back on the inspections and denied the International Atomic Energy Agency access to its key facilities. The United Nations Security Council has issued several resolutions demanding that weapons inspectors be provided unrestricted access to Qumar's nuclear facilities. Despite the resolutions, Qumar's government has recently balked at the agreement, and there is strong evidence to believe its nuclear scientists have been enriching uranium in undisclosed locations.

While this situation may seem comparable to the 2003 invasion of Iraq, this operation will be much more challenging. Qumar has studied the results of *Operation Desert Storm* (ODS) and decided to invest greatly in anti-access and area denial (A2/AD) measures to preclude a similar fate. The country's integrated air defense system (IADS) consists of advanced long- and short-range surface-to-air missile (SAM) systems purchased from Russia in 2015, as well as sophisticated early warning and command and control (C2) components. As the US Air Force (USAF) has been preoccupied with close air support (CAS) missions in a relatively uncontested environment over the past decade, Qumar's air defense systems have made them wary of sending multi-billion dollar aircraft into harm's way.

The above scenario is obviously fictitious; however, it is entirely plausible that the US could be forced to compete against an advanced IADS within the next ten years. The portion of the story that is not fictitious is the US focus on CAS missions in CENTCOM with a permissive air environment and a minimal surface-to-air threat. This has resulted in a generation of military aviators ill-versed in the suppression of enemy air defenses (SEAD) mission and unequipped to deal with a significant IADS threat as training efforts have largely ignored SEAD.[1]

Literature Review:

Since 1999, experts have argued that the USAF has not provided SEAD aircrews with either the quantity or quality of training required to conduct effective operations.[2] At that time, Major Jon Norman proposed that the Joint Chiefs of Staff (JCS) should identify Joint SEAD (J-SEAD) as a mission essential task (MET) and the joint training system should create a dedicated J-SEAD training program.[3] Major Norman's training program included J-SEAD support training for all mission areas and recommended that J-SEAD be incorporated into all USAF service exercises.[4] Additionally, Major Norman warned that both an increased reliance on simulator training and the use of notional assets during flight training would significantly reduce operational readiness. The term "notional" refers to a practice of training as if another platform or asset was participating when they are not physically present. Instead, he advocated for increased flight training opportunities with the joint and national level assets that a unit would work with during combat J-SEAD operations.[5] These training opportunities would allow USAF pilots to understand both the limitations and capabilities of assets that support and employ with them during J-SEAD operations. This knowledge is critical to permit USAF aircrews to employ J-SEAD forces in a manner that minimizes limitations while maximizing their own weapon system capabilities.

A few years later in 2001, Lieutenant Colonel Carey Stegall argued that J-SEAD had been less effective than it should have been in recent campaigns (primarily *Operation Allied Force* or OAF) due to a lack of emphasis from Joint Force Commanders and a lack of effective

J-SEAD doctrine.[6] He echoed Major Norman's findings and insisted that a focus on joint interoperability with regard to SEAD capabilities was required. Lieutenant Colonel Stegall observed that the various military services had developed their own "styles" of SEAD based on their particular needs, and that these styles did not necessarily complement each other. He argued for the importance of in-depth studies in order to formulate truly joint doctrine and proposed specific education for Commanders-in-Chief and Joint Task Force Commanders to ensure they realized the importance of J-SEAD in military operations.[7] Ultimately, Lieutenant Colonel Stegall assessed that the key to effective SEAD operations was to incorporate all SEAD assets in a combined effort to achieve the theater commander's objectives.[8]

Most recently, in 2008, Lieutenant Commander Michael Paul argued that J-SEAD capabilities were diminishing while the demands to meet a wide spectrum of SEAD requirements were actually increasing.[9] He highlighted several areas of concern for SEAD operations, to include: non-cooperative IADS, sensor-to-shooter delays in time-sensitive targeting, and low density/high demand assets.[10] Lieutenant Commander Paul advised that SEAD aircrews were not receiving enough training opportunities to fulfill their need to train "in a coordinated manner with the aircraft that they protect."[11] He argued that IADS technology and equipment were continuously improving and proliferating even as J-SEAD capabilities were actually diminishing. He concluded that, to be effective, SEAD aircrew needed to integrate with the aircraft they would protect in the training environment.[12]

Although experts have been arguing for increased SEAD training for over fifteen years, little to no improvements have been made to enhance SEAD training. Training sorties have decreased during this period due to fiscal constraints, and while headquarters guidance has listed J-SEAD as a competency that F-16 and F-35 pilots should be proficient in, no published standards or objectives for integration are in existence.[13] Opportunities for J-SEAD training in particular remain extremely limited, and there is no requirement for USAF units to train for multi-mission design series (MMDS) SEAD operations.[14] MMDS training includes the use of multiple USAF airborne platforms (i.e. F-16, F-15E, F-22, F-35, E-8, RC-135) while joint training integrates those weapons systems with airborne platforms from other services (i.e. Navy EA-18G and Marine EA-6B).

In modifying training to improve future SEAD combat operations, the USAF must increase both MMDS and J-SEAD training as well as improve the capabilities of its electronic warfare (EW) ranges in order to correct SEAD training deficiencies. There are currently no MMDS SEAD training requirements for USAF units.[15] Additionally, only operational F-16 and F-35 units have J-SEAD requirements; however, the quantity of training sorties for J-SEAD in these units is left to the squadron commander's discretion and the requirement is simply defined as "integration with at least one SEAD asset other than USAF fighters."[16] Training requirements vary based on airframe and primary mission statement, but MMDS and J-SEAD training must be included in Ready Aircrew Program (RAP) Tasking Memorandums (RTM) to ensure the training receives an appropriate level of emphasis.

Increasing MMDS and J-SEAD training will enable the USAF to "train how it fights." Multiple platforms from various services will be required to work in concert to conduct effective SEAD operations in the future. The USAF combat inventory contains a mixture of stealth and non-stealth aircraft with varying levels of susceptibility to SAM threats. The mission of locating and destroying advanced surface threats requires multiple low observable (LO) and non-LO platforms working together. The unique capabilities of dedicated SEAD platforms will be required to locate and disrupt IADS components such as early-warning radars and short-range

SAM systems, while LO aircraft will be necessary to attack long-range SAM systems. Additionally, since the retirement of the EF-111 in 1998, the USAF has not possessed a dedicated radar-jamming platform and must rely on other services for this capability, thus necessitating joint operations.[17]

Some have argued that simulator training can be used as a replacement for EW ranges.[18] While distributed mission operations (DMO) simulators may be useful in fulfilling building-block MMDS and J-SEAD requirements, they do not provide aircrew with a full understanding of the capabilities and limitations of their aircraft. SEAD aircrews require a complex training infrastructure that replicates the most sophisticated IADS possible.

The continued proliferation of advanced SAM systems throughout every major area of responsibility (AOR) dictates that SEAD capabilities will be required in any future conflict. Russia has sold or contracted S-300 variants (SA-10/12/20) to multiple countries such as Iran, Syria, Belarus, China, India, Venezuela, Vietnam, and Egypt.[19] The USAF neither allocates an appropriate number of missions to MMDS and J-SEAD training, nor has sufficient range resources to create a threat representative IADS for training. In order to be prepared for combat operations, the USAF must increase MMDS and J-SEAD training requirements and opportunities and bolster EW range capabilities.

Research Framework:

This paper will use the scenario-planning framework to postulate future SEAD requirements and analyze current SEAD training deficiencies that may preclude successful SEAD operations. The author will begin by providing a historical background of the SEAD mission and illuminating the problem's significance. The paper will then cover the current capabilities and SEAD training requirements for US aircraft, as well as the current capabilities of

US EW ranges and enemy SAM systems. Next, the author will analyze four distinct combat scenarios requiring varying levels of SEAD support and integration, ranging from a relatively uncontested air domain to a country employing an extremely efficient A2/AD strategy with a modern IADS. The four scenarios include: "Freedom to Roam," representing a relatively uncontested air environment; "Death by Tetanus," representing a legacy IADS; "Amazon Shopper," representing a mix of legacy and modern SAM systems and commercial off-the-shelf IADS components; and "They've Gone Plaid!" representing an extremely sophisticated and complex IADS. The paper will then discuss alternative ways to improve SEAD training and compare the alternatives using key objectives. Finally, the paper will make a recommendation to increase SEAD training requirements and EW range capabilities in order to ensure the USAF is prepared for future operations. Increasing the overall number of training requirements is not likely feasible due to fiscal constraints. Joint and MMDS SEAD training missions should be added as annual training requirements for all fighter aircraft by re-allocating existing RAP Tasking Memorandum RTM sorties to dedicated Joint and MMDS SEAD missions.

Problem Significance:

The US military's dominance in the aerial warfare arena is well established, as no US aircraft has been lost to an air-to-air engagement since 1991. All US combat aircraft losses since ODS have been to enemy IADS, and it is predicted that most countries will use surface-based IADS to challenge US air superiority in the future.[20] IADS are easy to procure and maintain and, by comparison, have a much lower price tag than the cost of training and sustaining an air force.[21] OAF and *Operation Unified Protector* (OUP) highlighted that enemy IADS components will be redundant and difficult to locate and destroy. Additionally, many advanced SAM systems are highly mobile. They possess sensitive radars, advanced missile guidance systems, and the capability to engage targets of all sizes at longer ranges than ever before.[22] Thus the SEAD mission must evolve into an all-inclusive approach that connects kinetic and non-kinetic capabilities to degrade enemy IADS as a whole.[23]

This holistic approach to SEAD requires significant training. MMDS and J-SEAD should be incorporated into all USAF exercises in order to expand training opportunities, using modern EW ranges to the maximum extent possible. Training exercises should include close integration with any and all assets that would be available during combat operations and must incorporate a realistic, modern IADS. Additionally, planners and aircrew must constantly re-evaluate what defines the "status quo" for IADS and learn to use SEAD doctrine as a guideline while employing critical thinking to accurately analyze the specific IADS they are facing.

Problem Background:

Joint Publication 3-01 defines SEAD as any "activity that neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive or disruptive means."[24] SEAD has been an important part of combat since World War II, which saw the introduction of the first IADS as Great Britain began to augment its air defenses with radar, command, and control.[25] In response, air forces applied technology to suppress air defenses, thus creating the SEAD mission. The first SEAD tactics involved modified B-25 bombers flying down the radar beam of German sites to strafe them with their nose cannons.[26] This mission has changed dramatically from its inception through the creation of dedicated SEAD platforms and technologies and the development of joint and coalition SEAD tactics.

In the Vietnam War, the US adapted to the first significant use of surface-to-air missile (SAM) systems by introducing the "Wild Weasel" SEAD mission. During this period, commanders were shocked to see how quickly a relatively poor and non-industrialized nation could create a threatening IADS when supplied with Soviet SAM systems. To counter the threat, the US developed specialized F-100F and F-105G aircraft to find SAM sites and launch anti-radiation missiles (ARMs) against the enemy radars. These “Wild Weasel” fighters paired up with new jamming aircraft like the Air Force’s EB-66 and the Navy’s EKA-3B and EA-6A to provide localized protection for US strike packages.[27]

The SEAD mission continued to grow after Vietnam in order to counter advancing IADS capabilities. The F-4G replaced the F-105G as the “Wild Weasel” platform, and the EF-111A and EA-6B took over the advanced radar jamming roles. Additionally, airborne signals intelligence (SIGINT) aircraft such as the RC-135 and EP-3 and communications jamming platforms like the EC-130H became operational. By the beginning of ODS in 1991, the US demonstrated effective integration of all of these assets with coordinated strikes against critical IADS and C2 nodes to decimate the Iraqi IADS and achieve air superiority.[28]

Coalition sensors detected roughly 100 radar emissions from Iraqi air defenses during the first four hours of ODS. These emissions resulted in the firing of over 500 AGM-88 high-speed anti-radiation missiles (HARM) from US aircraft in the first 24 hours of the war.[29] The operators of Iraq’s IADS quickly learned that to turn their radars on was to invite a deadly attack, and by the sixth day of ODS radar emissions had dropped by 95 percent. Sufficiently intimidated, SAM operators ceased to radiate their systems, enabling the campaign’s SEAD objectives to progress from suppression via HARM and electronic attack (EA) to permanent destruction via bombing runs.[30] During ODS, coalition planners attacked virtually every component of the Iraqi IADS simultaneously and neutralized them such that they could not recover.

ODS provided the best example of AOR/joint operating area (JOA)-wide air defense (AD) system suppression, which involves the degradation or disruption of an enemy’s entire

IADS capability by attacking key C2 nodes and destroying the enemy's capability to integrate and synchronize air defenses. This SEAD game plan is now seen as the preferred method for protecting friendly forces during a major theater war.[31]

ODS proved the effectiveness of AOR/JOA-wide AD system suppression in one situation, but technological improvements in IADS capabilities following the war required new upgrades to SEAD platforms. In the 1990s, the USAF began replacing the F-4G with the F-16CJ, which enhanced "Wild Weasel" SAM detection and ARM employment capabilities but not offensive jamming capabilities. To meet this capability, the Navy replaced its EA-6B fleet with the EA-18G as an enhanced radar-jamming platform. When the Air Force decided to retire its fleet of EF-111A aircraft without a replacement, the Navy EA-18G and a few remaining Marine EA-6Bs became the nation's primary radar jamming platforms.[32] Instead of investing money on advanced radar jamming, the Air Force chose to rely on stealth platforms such as the F-117, B-2, F-22, and F-35. While stealth technology provides aircraft with a reduced vulnerability against radar threats by significantly reducing a SAM weapons engagement zone (WEZ), it does not make them invincible.

Eight years after ODS, OAF presented a markedly different story. In contrast to the Iraqis, the Serbs kept their SAM systems dispersed defensively and operated them in an emission-control (EMCON) mode.[33] The SAM operators' reluctance to radiate made them difficult to locate, forcing allied aircrews to remain constantly alert to the SAM threat throughout the entire war. In perhaps the greatest SEAD failure of OAF, an apparent barrage of missiles from a SA-3 brought down an F-117 stealth fighter on the fourth night of air operations. This costly loss served as a wake-up call for the USAF to improve tactics, techniques, and procedures (TTPs) for SEAD operations. The SA-3 had reached initial operating capability (IOC) as early as 1961.[34]

The loss of a F-117 to such a legacy SAM system during OAF and recent improvements in counter-stealth technology such as very high frequency (VHF) radars, passive detection systems, and infra-red search and tracking systems (IRSTS) highlight the fact that stealth technology will not always protect an aircraft.[35]

Nearly twenty years after OAF, US airpower capabilities have improved dramatically. Enemy IADS capabilities, however, have improved at the same rate, if not more rapidly. With an emphasis worldwide on A2/AD measures, the SEAD mission will be an extremely important part of future conflicts for the foreseeable future. The USAF must properly train for this mission in order to be prepared for what may lie ahead.

Current J-SEAD Capabilities

It is important to understand the SEAD capabilities of joint aircraft in order to comprehend the level of integration required to conduct effective SEAD training. JP 3-01 does not list specific aircraft or systems that should be dedicated to the SEAD mission, but it does state that SEAD aircraft are traditionally equipped with "special electronic detection and electronic countermeasures (ECM) equipment, deceptive expendables (chaff, flares, or decoys), and anti-radiation missiles (ARMs) for use against emitting radars."[36] Traditionally, the fighter aircraft most associated with the SEAD mission include the F-16, EA-6B, EA-18G, and F-15E.[37] JP 3-01 fails to mention LO aircraft as a component of SEAD doctrine; however, the unique capabilities of LO aircraft like the F-22, F-35, and B-2 will be essential to SEAD operations in an A2/AD environment. Additional USAF SEAD assets include the EC-130H "Compass Call" and the "Iron Triad" composed of the RC-135 "Rivet Joint," E-3 "Sentry" Airborne Warning and Control System (AWACS), and E-8 Joint Surveillance Target Attack Radar System (JSTARS). The following aircraft profiles provide a basic description of their SEAD capabilities.

USAF F-16 "Viper"

Figure 1: F-16 "Viper"
(Photograph credit af.mil)

It is important to note that not all F-16s are the same. The F-16 is a compact, multi-role fighter, which has gone through several upgrades since its IOC in 1979. These upgrades have resulted in numerous models and avionics "blocks" in existence today. The F-16 has nine hard-points to carry air-to-air missiles, air-to-ground munitions, external fuel tanks, and specialty pods. Of the 1017 Vipers in the USAF inventory, all combat-coded active-duty squadrons have been upgraded to either Block 40/42 or Block 50/52 with a common configuration implementation program (CCIP) that provided these blocks with similar avionics capabilities.[38] There are currently thirteen combat coded F-16 units in the USAF, seven of which are Block 40/42 with the remaining six Block 50/52.

While CCIP nearly leveled the field between Block 40/42 and Block 50/52 F-16 capabilities, the two blocks only share one primary mission set. The Block 40/42 primary missions are Air Interdiction (AI)/Offensive Counter Air-Attack Operations (OCA-AO), CAS, and Defensive Counter Air (DCA).[39] The Block 50/52 primary missions are OCA-SEAD, DCA, and OCA-ESCORT.[40] The Block 50/52 F-16 is one of the USAF's primary SEAD aircraft. Block 40/42

CCIP aircraft can be equipped for the SEAD role; however, as SEAD is not a primary mission set, they have no requirement to train to it so this thesis will focus on the Block 50/52 variant.

The Block 50/52 contains specialized equipment for the SEAD mission. While it is capable of carrying precision and non-precision air-to-ground munitions of up to 2000lbs, its primary SEAD weapon of choice is the AGM-88 high-speed anti-radiation missile (HARM). Additionally, it carries either the ALQ-131 or ALQ-184 self-protection ECM pod, the Sniper or Litening advanced targeting pod (ATP), and the HARM targeting system (HTS) pod.[41]

The HTS pod features a passive digital receiver that cues the HARM against SAM radars. In 2008, the USAF finalized the upgrade of all HTS pods to Release 7+ (R7+), which incorporates a GPS receiver and redesigned software to precisely geo-locate radar emissions. This capability, known as precision targeting or "PT ranging", uses cooperative multi-aircraft targeting algorithms to network the HTS pods on multiple F-16s to exchange time and frequency difference of arrival (TDOA/FDOA) information on threat emissions. With information from multiple HTS pods, F-16s can triangulate the precise location of an emitter.[42]

USMC EA-6B "Prowler"

Figure 2: EA-6B "Prowler"
(Photograph credit navy.mil)

The US Navy designed the EA-6B, a four-seat advanced modification of the EA-6A, specifically for the SEAD mission. It primarily carries the ALQ-218 tactical jamming receiver, ALQ-99 tactical jamming pods, and USQ-113 communications jammer. While initially designed as a standoff-jamming platform, the Prowler was later modified to carry two AGM-88 HARMs. The EW suite of the Prowler allows it to detect, sort, classify, jam, and destroy enemy air defense radars. To complete a SAM engagement, a system must "see" the target and guide a missile throughout the time of flight. The radar jamming pods on the Prowler allow it to either "blind" or deceive enemy radars, thus interrupting the kill chain. Although retired from the Navy fleet in 2015, the Prowler will remain in service with the US Marine Corps through 2019.[43]

USN EA-18G "Growler"

Figure 3: EA-18G "Growler"
(Photograph credit navy.mil)

The EA-18G is a variant of the F/A-18F Super Hornet, designed to replace the EA-6B and provide tactical jamming and electronic protection to US military forces around the world. The Growler is the most advanced airborne EA platform in production, and the only one to carry an air-to-air missile capability, primarily for self-defense purposes.[44] It has an upgraded version of the Prowler's ALQ-218 tactical jamming receiver, which provides it with an improved capability to precisely geo-locate air defense radars, similar to the F-16's PT ranging capability. The ALQ-

218 also integrates with the Growler's APG-79 active electronically scanned array (AESA) radar, whose synthetic aperture radar (SAR) mapping capabilities provide enhanced image resolution for targeting and tracking surface threats. Through Link-16, the Growler can then share this threat information with other US and allied aircraft.[45]

The Growler carries up to three ALQ-99 jamming pods, as well two AGM-88 HARMs. It also carries the improved ALQ-227 communications countermeasure set, allowing it to locate, record, play back, and digitally jam enemy communications over a broad frequency range.[46] In the future, the EA-18G will replace its ALQ-99 pods with the Navy's next-generation jammer (NGJ). Slated to be operational by 2021, the NGJ uses AESA technology to provide increased power and flexibility while jamming multiple signals simultaneously.[47]

USAF F-15E "Strike Eagle"

Figure 4: F-15E "Strike Eagle"
(Photograph credit af.mil)

The F-15E is a dual-role fighter designed for both air-to-air and air-to-ground missions. It has the capability to fight at low-altitude, day or night, and in all weather via terrain following equipment. The Strike Eagle has a 23,000-pound payload capacity and can carry virtually every air-to-air or air-to-ground weapon in the USAF inventory, with the notable exception of the

HARM.[48] Its original radar was the APG-70, but a portion of the fleet is currently being upgraded with the APG-82 AESA radar.[49] Both radars provide SAR capability to image and target surface threats.

The Strike Eagle also carries an ATP and the ASQ-236 radar (or recce) pod to enhance targeting capabilities. The ASQ-236 contains a built-in AESA synthetic aperture radar that provides detailed maps for surveillance, coordinate generation, and bomb impact assessment purposes.[50] The integration of SAR into the F-15E provides all-weather geo-location and surveillance capability against surface targets that its fourth-generation F-16 brother lacks. It requires an accurate cueing source to engage this feature, however, which in the case of mobile SAM systems traditionally come from a SEAD platform like the F-16 or RC-135.

USAF F-22 "Raptor"

Figure 5: F-22 "Raptor"
(Photograph credit af.mil)

The F-22 is the USAF's first fifth-generation fighter aircraft. It combines stealth, super-cruise, maneuverability, and integrated avionics that allow it to conduct both air-to-air and air-to-ground missions. While designed originally as an air dominance aircraft, the unique LO capabilities of the F-22 make it well suited for destructive SEAD missions against advanced

SAMs. The Raptor's air-to-ground ordnance consists of two GBU-32 1000-pound joint direct attack munitions (JDAMs) carried internally to prevent a loss of LO capability. An upgrade currently in the works will enable the Raptor to carry up to eight GBU-39 small-diameter bombs (SDBs) that would increase both the number of targets it could service as well as its standoff range.[51]

The Raptor's combination of all-aspect stealth, speed, and avionics integration or "sensor fusion" drastically shrinks SAM engagement envelopes and minimizes a threat's ability to track and engage the F-22. The Raptor's sensor fusion, or "hyper-spectral suite of embedded sensors," allows the aircraft to map and exploit gaps in enemy radar coverage real time, as the aircraft displays known safe and danger zones. Future software upgrades of the raptor's APG-77 radar may even provide final-stage jamming of threat radars.[52]

USAF F-35 "Lightning"

Figure 6: F-35 "Lightning"
(Photograph credit af.mil)

The F-35 is the USAF's newest fifth-generation fighter, designed to replace its aging fleet of F-16 and A-10 aircraft. Aside from the F-16, it is the only other USAF fighter with a dedicated SEAD mission. Like the Raptor, it provides next-generation stealth, enhanced situational awareness, and reduced vulnerability to threats due to LO characteristics that shrink SAM engagement capabilities. The advanced sensor package on the F-35 is designed to "gather, fuse, and distribute more information than any fighter in history," providing the pilot with a decisive advantage.[53] This sensor package includes an electro-optical distributed aperture system (DAS) that provides pilots with situational awareness in a sphere around the aircraft for missile warning, aircraft warning, and day/night pilot vision. Additionally, the sensor suite includes an electro-optical targeting system (EOTS) that delivers range detection and precision targeting against ground targets (similar to ATP) as well as long-range detection of air threats.[54]

Although it has yet to reach full IOC, the USAF F-35 is advertised to have advanced EW capabilities that will enable it to "locate and track enemy forces, jam radars, and disrupt attacks with unparalleled effectiveness."[55] The sensor fusion of the F-35 will greatly enhance future SEAD capabilities. It uses the APG-81 AESA radar for both air-to-air and air-to-ground operations, enabling all SAR and other features previously discussed with the EA-18G, F-22, and upgraded F-15E AESAs. The F-35 is a "network centric" aircraft, and like the Raptor, it has its own tactical data link. Unlike the F-22, however, the F-35 can also populate the Link-16 network and therefore provide real-time data to any other USAF and coalition aircraft.[56]

USAF B-2 "Spirit"

Figure 7: B-2 "Spirit"
(Photograph credit af.mil)

The B-2 Spirit is the USAF's premier stealth bomber, boasting a 40,000-pound payload capacity and the ability to deliver both nuclear and conventional munitions. Derived from a combination of reduced infrared, acoustic, electromagnetic, visual, and radar signatures, its LO characteristics give it the capability to penetrate sophisticated defense systems.[57] This LO capability makes it a key player in the SEAD mission, as it is one of the few aircraft that can penetrate a SAM missile engagement zone (MEZ) deep enough to achieve weapons employment.

USAF EC-130H "Compass Call"

Figure 8: EC-130H "Compass Call"
(Photograph credit af.mil)

The EC-130H is a heavily modified C-130 Hercules, designed as an airborne tactical weapon system. The mission of the Compass Call is to disrupt enemy C2 communications and limit the adversary coordination required for force management. Compass Call employs offensive counter-information capabilities and EA capabilities against communications systems, early warning radars, and SAM acquisition radars. The EC-130H accomplishes this through the use of higher effective radiated power, extended frequency range, and the insertion of digital signal processing.[58]

USAF “Iron Triad”

Figure 9: RC-135 "Rivet Joint"
(Photograph credit af.mil)

The Iron Triad consists of the RC-135 “Rivet Joint,” E-3 “Sentry” AWACS, and E-8 JSTARS. The RC-135 “Rivet Joint” is a reconnaissance aircraft that provides theater- and national-level customers with near real-time intelligence collection, analysis, and dissemination. The on-board sensor suite of the Rivet Joint has the capability to detect, track, and identify signals throughout the electromagnetic spectrum. Once the RC-135 detects a threat, it can then pass any information it gathers through various formats due to its extensive communications suite. The Rivet Joint plays a crucial role in detecting, classifying, and locating enemy IADS components during SEAD operations.[59]

Figure 10: E-3 "Sentry" (AWACS)
(Photograph credit af.mil)

The E-3 Sentry serves as an airborne warning and control system, providing integrated C2 battle management, surveillance, target detection, and tracking. The distinctive feature of the E-3 is its thirty-foot rotating radar dome for the battle management and early detection of enemy aircraft. The Sentry also possesses additional passive detection sensors that allow it to detect, locate, and identify threat emitters of fixed or dynamic target sources, making it extremely useful in a SEAD mission.[60]

Figure 11: E-8C JSTARS
(Photograph credit af.mil)

The E-8C JSTARS is an airborne battle management, C2, and intelligence, surveillance, and reconnaissance (ISR) platform. The most prominent system on the E-8 is the twenty-seven foot dome under the fuselage that houses a side-looking phased array radar antenna. This radar tracks moving vehicles and can detect fixed targets through both Synthetic Aperture Radar (SAR) and its Fixed Target Indicator (FTI) capabilities.[61] This capability supports its primary mission of providing ground surveillance in support of ground attack operations as well as targeting that contributes to the delay, disruption, and destruction of enemy forces. The Moving Target Indicator (MTI) capability of the E-8C provides an all-weather geo-location capability, as well as the ability to track enemy forces that are on the move. As SAM systems become more and more mobile, assets like the JSTARS will be essential in tracking the movement of portable systems during SEAD missions.

SEAD Training Requirements

AFI 11-2MDS-Vol1 and the associated MDS RAP Tasking Memorandum (RTM) dictate USAF aircrew training requirements. The MAJCOM/A3 office publishes RTMs at the beginning of each fiscal year. They detail the number of sorties each aircrew is required to fly per calendar month, the number and type of training sorties each aircrew is required to fly per "training cycle" or fiscal year, and specific flight, ground, and simulator training events aircrew must accomplish. Figure 12 below provides an example of RAP sortie requirements from the Block 50/52 F-16 RTM. In this example, the highlighted areas indicate that an inexperienced active-duty combat mission ready (CMR) F-16 pilot must fly nine sorties per month and 108 sorties per year to meet the minimum RAP requirements, while an experienced CMR pilot requires eight sorties per month and 96 sorties per year to make RAP. These annual requirements (108 for inexperienced and 96 for experienced) are common to all USAF fighter aircraft.[62]

Table 5a – RAP Sortie Requirements

ORG	Cycle	CMR Sorties Inexp/Exp	CMR MTCs Inexp/Exp	BMC Sorties Inexp/Exp	BMC MTCs Inexp/Exp	Notes
RegAF	12 Month	108/96	36/36	72/60	24/24	1,2,3
	3-Month Lookback	27/24	9/9	18/15	6/6	1,2,3
	1-Month Lookback	9/8	3/3	6/5	2/2	1,2,3
AFRC	12 Month	120/72	24/12	72/60	12/12	3,4
	3-Month Lookback	30/18	**	18/15	**	3,4
	1-Month Lookback	10/6	**	6/5	**	3,4
ANG	12 Month	92/68	8/8	68/56	8/8	3,4
	3-Month Lookback	23/17	**	17/14	**	3,4
	1-Month Lookback	8/6	**	6/5	**	3,4

Figure 12: Sample RAP Sortie Requirements from Block 50/52 F-16 RTM[63]

In addition to the items above, RTMs delineate primary and secondary mission sets for each MDS, directing that aircrew will be "proficient" in their primary missions and "familiar" with their secondary missions.[64] Figure 13 below provides an example of the specific mission requirements from the Block 50/52 F-16 RTM. The highlighted section towards the bottom represents the total sorties required per training cycle as previously discussed, while the highlighted section towards the top identifies OCA-SEAD as a primary mission and directs that 27 (inexperienced) or 25 (experienced) of the 108 or 96 total sorties will be dedicated OCA-SEAD sorties. The RTM defines proficient and familiar as:

> **Proficient:** Aircrew have a thorough knowledge of mission area but occasionally make an error of omission or commission. Aircrew are able to operate in a complex, fluid environment and are able to handle most contingencies and unusual circumstances. Proficient aircrew are prepared for mission tasking on the first sortie in theater.
> **Familiar:** Aircrew have a basic knowledge of mission area and may make errors of omission or commission. Aircrew are able to operate in a permissive environment and are able to handle some basic contingencies and unusual circumstances. Familiar aircrew may need additional training prior to first mission tasking.[65]

Table 5b – Flight Mission/Sortie Requirements								
MISSION	**TASK ID**	**CMR (INEXP/EXP)**			**BMC (INEXP/EXP)**			**NOTES**
		RegAF	**AFRC**	**ANG**	**RegAF**	**AFRC**	**ANG**	
PRIMARY MISSIONS (PROFICIENT)								
OCA-SEAD (day/night)	SR29/SR30	27/25	27/17	22/15	14/11	14/11	14/11	5, 6
DCA (day/night)	SR21/SR22	10/10	10/6	8/5	6/5	6/5	6/4	6
OCA-ESC	SR08	8/8	8/6	8/6	6/5	6/5	6/4	6
SECONDARY MISSIONS (FAMILIAR)								
CC Option	N/A	6/6	19/6	5/5	5/5	5/8	4/6	1,7
AI/OCA-AO (day/night)	SR72/SR73	4/3	4/3	4/3	4/3	4/3	4/3	6
CAS (day/night)	SR18/SR19	4/3	4/3	4/3	4/3	4/3	4/3	6
Counter FAC/FIAC (CFF) (day/night)	SR45/SR46	4/3	4/3	4/3	4/3	4/3	4/3	6, 11
BASIC SKILLS								
TI	SR63	3/2	3/2	3/2	2/1	2/1	2/1	
BSA	SR17	6/4	6/2	6/2	2/1	2/1	2/1	
BSA (night)	SR33	2/2	2/2	2/2	2/2	2/2	2/2	6
BFM	SR16	7/5	7/4	6/4	4/3	4/3	4/3	
ACM	SR15	7/5	6/4	6/4	4/3	4/3	4/3	
AHC	SX10	2/2	2/( )	( )	1/1	1/( )	( )	
INSTRUMENT	SX08	4/4	4/( )	( )	2/2	2/( )	( )	9
RED AIR								
Red Air	SR26	14/14	14/14	14/14	12/12	12/12	12/12	8
HHQ Red Air	SC03	--	--	--	--	--	--	8, 10
TOTAL RAP		**108/96**	**120/72**	**92/68**	**72/60**	**72/60**	**68/56**	

Figure 13: Sample Mission/Sortie Requirements from Block 50/52 F-16 RTM[66]

Each MDS has training requirements that are specific to their primary or secondary mission sets. For the purposes of this paper, the focus will be on specific guidance regarding SEAD training. The following section covers any aspect of SEAD training mentioned in the various 11-2MDS-Vol 1s and RTMs.

Block 50/52 F-16

The Block 50/52 F-16 RTM identifies SEAD as a primary mission set, requiring a minimum of 27 SEAD sorties a year for inexperienced CMR pilots and 25 SEAD sorties a year for experienced CMR pilots.[67] SEAD missions therefore account for roughly 25 percent of all sorties a Viper pilot will fly over the course of a year. The RTM states that a SNIPER or advanced targeting pod (ATP) is desired on SEAD sorties to help with identification and precision targeting of SAM sites. It also states: "commanders will determine a number of J-SEAD sorties which, to meet the intent, require integration with at least one SEAD (or SEAD support) asset other than USAF fighters (Growler, RJ, etc.)." While this identifies the need for J-SEAD integration during training, interpretation of the number of J-SEAD sorties required per training cycle is left to the discretion of a unit commander, who could in turn decide that no J-SEAD sorties were necessary. Most J-SEAD training occurs at large-force exercises (LFEs) such as RED FLAG, and the typical F-16 pilot does not have the opportunity to integrate with joint assets outside of those exercises. Furthermore, there is no mention of MMDS SEAD training in the F-16 RTM.

In addition to flight events, F-16 pilots must accomplish a minimum of 36 Mission Training Center (MTC) simulator events per training cycle, with 14 (39 percent) of those dedicated to SEAD.[68] Like the total aircraft sorties, the minimum of 36 annual MTC events is common across all USAF fighters, with the exception of the F-35.[69] Figure 14 depicts the breakdown of MTC requirements, with a note for the six OCA-SEAD "Pkg Escort" missions dictating that those specific events must be accomplished using Distributed Mission Operations (DMO) entities such as "AWACS or other players."[70]

F-16 pilots are further required to conduct specific training events on a portion of SEAD missions, including 20 training events on an electronic warfare (EW) range. AFI 11-2F-16v1 defines an EW range event as "inflight operations conducted on an EW range with fixed or mobile surface-to-air emitters operating and detection/threat reaction emphasized."[71] Training against actual threat emitters is an important part of a SEAD mission in order to gain proficiency in threat detection, geo-location, and defensive maneuvering.

Table 6a – MTC Mission Requirements								
MTC MISSIONS	TASK ID	CMR (INEXP/EXP)			BMC (INEXP/EXP)			NOTES
		RegAF	AFRC	ANG	RegAF	AFRC	ANG	
OCA-SEAD Pkg Escort	MT03	6	( )	2	2	( )	2	22
OCA-SEAD	MT10	6	( )	( )	2	( )	( )	
Maritime SEAD	MT02	2	( )	( )	1	( )	( )	
DCA	MT04	2	( )	2	1	( )	2	
OCA-ESC	MT21	1	( )	( )	2	( )	( )	
AI/OCA-AO	MT20	( )	( )	( )	( )	( )	( )	
CAS	MT14	( )	( )	( )	( )	( )	( )	
CFF	MT01	4	( )	( )	2	( )	( )	
CC Option	N/A	5	24/12	4	5	12	4	25
TI	MT18	4	( )	( )	3	( )	( )	
Tactical Skills Drills	MT08	( )	( )	( )	( )	( )	( )	23
Instruments	SQ17	2	( )	( )	1	( )	( )	38
Emergency Procedures	MT17	4	( )	( )	4	( )	( )	24, 38
Totals		36	24/12	8	24	12	8	4

Figure 14: F-16 MTC Mission Requirements[72]

The final mention of SEAD in the F-16 RTM is essentially a road map of priorities for SEAD missions. Figure 15 shows the list of priorities listed in the RTM, which includes proficiency in J-SEAD, as well as proficiency in SEAD in the vicinity of 4th-generation (air) threats with dedicated OCA-Escort forces and proficiency in self-escort against 2nd- and 3rd-generation (air) threats. The priority list mentions force protection and escort tactics, techniques, and procedures (TTPs), but it does not specifically include integration with a strike package or LO assets. Additionally, it seems contradictory to direct F-16 pilots to be proficient in J-SEAD in this area of the RTM without necessitating a minimum number of J-SEAD missions to maintain that proficiency.

<u>Mission Priorities</u>
OCA-SEAD:
Proficient:
- SEAD CAP/Flow-thru/Force Protection/Escort TTPs
- All theaters
- Deliberate planning/execution
- Day/night
- HTS operation
- J-SEAD
- Detect, ID, target, and engage targets with on-board/off-board sensors
- OCA-SEAD IVO 4th gen threats w/dedicated OCA-Escort
    - Employing self-escort against 2nd / 3rd gen threats
- Contested EMS environment

Familiar:
- IMC operations
- Low altitude operations
- Combat Search and Rescue – On Scene Commander (CSAR-OSC) duties

Figure 15: F-16 SEAD Mission Priorities[73]

EA-18G Training

The US Navy's version of a RTM is the Training and Readiness (T&R) Program. The requirements for carrier-based squadrons and expeditionary squadrons differ, thereby requiring multiple addendums or "enclosures" to the T&R regulation. Rather than a sortie-based requirement per month, the Navy system uses an hour-based requirement. Carrier-based EA-18G aircrews are to average 27 flight hours per month, while expeditionary aircrews are to average 25 flight hours per month.[74] Like F-16 pilots, both carrier-based and expeditionary EA-18G aircrews are required to be proficient in SEAD missions and to conduct flights on an EW range. The T&R documents encourage the use of EW emitters with "feed-back capabilities" capable of generating high-fidelity threat signals and providing jamming effectiveness reports on all SEAD flights.[75] While the F-16 RTM acknowledges J-SEAD, there is no mention of J-SEAD requirements in any of the EA-18G T&R documents.[76] The only opportunities Growler aircrews have to conduct J-SEAD are when expeditionary squadrons participate in LFEs like RED FLAG.[77]

F-15E Training

The primary missions of the F-15E include AI/OCA-AO, DCA, and CAS.[78] Like F-16s, they have a requirement to train on an EW Range, but with only six events required per year compared to the 20 required for F-16 aircrew.[79] As SEAD is not a primary mission for the Strike Eagle and SAM system detection and geo-location are not primary capabilities, the reduction in EW Range requirements is entirely logical. The only true mention of SEAD in the F-15E RTM occurs in the mission priorities section, where it dictates that F-15E aircrew will be proficient in self-escort against legacy SAMs and proficient in integration with SEAD assets to include Mission Commander responsibilities against modern short- and medium-range SAMs.[80]

Table 5b – Flight Mission/Sortie Requirements

MISSION	TASK ID	CMR		BMC		NOTES
		INEXP	EXP	INEXP	EXP	
PRIMARY MISSIONS (Proficient)						
AI/OCA-AO (day)	SR72	24	22	18	14	
AI/OCA-AO (night)	SR73	6	5	4	4	4, 5
DCA (day)	SR21	9	8	7	6	6
DCA (night)	SR22	3	3	2	2	4, 5, 6
CAS (day)	SR18	9	8	7	6	
CAS (night)	SR19	3	3	2	2	4, 5

Figure 16: F-15E Flight Mission Requirements

F-22 Training

The primary missions for the F-22 include OCA-Escort/Sweep and DCA, with AI/OCA-AO included as a secondary mission.[81] Of note, a mix of their 21 (inexperienced) or 19 (experienced) OCA-Escort/Sweep missions are dedicated to Global Strike missions, to be planned and flown with the B-2; however, like J-SEAD for the F-16, the exact number is left to the Commander's discretion.[82] Surprisingly, F-22 pilots are only required to accomplish one EW Range event per training cycle, with no specific requirements to perform SAM/IADS attacks. This requirement is low due to an embedded training capability in the F-22 that allows the aircraft to simulate surface threats. The simulation is only useful to the F-22 pilots and does not allow for integration with other airframes; therefore any SEAD mission involving integration with other MDSs should take place on an actual EW range.

Like the F-15E, the primary mention of SEAD in the F-22 RTM is in the mission priorities section, where it dictates that pilots be proficient in integration with strike, OCA and SEAD assets, and familiar with employing self-escort against modern short- medium-range SAMs and with weapons employment against Legacy SAMs.[83] As the F-22 gains increased geo-location and electronic protection capabilities with Suite 3.2B upgrades and beyond, there should be an increased shift towards destructive SEAD missions and integration.[84]

Table 5b Flight Mission/Sortie Requirements

MISSION	TASK ID	CMR (INEXP/EXP)			BMC (INEXP/EXP)			NOTES
		REGAF	AFRC	ANG	REGAF	AFRC	ANG	
PRIMARY MISSIONS								
OCA-ESC/SW	SR37	21/19	18/12	16/10	12/11	12/11	10/9	5
DCA	SR62	13/11	11/9	10/8	9/6	9/6	8/5	
SECONDARY MISSIONS								
AI/OCA-AO	SR39	11/9	9/6	8/5	6/5	6/5	5/4	
CC OPTION	N/A	15/12	15/12	15/12	13/12	13/13	13/13	7

Figure 17: F-22 Flight Mission Requirements

Table 5c – Flight Event Requirements								
EVENT	TASK ID	CMR			BMC			NOTES
		RegAF	AFRC	ANG	RegAF	AFRC	ANG	
4-Ship Employment	RA02	12	9	9	( )	( )	6	
A/A Night	SR38	15	9	9	*4	4	4	14
AAR (day)	AR01	3	2	2	2	2	2	
AAR (night)	AR02	2	2	2	2	2	2	
Aerial Gunnery	GU01	2	2	2	2	1	1	
Alert Scramble	RA10	2	2	2	1	1	1	
Chaff	RA13	18	18	18	12	12	12	
Composite Force (CFTR)	RA12	8	4	4	( )	( )	( )	16
CSAR(On-Scene Cmdr)	RA96	2	2	2	1	1	1	
Dynamic Targeting A/G	WD31	6	4	4	( )	( )	3	12
EP A/A	RA15	7	6	7	6	6	6	
EP A/G	RA16	2	2	3	( )	( )	2	
EW Range	RA32	1	1	1	( )	( )	( )	
Flag Exercise	RA20	2	1	1	( )	( )	0	13
Flare	RA21	18	18	18	12	12	12	
IAM	RA27	1	1	1	( )	( )	( )	
Have Quick/Secure Voice	RA26	12	12	12	( )	( )	8	
Low A/A	LE06	6	6	6	( )	( )	3	10
Low ALT	LE03	( )	( )	( )	( )	( )	( )	11
Low Slow VID	RA43	1	1	2	1	1	1	
Off-Station Sortie	SD03	8	( )	( )	( )	( )	( )	15
Slow Shadow	RA50	1	1	1	1	1	1	
CMD	RB04	3	3	3	2	2	2	

Figure 18: F-22 Flight Event Requirements

F-35 Training

Aside from the F-16, the F-35 is the only USAF fighter to have SEAD as a primary mission statement. OCA-SEAD, AI/AOCA-AO, and CAS are listed as the F-35 primary missions, with OCA-Escort, DCA, and Forward Air Controller –Airborne (FAC(A)) listed as secondary missions.[85] SEAD missions comprise approximately 19 percent of the required annual training sorties for an F-35 pilot, with the same F-16 caveat that commanders determine the number of J-SEAD sorties required.[86] The only other requirements that are left to a commander's discretion across the USAF RTMs are the percentage of primary mission sorties that must be flown at night for the F-16 and F-35, but even those have an established minimum of 25 percent.[87] F-35 pilots are required to complete 12 EW Range events per year, which is roughly 60 percent of their SEAD sorties.[88]

Table 5b Flight – Mission/Sortie Requirements						
MISSION	TASK ID	RegAF / AFRC / ANG				NOTES
		CMR		BMC		
		Inexp	Exp	Inexp	Exp	
PRIMARY MISSIONS (PROFICIENT)						
OCA-SEAD (Day/Night)	SR29/30	20	20	14	14	6,7
AI/OCA-AO (Day/Night)	SR72/73	14	14	9	9	7
CAS (Day/Night)	SR18/19	12	12	7	7	7
SECONDARY MISSIONS (FAM)						
CC Option	N/A	6	4	4	2	8
OCA-Escort	SR08	6	5	4	3	7
DCA (Day/Night)	SR21/22	7	6	6	5	7
FAC(A) (If Qualified)(Day/Night)	SR23/24	6	4	4	2	7,11,14

Figure 19: F-35 Flight Mission Requirements

In a comparison of simulator requirements, the F-35 uses the new Full Mission Simulator (FMS) rather than the MTC, with a requirement for 48 events per year.[89] This represents a 33% increase in simulator requirements over all other USAF fighter aircraft. Of those 48 FMS events, 12 (25 percent) are required to be SEAD missions that must all be flown in a DMO environment if the capability exists to do so. These requirements may change as the F-35 reaches IOC; however, the increased sensor integration and overall capabilities of the F-35 likely require additional simulator missions to obtain proficiency.

Table 6a – FMS Mission Requirements						
FMS MISSION	TASK ID	RegAF / AFRC / ANG				NOTES
		CMR		BMC		
		Inexp	Exp	Inexp	Exp	
OCA-SEAD	MT10	12	12	6	6	27
AI/OCA-AO	MT20	9	9	4	4	
CAS	MT14	7	7	3	3	
OCA-Escort	MT20	2	2	1	1	27
DCA	MT04	4	4	2	2	
FAC(A) (if qualified)	MT15	2	2	1	1	29
TI	MT18	4	4	2	2	
Instruments	SQ17	2	2	1	1	
Emergency Procedures	MT17	6	6	4	4	28
TOTALS		48	48	24	24	30

Figure 20: F-35 FMS Requirements

The mission priorities list for F-35 SEAD is a carbon copy of the F-16 SEAD list depicted in Figure 15, with the exception of F-16 HTS pod operations.[90] Two key differences in the F-35 RTM are the discussion of expectations when the aircraft reaches Initial Operating Capability (IOC) and a note that integration will be required for all primary mission sets.[91] While the F-35 RTM does not specify what level of integration will be necessary (i.e. integration only with other LO assets versus integration with non-LO platforms), in reality all RTMs should emphasize integration. Additionally, while F-35 SEAD capability is expected to be "limited" at IOC, the definition it provides in Figure 21 below is the only mention of long-range SAMs in any USAF RTM. This is a noteworthy event as it finally shows a shift towards the consideration of advanced SAM threats in training.

Primary Missions—Expectations at Initial Operational Capability (IOC)

[Basic] CAS: Support the Ground Commander with detailed integration and precision employment of sensors and weapons against a wide array of static targets in close proximity to friendly forces.

AI/OCA-AO: Destroy select enemy targets in a contested environment.

[Limited] OCA-SEAD: Support A/A and A/G force packages by detecting, geo-locating, suppressing, and degrading long- and medium-range SAMs or provide adequate SA to the force package to effectively negate or avoid the threats. Also, support A/A and A/G force packages by detecting, geo-locating, suppressing, and destroying short-range SAMs or provide adequate SA to the force package to effectively negate or avoid the threats.

Note: Integration is required for all primary missions; all missions are limited by weapons load-out.

Figure 21: F-35 Expectations at IOC[92]

B-2 Training

The B-2 falls under Global Strike Command, and therefore the RTM requirements and format are slightly different then the fighter aircraft mentioned above. The annual flight requirements are significantly less (75 percent) than fighter requirements, with only 26 annual sorties required per year for inexperienced aircrew and 24 required for experienced aircrew.[93] This is due to the extended length and cost of each B-2 sortie, with aircrew maintaining basic proficiency and currency in the T-38 companion trainer and meeting increased simulator requirements (44 total).[94]

Since the B-2 is not a multi-role aircraft, primary missions are simplified into either conventional or nuclear training.[95] B-2s must conduct 12 events per training cycle on an EW Range, although they refer to these events as "DMS Activity." This is in reference to their Defensive Management System, which geo-locates threat emitters and displays them to the aircrew in order to aid in avoidance.[96] Aside from the DMS event requirement, there are no specific references to SEAD integration in the B-2 RTM.

US EW Range Capabilities

The US has several ranges with varying EW capabilities around the globe. For the purpose of simplicity, this paper will focus on the Poinsett Electronic Combat Range and the Nevada Test and Training Range (NTTR). The Poinsett Electronic Combat Range includes systems in the Bulldog and Gamecock Military Operating Areas (MOAs), and it is the primary training range for the three squadrons of F-16s stationed at Shaw AFB, South Carolina. As the only active duty SEAD squadrons stationed in the US, these three F-16 squadrons have the largest requirement to train on EW ranges. The NTTR is the "USAF's premier battle space" and the primary training range for RED FLAG LFEs, the USAF Weapons School, and the 422d Test and Evaluation Squadron.[97]

The Poinsett Electronic Combat Range uses the manned AN/MST-T1A Multiple Threat Emitter System (MUTES) in combination with unmanned AN/MST-T1V mini-MUTES and AN/VPQ-1 Tactical Radar Threat Generators (TRTGs) to simulate real-world threat radar systems.[98] The current SAM replication capabilities for these systems include the SA-2, SA-3, SA-6, SA-8, SA-15, and CSA-1.[99] Additionally, the systems can replicate Flap Wheel early warning radars and the targeting radar of the ZSU 23-4 "Shilka" Anti-Aircraft Artillery (AAA) system. The MUTES and mini-MUTES are all stationary systems that operate on prepared pads, whereas the TRTGs offer a semi-mobile option to replicate the SA-8 and ZSU 23-4. The term "semi-mobile" is used because the TRTGs can be moved around the range to pre-coordinated locations, but will not pick-up and move during training missions.

The NTTR uses MUTES, mini-MUTES, and TRTGs like the Poinsett range, but also has AN/TPT-T1 Unmanned Threat Emitters (UMTEs), AN/FSQ-T34 Joint Threat Emitters (JTEs) and GSG-11 Roland emitters.[100] The NTTR has a total of 37 emitters, with the capability to replicate SA-2, SA-3, SA-6, SA-8, SA-13, and Roland SAMs, as well as AAA and early warning radars. All of the systems operate from prepared locations with the exception of the TRTGs and GSG-11s. The GSG-11s are more mobile than the TRTGs, and will typically move throughout a training mission, although they do not have the ability to radiate while they are moving.[101]

Adversary Air Defense Capabilities

A myriad of SAM systems are in existence around the world, built by dozens of countries and globally exported to countless more. The focus of this paper will be on systems produced in Russia, as they have been the primary exporter of SAM systems for several decades and their products are the most widespread.[102] Russian SAM designs have made vast improvements from the Vietnam and Cold War era systems the US has become accustomed to fighting. Figure 22 compiles data on key Russian SAM systems, which will be referenced through the remainder of the discussion.

System	NATO Designation	IOC	Min Range (nm)	Max Range (nm)	Min Altitude (feet)	Max Altitude (feet)	Simultaneous Targets	Missiles per Target	System Mobility
SA-2D	Guideline	1959	3.2	26.9	350	98K	1	2	Semi-Mobile
SA-3	Goa	1964	1.9	13.4	100	59K	1	2	Semi-Mobile
SA-5	Gammon	1967	9.2	129.6	1600	UNLIM	1	2	Poor Mobility
SA-6	Gainful	1967	2.2	12.9	100	46K	1	2	5' Set Up
SA-8	Gecko	1971	0.8	5.4	82	16K	1	2	3-5' Set Up
SA-10	Grumble	1985	2.7	40.5	SFC	82K	6	1	5' Set Up
SA-11	Gadfly	1980	1.6	18.9	50	72K	6	1	5' Set Up
SA-12A	Gladiator	1988	3.2	40.5	SFC	82K	8	1	5' Set Up
SA-12B	Giant	1988	7.0	54.0	3200	98K	8	1	5' Set Up
SA-15	Gauntlet	1986	0.8	6.5	32	20K	2	2	Tgt on the Move
SA-17	Grizzly	2008	1.6	27.0	32	82K	6	2	3-5' Set Up
SA-20	Gargoyle	1997	2.7	108.0	SFC	98K	6	2	5' Set Up
SA-21	Growler	2006	1.1	135/215	SFC	UNLIM	6	2	5' Set Up
SA-22	Greyhound	2007	0.6	10.8	SFC	49K	2	2	Fire on the Move
SA-23	Giant	2011	7.0	135.0	82	98K	8	1	5' Set Up
S-500	N/A	2017?	UNK	350	SFC	UNLIM	10	1	5' Set Up

Figure 22: Russian Radar-Guided SAM Quick-look[103]

Russia's major entry into the SAM export game began with the protracted Vietnam conflict, where it deployed the SA-2 "Guideline" to defend North Vietnam. The US answered the threat with specialized SEAD aircraft like the EA-6A/B, EF-100F, and F-105G, as well as improved low-altitude tactics to evade the SA-2 radars. In response to US success, the SA-3 "Goa" improved low-altitude SAM capability, with the SA-6 "Gainful" arriving soon thereafter and providing the first highly mobile system. The SA-5 "Gammon" also emerged at this time as a strategic, long-range SAM to target non-maneuverable high valued airborne assets (HVAA) such as AWACS, air refueling tankers, and high altitude bombers. These four systems constitute what will be referred to as the "legacy" Russian SAMs. These systems remain in service in several countries and represent the bulk of the systems the US has engaged during combat operations over the past 50 years.

Russia began work on a new generation of SAMs following the unconvincing performance of their systems during the Yom Kippur conflict in 1973 and the introduction of the F-4G and EF-111A in the late 1970s.[104] Focused on increased range and mobility, these improvements resulted in the development of the SA-10 Grumble, SA-11 Gadfly, and SA-12 Gladiator/Giant in the 1980s. All Russian SAM systems since the release of the SA-6 in 1967 have been designed to "shoot and scoot" in under five minutes, meaning they can fire within five minutes of coming to a halt and depart within five minutes of completing an engagement. Improved point defense systems such as the SA-15 "Gauntlet" and SA-22 "Greyhound" boast the ability to target and fire while still on the move.[105]

Russian SAMs can be divided into three main categories based on range. The first short-range/point defense SAM was the SA-8 "Gecko," released in 1971, replaced by the SA-15 "Gauntlet" in 1986, and then improved upon again with the release of the SA-22 "Greyhound" in 2007. The short-range systems typically deploy with Army units or in point defense of high-valued assets, have the highest mobility of any Russian SAMs, and have a typical maximum range of five to ten nautical miles.[106] The medium-range category started with the release of the SA-6 "Gainful" in 1967, which has also evolved twice with the SA-11 "Gadfly" in 1980 and the more recent SA-17 "Grizzly" in 2008. These systems are highly mobile, with an average max range of approximately 20 nautical miles.[107] Most of Russia's modern SAMs are in the long-range category, which began with the development of the SA-10 Grumble in 1985, progressing to the SA-12 Gladiator/Giant in 1988, the SA-20 Gargoyle in 1997, the SA-21 Growler in 2006, and the SA-23 improved Giant in 2011.[108] Their most recent system, the S-500, has yet to be named by NATO but boasts an expected range of up to 350 nautical miles.[109]

Several trends can be seen throughout the evolution of these systems, as they are continually improved to counter US SEAD and LO capabilities. All variants are highly mobile, with all key components self-propelled on terrain-wheeled vehicles. Even large target acquisition radars have been built to redeploy inside of fifteen minutes, and upgrades to legacy systems like the SA-2 and SA-3 are in production to increase their mobility.[110] All modern Russian SAMs have also moved to phased array radars, with elevated power output and enhanced resistance to jamming. The increased power output extends the maximum range of the system with the bonus side effect of enhancing the detection range of LO targets. Improved solid propellants for the missiles and upgraded digital guidance systems and control laws also help increase the overall kinematic capabilities of the systems.[111]

In addition to mobility, radar, and range enhancements, Russian systems are beginning to use lower operating frequencies to improve resistance to jamming and counter US stealth technology. They have advanced digital signal and data processing capabilities, which reduces false targets and surface clutter, provides target identification capabilities, and aids in the rejection of chaff or decoys. Many systems are deployed with radio frequency decoys that distract anti-radiation missiles like the HARM, as well as visual decoys that complicate ATP and SAR map targeting of the systems.[112]

Most modern Russian systems use digital data links and wireless networks to communicate with each other, enhancing information passage between systems and permitting the “shooters” to reduce emission times. This allows them to wait until a target is in the heart of the envelope before they engage with their own radars and expose their location. Furthermore, whereas early systems could only target one aircraft at a time, newer engagement radars have the capability to track hundreds of aircraft, targeting up to ten simultaneously.[113] Improved point defense systems such as the SA-15 and SA-22 are advertised to be highly effective in shooting down smart munitions like JDAMs that are targeting other SAM batteries.[114] When layered together, this drastically increases the number of weapons required to achieve a kill on one SAM battery, assuming that one could locate the SAM in the first place.

Future SEAD Scenarios

The scenario planning method is used "to make predictions about the future so that long-term plans can be developed in anticipation of those predictions."[115] The future of SEAD operations depends on the threats the US will face, and training plans must be developed to counter the expected threat. The surface threat may vary from small-arms fire to an extensively redundant and layered IADS, and training to only one scenario would leave the US ill-prepared to counter another.

The following four scenarios cover the most likely surface threat environments the US could face in the near future, ranging from light to extremely complex. Each scenario will be graded on two major axes, as depicted in Figure 23: the technological capabilities of the surface threats expected and the level of joint or MMDS SEAD integration required to overcome such a threat. The level of threat technology in each scenario moves left to right on the X-axis from limited to advanced, while the level of SEAD integration required in each scenario moves vertically on the Y-axis from minimal to heavy. Surface threats will be compared based on the number of surface threats expected, their engagement ranges and capabilities, and their mobility. An assessment of the level of joint or MMDS SEAD integration required will be made based on these factors.

It is important to note that these scenarios, while plausible, are not intended to represent any specific threat country. They are hypothetical situations based on IADS components that are currently fielded and available to other nations as well as the current capabilities of the US. These scenarios represent an IADS threat the US could face in the very near future (within the next five years). The focus of each scenario is on surface threats. The addition of air threats would complicate the scenarios, but this complication is ignored as air threats are beyond the scope of this paper.

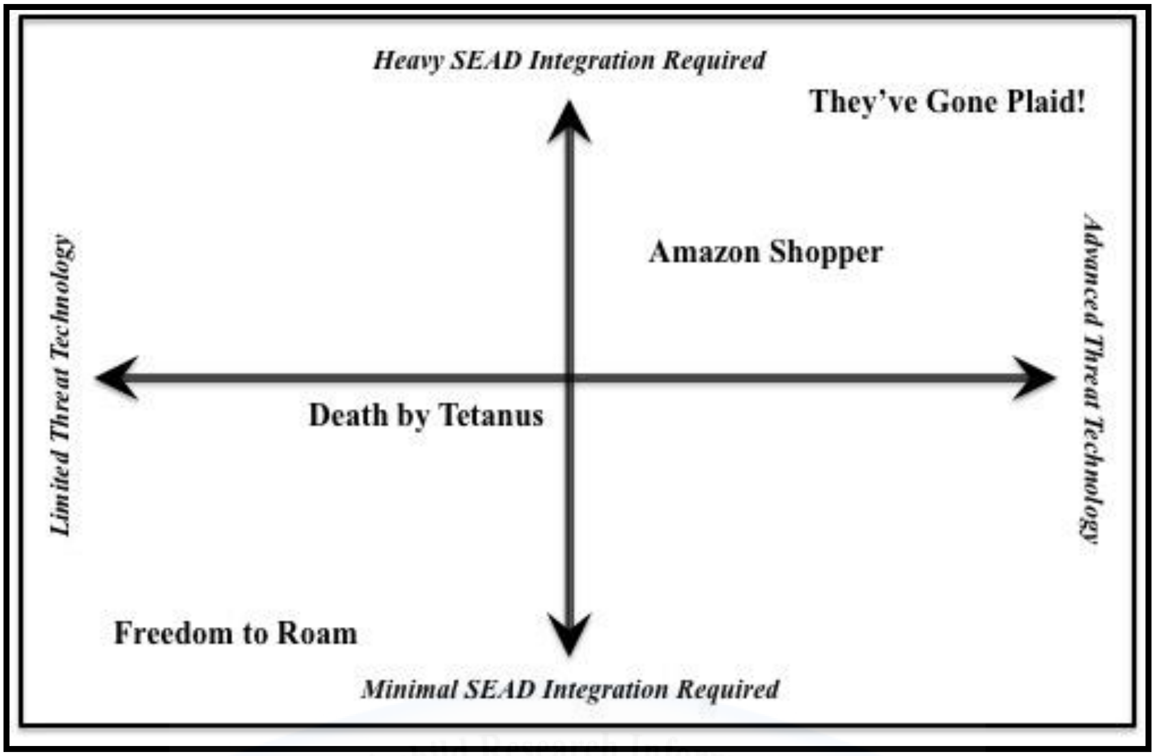

Figure 23: Scenario axis plot

Scenario 1: Freedom to Roam

Threat Capabilities

The US has enjoyed a relatively uncontested air environment over the last decade of offensive operations. It is plausible this trend will continue and that the next conflict will consist of CAS and AI/OCA-AO missions used to dismantle terrorist organizations or other non-state actors. "Freedom to Roam" is based on such a scenario in which surface threats are relatively non-existent and air assets are "free to move about the cabin" if you will.

Terrorist organizations and non-state actors have traditionally gained access to small arms, man-portable air defense systems (MANPADS), and light AAA.[116] While such threats pose a hazard to low-flying and non-maneuverable aircraft, tactical aircraft can typically avoid them by flying in the medium- to high-altitude environment or defeating them with a combination of counter-measures and defensive maneuvering.

If an adversary of this type obtained SAM systems, it would probably be a small number of short- or medium-range mobile systems obtained illegally from the official government of the host nation-state. As these systems would most likely be stolen, unskilled personnel would operate them. Terrorists and non-state actors appreciate the need for rapid mobility, ease of concealment, and ease of use. If they were to obtain SAM systems, they would be apt to take ones from the SA-8 or SA-15 family. These systems are the smallest, most mobile, and require the least amount of integration.[117] SAMs from this family have a limited maximum-range (roughly six nautical miles), but require little to no setup time. Like most legacy SAMs, they are also limited in the number of simultaneous targets they can engage, with a best case of two individual targets and two missiles per target.[118]

SEAD Integration Required

Free-roaming SAMs would be forced to use their own radars to target aircraft without an integrated surveillance feed to connect to. This leads to longer emission times and subsequent ease of detection and location of the threats by SEAD aircraft. While coalition air forces may trade shots with the systems, the odds are that they could be quickly located and destroyed. With a minimal surface threat, AOR/JOA-wide air defense (AD) system suppression would be the preferred category of SEAD execution, which would be relatively easy to achieve.

Threats in this scenario would be sporadically spaced out with ground forces, or strategically placed in point defense of key personnel, equipment, and resources. As tactical aircraft are deployed to dismantle enemy operations and provide CAS for friendly ground forces, a small contingent of dedicated F-16 or EA-18G aircraft could be used to locate these SAMs. As soon as a SAM is located, its position would be transmitted via data-link and voice communications to friendly forces. Any aircraft in the immediate vicinity could avoid the SAM threat by flying outside of its maximum range or above its maximum engagement altitude.

A four-ship of F-16s carrying a mixed weapons load of HARM and precision-guided munitions (PGMs) could target and destroy a handful of these short-range SAMs while remaining outside the threat's maximum engagement range and self-suppressing with HARM. Each F-16 can carry a mixed load out of 1xHARM plus 1x2000-pound PGM, 2x500-pound PGMs, or 4x250-pound PGMs.[119] The Joint Direct Attack Munition (JDAM) carried by the F-16 is made in the 500- to 2000-pound class, with a published maximum range of approximately 15 nautical miles, well outside the engagement capability of a short-range system like the SA-8 or SA-15.[120] If weather precluded location of the threats with the advanced targeting pod (ATP), HARM Targeting System (HTS) PT-ranging could be used to locate the threats and a pattern of weapons could be dropped to ensure destruction.

Virtually no joint or MMDS SEAD integration would be required to counter a few short-range SAMs. Integration would merely be a bonus, resulting in overall mission risk reduction if additional resources like radar-jamming or synthetic aperture radar (SAR) mapping were available for SEAD operations. US aircraft would therefore be free to roam the airspace.

Scenario 2: Death by Tetanus

Threat Capabilities

A future scenario may exist in which the US must conduct operations against an enemy nation-state that has a large number of legacy SAM systems that are well connected in an IADS. Just as a man could step on a box of rusted nails and subsequently die from the bacterial disease of tetanus, a large and sophisticated air force could face losses due to overwhelming numbers of aging SAM systems. Russia has been heavily exporting legacy SAMs for over 50 years, and even a relatively small country like North Korea has over 70 of Russia's SA-2, SA-3, and SA-5 systems.[121]

Most legacy systems like the SA-2 and SA-3 are not mobile, as discussed in the SAM capabilities section. They traditionally operate from prepared locations and require several hours for site tear down, relocation, and reconstruction. The average maximum range of legacy SAM systems is 20-30 nautical miles, with each site only capable of conducting a single engagement at any given time.[122] The exception to the range rule is the SA-5, which boasts a 130 nautical mile range but has virtually no mobility and little to no capability to engage a maneuvering target (i.e. a tactical aircraft).[123] Although some countries have updated SA-2 and SA-3 systems with mobile transporter erector launchers (TELs) as well as digital and mobile radars, they lack the full mobility and range capabilities of Russia's newer systems.[124]

When a large number of legacy systems are linked via an advanced command and control (C2) network, an integrated surveillance picture can be communicated to each SAM site for target sorting and prioritization. Each legacy SAM in this scenario, however, will be limited to a single target per engagement. It is believed that legacy systems are only capable of targeting host aircraft; therefore they would have no capacity to target actual munitions once they have been released or launched.[125]

SEAD Integration Required

A nation with a large number of legacy SAMs would be expected to organize them in such a way to provide overlapping coverage of their borders in order to prevent invasion, as well as overlapping coverage of key cities or facilities. The US could conduct strikes on the nation's interior using available LO aircraft like the B-2, but it would need to destroy at least the outer ring of SAMs in the initial phase of a conflict to enable air interdiction strikes by non-LO platforms and provide true AOR/JOA-wide AD system suppression.

The majority of the SAM locations would be known before the attack began, as they are predominantly immobile and their locations can be identified through satellite imagery. This would allow a large number of systems to be targeted by surface-to-surface and air-to-surface standoff munitions at the initial stages of combat. Even if SAMs moved between prepared sites, ISR assets could verify which sites were "occupied" well before launching weapons. Extra weapons could also be launched against the vacant sites to destroy the enemy's ability to operate from those locations if they decided to move their systems.

The US may not want to leave the nation completely defenseless at the end of the war, for either fiscal reasons such as war cost management or political reasons such as the prevention of future instability in the specific region. If that is the case, total annihilation of the enemy's air defenses may not be the ultimate goal. The preferred strategy may be to create a hole in the "wall" of SAMs, and then clear a path large enough to allow non-LO platforms to enter the country's airspace and reach their targets. JP 3-01 refers to this form of SEAD as "localized suppression." It requires the destruction of key SAM systems and C2 nodes as well as kinetic and non-kinetic suppression of key geographic areas associated with targets or transit routes.[126]

The adversarial nation in this scenario is likely to have several early model short-range systems for point defense, as well as legacy medium-range mobile systems from the SA-6 family for protection of high-valued assets. Dedicated SEAD assets like the F-16 would be required to escort strike aircraft and conduct effective localized suppression, or to "clean up" any remaining threats after initial strikes in a AOR/JOA-wide AD system suppression scenario.

F-16s paired with F-15Es in "hunter/killer" roles could be optimized for locating and destroying any remaining medium-range threats after the initial attack. F-16s can use HTS to initially locate threats, passing data to the F-15Es to SAR map for precise coordinates and for targeting with longer-range PGMs. Both the F-16 and F-15E are capable of carrying the 250-pound class GBU-39 Small Diameter Bomb (SDB), which possesses a range of up to 60 nautical miles and can be used to destroy medium-range SAMs without forcing the aircraft to penetrate a medium-range missile engagement zone (MEZ).[127] If forced to penetrate the MEZ, F-16s could continue to suppress threats with HARM while EA-18Gs provided radar jamming for the strike package. A combination of standoff munitions and traditional SEAD escort would provide the vaccine necessary to prevent death by tetanus.

Scenario 3: Amazon Shopper

Threat Capabilities

If the country from the "Death by Tetanus" scenario went shopping for a few newer SAM systems from the Russian government's equivalent of Amazon.com, an entirely new level of sophistication would be added to its IADS. A country can make relatively inexpensive improvements to a legacy IADS by investing in digital and mobility upgrades for its current SAM systems. Additionally, they can purchase improved early warning and target tracking capabilities like very high frequency (VHF) radars, passive detection systems, and infrared search and track systems (IRSTS). These upgrades can boost the range of their medium-range SAMs and enable them to track (if not target) some LO platforms.[128]

Additional "orders" of one to two Russian long-range systems in the SA-20 family would dramatically change the threat picture. The SA-20 can engage six targets at a time at ranges over 100 nautical miles. It can engage targets with very small radar cross sections (RCSs) such as air-to-ground munitions, cruise missiles, and possibly LO-aircraft. If a country added a single SA-20 battalion, any non-LO platform would be forced to operate from outside 100 nautical miles of its position.[129] This would prevent any non-LO platform from employing weapons other than standoff munitions and would minimize the radar jamming effectiveness of SEAD aircraft like the EA-18G. The SA-20 is highly mobile, with the ability to "shoot and scoot" in under five minutes. This makes it very difficult to target with standoff weapons. Even if its location were known to pinpoint accuracy, the entire system could pack up and move during the standoff weapon's time of flight.

A few orders for improved medium-range systems like the SA-17 and short-range systems like the SA-22 would also add a layer of difficulty to SEAD operations. While the SA-22 has a relatively short range at 10 nautical miles, it can engage multiple targets simultaneously and is optimized to target inbound weapons in point defense of high-valued targets. Due to their powerful radars, high mobility, and the ability to engage multiple low RCS targets, these threats would increase the number of weapons required to achieve a kill on any system or target they protect.

SEAD Integration Required

The first step in defeating the IADS of the country from this scenario would be to neutralize the long-range SAM threat to allow access to other targets. While destroying a single SA-20 site may sound trivial when compared to the more than 70 legacy SAMs possessed by a country like North Korea, it requires an entirely separate SEAD strategy. As the system is highly mobile, the first challenge is to locate it. SEAD platforms like the F-16 will have to operate in conjunction with a combination of ISR platforms such as space assets and the "Iron Triad" to locate these systems.

For a SEAD platform to locate an SA-20 site, the system must first turn on its radar. Stimulating the IADS may be accomplished through the use of miniature air-launched decoys (MALD) and/or through the use of standoff munitions targeting known threat locations. Until the SA-20 can be destroyed, all non-LO platforms will have to operate from outside the MEZ, which also places these aircraft outside the weapons' employment range of traditional PGMs and HARMs.

Once located, the SA-20 may be targeted with standoff munitions, but it could still move during the weapon's flight. Transmitting coordinates to LO platforms in order to prosecute with conventional PGMs would be a more effective solution. LO platforms can operate closer to the threat due to their reduced RCS and therefore reduced detection range. Employing ordnance from a shorter range will minimize the weapon time of flight, thereby increasing the probability of hit against a mobile target.

Since the SA-20 can engage at least six targets simultaneously, including air-to-ground munitions, it could take seven or more bombs to achieve a single hit on the SAM. This means it could take an entire four ship of F-22s, carrying two JDAM each, to target a single SA-20. If that SA-20 is protected by a few smaller SA-22s, the number of weapons required to achieve a hit increases dramatically.

When attacking advanced SAMs, the time between detection and weapons impact must be minimized to counter the rapid mobility of the systems. Additionally, a larger number of weapons will be required in order to overcome the multi-target capability and saturate a system. For long-range SAMs this will require close integration between traditional SEAD assets like the F-16 and EA-18G operating outside the MEZ and LO platforms like the F-22 and F-35 operating at close range.

Once the long-range SAMs are destroyed, the principles of rapid destruction and weapons saturation remain the same for advanced medium-range SAMs. The reduced range of these threats, however, means radar jamming platforms like the EA-18G can move in closer and become more effective. Additionally, the reduced range means SEAD players can operate within employment range of the HARM, and non-LO platforms like the F-15E can take over bombing roles and drop traditional PGMs (or at least SDB) while remaining outside of a MEZ.

Regardless of whether a country possesses a few advanced long-range SAMs, a few advanced medium-range SAMs, or both, close integration and rapid information passage between multiple platforms will be required in order to effectively neutralize the IADS threat. Specialized SEAD aircraft will be required to locate threats and suppress them with radar jamming and HARM, LO platforms will be required to attack long-range threats, and non-LO attack platforms will be required to help locate and carry the additional weapons necessary to eradicate the remainder of the medium-and short-range threats. MMDS and J-SEAD teams working in concert will be required to counter the "Amazon Shopper's" new purchases.

Scenario 4: They've Gone Plaid!

Threat Capabilities

In honor of the 1987 science fiction film "Spaceballs," the final scenario involves a country that has surpassed the ludicrous phase of IADS development and procurement so far that they've gone plaid! This country has a plethora of advanced long-, medium-, and short- range SAMs, backed up by extensively modernized legacy SAMs with overlapping coverage. All SAMs are networked through redundant communications systems and combined into several centralized IADS feeds to present a common operating picture to all systems.

The centralized IADS feed combined with VHF radars, passive detection systems, and IRSTS threaten even LO platforms' capability to penetrate the SAM MEZ. All previously discussed capabilities of advanced and legacy SAMs are combined into a super MEZ, and the overlapping coverage is such that any individual SAM can shut down and move without creating a gap in coverage. Additionally, the country uses heavy camouflage, concealment, and deception (CC&D) tactics and the majority of its advanced SAMs are collocated with physical and electronic decoys.

SEAD Integration Required

In order to attack an IADS like this with the US's current technology, the US must saturate it with a barrage of MALD and standoff weapons. The use of every available ISR asset will be required, using ceaseless analysis to create a list of priority targets on every possible IADS component. This intelligence must be updated on an hourly basis leading up to the initial attack in order to provide the highest fidelity coordinates for each IADS component.

The advanced capability of the IADS to engage multiple targets simultaneously will mean that dozens of weapons (if not more) will be required for each intended target in an attempt to gain a single successful impact. In this scenario, everything in the air will essentially be a surrogate decoy for anything else as the IADS attempts to sort and target all airborne objects.

"They've Gone Plaid!" is truly a scenario of attrition. Until a path can be carved out through the long-range systems, non-LO platforms will be limited to launching standoff weapons and performing duties outside the MEZ. Only LO platforms will be capable of operating within the MEZ, but they will not have complete freedom of movement due to the enemy's counter-stealth technology. There will be heavy losses.

The US is unequipped to deal with a scenario such as this. To be successful, a complete analysis of the IADS capabilities and weaknesses must be accomplished. With infinite time to prepare, hundreds of computer simulations may be able to produce a single scenario that exploits a weakness in the IADS and results in mission success. These simulations would only be as good as the intelligence data behind them, however, and this data can change from minute to minute since virtually every IADS component is mobile. To succeed would likely require every LO asset in the inventory, as well every PGM and standoff munition available. To be more effective, the US would need to "catch up" to the ludicrous speed of the enemy by heavily investing in technological advancements and additional platforms or weapons designed to counter the IADs threat.

Conclusion

Current SEAD training is insufficient, as it does not adequately prepare US forces to face the advanced long-range and mobile SAM threat in existence today. The US has grown accustomed to fighting in scenarios such as "Freedom to Roam," with a minimal surface threat and hardly any requirement for SEAD support. If this were the only scenario in existence, current training would be satisfactory to counter the threat. The reality of the situation, however, is that the US is more likely to face a "Death by Tetanus" or "Amazon Shopper" scenario during the next engagement with an enemy nation. The "Death by Tetanus" scenario is representative of the current threat baseline that US forces train to; however, this baseline should be shifted to the "Amazon Shopper" scenario to account for advancements in adversary threat capabilities. In order to effectively train to this new baseline threat, the US must improve EW range capabilities and emphasize MMDS and J-SEAD training.

The level of joint and MMDS SEAD integration presented in "Death by Tetanus" is similar to what was conducted in *Operation Desert Storm* (ODS). This scenario is also representative of the baseline training conducted during large-force exercises (LFE) such as RED FLAG, the US Air Force's premier combat training LFE. There are few opportunities and no requirements for US forces to conduct MMDS and J-SEAD training missions outside of these LFEs.

The threat level in "Death by Tetanus" can be sufficiently simulated on many of the electronic warfare (EW) training ranges across the country. The MUTES, mini-MUTES, UMTEs, TRTGs, and JTEs found on US EW ranges are designed to represent legacy SAM systems, with limited mobility and a maximum engagement range of approximately 30 nautical miles. No capability currently exists on US EW ranges to simulate advanced long-range and mobile threat systems.

Simulating a long-range SAM on an EW range creates problems with airspace restrictions. The NTTR is one of the largest military operating areas (MOA) in the country, 150 nautical miles wide at its widest point.[130] If a simulated SA-20 were at one corner of the airspace, non-LO platforms operating outside of the 108 nautical mile max range would barely be able to remain in the training airspace. By contrast, Bulldog MOA (Shaw AFB's primary EW range) is only 55 nautical miles across at its widest point, which would prohibit any aircraft from operating outside the max range of even a simulated SA-10 threat in the airspace.[131]

It is unlikely that MOAs will be able to expand to accommodate the long-range capabilities of modern threats due to US National Airspace System restrictions. The focus of enhancing EW range threat systems should be to accurately replicate the emissions and mobility of modern SAM systems. Current threat emitters cannot replicate the radar signals of advanced SAMs, nor can they replicate the ability to relocate within minutes of an engagement. Accurately replicating radar signals is important because it allows aircrew to train to what they would actually observe with their onboard sensors in combat. Additionally, it permits SEAD assets such as the EA-18G to train with non-kinetic effects like radar jamming and evaluate their effectiveness.

In order to train for the difficult task of locating and destroying an advanced mobile SAM, the US must invest in highly mobile threat systems. This is perhaps the largest shortfall in current SEAD training. Without a truly mobile threat to train against, aircrew cannot gain an appreciation for the challenge of conducting SEAD against these systems and will be unprepared to handle the threat in combat. Additionally, aircrew cannot train to the level of SEAD integration required by the "Amazon Shopper" scenario without an appropriately representative threat system.

Currently, dedicated SEAD assets like the F-16 conduct the majority of their training internally, with little to no MMDS or J-SEAD integration. The aircrew that do not have SEAD as a primary mission rarely get the opportunity to train to it outside of LFEs. As expressed in the "Amazon Shopper" scenario, the level of integration required to counter an advanced SAM threat can be extremely complex. The coordination to effectively locate a system, pass that location to another aircraft for targeting, and then successfully engage the system before it relocates requires significant practice. Aircrew need to train to this level of integration on a regular basis to develop tactics and build the muscle memory required to find, fix, track, target, and engage advanced SAMs in the minimum amount of time possible.

SEAD should be added as a secondary mission set for F-15E and F-22 aircrew to ensure SEAD training obtains the level of focus it requires. All sorties reallocated to the SEAD mission for F-15E and F-22 aircrew should require MMDS or J-SEAD integration on an EW range to guarantee aircrew train to this mission set on a regular basis. SEAD requirements for the F-22 should diminish as the F-35 becomes operational, however, the F-22 will play an important role in long-range SAM targeting until the F-35 fleet reaches combat capability. In addition to the reallocation of F-15E and F-22 sorties to SEAD, F-16 and F-35 aircrew with SEAD as a primary mission should be required to dedicate at least 25 percent of those sorties to MMDS or J-SEAD integration on an EW range.

The US must shift the baseline training threat to the "Amazon Shopper" scenario now to be better prepared for future combat engagements. It must invest in EW range improvements and increase SEAD training across all tactical platforms to effectively train for the emerging IADS threat. US aircrew will be unprepared to face an advanced SAM equipped adversary if it does not make these training adjustments immediately.

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