

An hourglass-shaped graphic with a globe inside. The top bulb is dark blue, and the bottom bulb is light blue. The globe is centered in the narrow neck of the hourglass. The top bulb has a dark blue cap, and the bottom bulb has a light blue cap.

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*Military Suppression of Enemy Air Defenses (SEAD):
Assessing Future Needs*

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Abstract. Suppressing enemy air defenses (SEAD) has been a central element of projecting military air power for over 50 years. However, several developments suggest that this mission is of growing importance to the Department of Defense (DOD). Some say that the emergence of new technologies and air defenses will increasingly challenge U.S. SEAD efforts. Making budgetary judgments on SEAD programs and processes requires the assessment of complex factors.

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Military Suppression of Enemy Air Defenses (SEAD): Assessing Future Needs

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Summary

Suppressing enemy air defenses (SEAD) has been a central element of projecting military air power for over 50 years. However, several developments suggest that this mission is of growing importance to the Department of Defense (DOD). Some say that the emergence of new technologies and air defenses will increasingly challenge U.S. SEAD efforts. Making budgetary judgments on SEAD programs and processes requires the assessment of complex factors. This report will be updated.

Introduction

Suppression of enemy air defenses (SEAD) is defined by the Department of Defense (DOD) as “That activity that neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive and/or disruptive means.”¹ By this definition, many military platforms, munitions, and processes contribute to SEAD, including reconnaissance and surveillance, stand-off jamming, employment of air-to-surface munitions, and electronic and infrared (IR) countermeasures.²

A variety of weapons platforms and munitions can and have been used to attack enemy air defenses, including long range bombers, helicopters, surface-to-surface missiles, precision guided munitions (PGMs), rockets, and “dumb bombs.” However, some combat aircraft have been designed or modified to increase their effectiveness against enemy air defenses and are typically thought of as SEAD assets. These include the F-16, EA-6B, F/A-18, F-15E, and recently F-22A. These aircraft carry a number of munitions useful against surface-to-air missiles (SAMs). Some carry the AGM-88 High Speed Anti Radiation Missile (HARM) which is designed to lock-on to and destroy the ground-based radars used by some SAMs and anti-aircraft artillery (AAA). Also, the HARM Targeting System (HTS) and the Tactical Electronic Reconnaissance Processing

¹ Joint Publication 1-02. DoD Dictionary of Military and Associated Terms, Apr. 12, 2001.

² For discussion of stand-off jamming and electronic warfare, see CRS Report RL30639.

and Evaluation System (TERPES), improve the ability of the F-16CJ and Marine Corps EA-6B Prowlers to target enemy air defense radars.

Suppressing enemy air defenses has always been an important means of protecting U.S. aircraft, and enabling effective air operations. However, SEAD may be of growing importance to DOD and Congress for at least three reasons.

- While combat aircraft have played an important role in most U.S. conflicts since World War I, the last several conflicts (Bosnia in 1995, Kosovo in 1999, Iraq 1996-present, and Afghanistan in 2001) have emphasized the use of airpower.
- There appear to be very few countries capable of seriously challenging U.S. air forces in air-to-air combat. Since Operation Desert Storm, 100 percent of all U.S. combat aircraft losses have been due to enemy air defenses. No U.S. aircraft has been lost to an enemy aircraft since 1991. Most countries will challenge U.S. airpower primarily with surface-based air defenses.³
- DOD finds some air defenses difficult to suppress or destroy. Many analysts say that emerging air defense technologies and tactics will prove more threatening and more difficult to counter than current systems.

Issues of Concern

The Pentagon frequently expresses concern over several interrelated developments in enemy air defenses: the emergence and proliferation of a new generation of Russian SAMs, and the application of new technologies, either in conjunction with these or with other air defense elements. Shoulder-fired missiles continue to pose a problem for today's SEAD forces. Observers are also concerned about the effect of strict rules of engagement on SEAD effectiveness.

Russian SA-10 and SA-12 SAMs have been operational since the 1980s, but currently are in the inventory or possession of only a handful of countries (e.g., Russia, China, Cyprus, The Czech Republic, and Germany).⁴ These "double digit" SAMs are a concern for military planners due to their mobility, long range, high altitude, advanced missile guidance, and sensitive radars. The Russian SA-20, still under development, has been likened to the U.S. *Patriot* PAC-2 missile, but with an even longer range and a radar capable of detecting stealthy aircraft. Military planners are concerned that a country with only a handful of these SAMs could effectively challenge U.S. military air operations by threatening aircraft and disrupting operations from great distances.

³ Historically, the percentage of U.S. combat losses due to aerial combat has steadily declined and the percentage of losses due to enemy air defenses has steadily risen. In World War II, U.S. air combat losses were split almost evenly between aerial combat (46%) and air defenses (54%). By the Korean and Vietnam wars however, combat losses due to enemy air defenses had risen to approximately 90% and aerial combat losses had dropped to approximately 10 percent.

⁴ *World Missiles Briefing*, Teal Group, Inc., Feb. 2005. India, Iran, Syria and Vietnam are known to have negotiated with Russia for these systems, but acquisition has not been confirmed.

A variety of new technologies and military systems could exacerbate the “double digit” SAM challenge. First, commercial information and communications technologies are enabling adversaries to better network the elements of their air defense systems. This allows them to disperse radars, SAM launchers and other associated platforms throughout the battlespace, and to share targeting information between launchers. This, in turn, suggests that radars may be used less frequently and for shorter periods of time, complicating U.S. SEAD efforts. Second, terminal defenses are being marketed by a number of international defense companies. These radar-guided Gatling guns are designed to protect “double digit” SAMs or other high value air defense assets by shooting 3,000 to 4,500 rounds per minute into the sky. These systems could prove quite effective in shooting down HARM or other missiles aimed at enemy air defenses. Third, Russia and other countries have developed and are selling GPS jammers. Over varying distances, these low-watt jammers degrade or totally disrupt the GPS guidance signals used by many U.S. PGMs to augment inertial guidance systems, reducing their accuracy.

U.S. military planners must also grapple with today’s pernicious air defense threats, such as shoulder-fired missiles. Unlike “double digit” SAMs, MANPADs (eg. the U.S. *Stinger*, Russian SA-7, and French *Mistral*) are widely proliferated, and found in the inventories of scores of countries. These missiles are difficult to suppress due to their small size, high mobility and IR guidance. Unlike radar guidance, IR guidance — which MANPADs tend to use — does not emit energy that U.S. self-defense systems can detect. Thus, the launch of an IR-guided missile often comes as a surprise to the targeted aircraft, reducing the time for evasive maneuvers or deployment of self protection countermeasures. This increases MANPADs effectiveness. IR guided SAMs were the primary source of air combat losses in Operation Desert Storm,⁵ and since 1973, nearly half of all air losses in combat have been attributed to IR-guided SAMs, many of them launched from MANPADs. Others estimate that MANPADs caused 90% of worldwide combat aircraft losses from 1984-2001.⁶

Shoulder-fired missiles also pose a terrorist threat to civilian aircraft. RAND estimates that at least 20 and as many as 40 civilian airliners were shot down by terrorists using MANPADs between 1975 and 1992.⁷ (CRS estimates six of these aircraft were actually airliners, the others were smaller than most commercial aircraft.)⁸ The threat to civilian airliners posed by terrorists with shoulder-fired missiles appears to be an issue of increasing congressional concern. At least three bills introduced during the FY2005 budget cycle addressed methods for mitigating the threat of shoulder-fired missiles to commercial aviation.⁹

Rules of engagement (ROE) are designed by military planners to reduce the likelihood of fratricide (shooting down friendly aircraft), to minimize unintended civilian casualties, and in some cases, for political feasibility (e.g., operating in ways palatable to

⁵ Steven Zaloga, “The Evolving SAM Threat: Kosovo and Beyond,” *Journal of Electronic Defense*, May 2000.

⁶ Michael Puttre, “Facing the Shoulder-Fired Threat,” *Journal of Electronic Defense*, Apr. 2001.

⁷ Marvin B. Shaffer, *Concerns about Terrorists with Manportable SAMs* (RAND, 1993), p. 3.

⁸ CRS Report RL31741, *Homeland Security: Protecting Airliners from Terrorist Missiles*.

⁹ *Ibid.*, p 20.

coalition partners). Some have asserted that ROE in recent conflicts have been “draconian” and tied the hands of SEAD pilots; reducing their effectiveness.¹⁰ DOD may seek congressional support for more lenient ROE in future wars.

Assessing Future SEAD Needs

There are many factors that can be weighed, when attempting to measure the success of DOD SEAD efforts, and determining what future needs (e.g., new aircraft, upgrades to self-protection capabilities, better munitions) may be. DOD has had considerable experience suppressing enemy air defenses over the last 50 years. A survey of this experience provides some insight into SEAD success and challenges, and helps provide a context in which Congressional oversight decisions can be made. The following section describes three “measures of effectiveness” (MOEs) that can be used to focus Congressional inquiry into future SEAD needs.

MOE 1: Combat Attrition. The first area that merits examination is combat attrition. How many U.S. combat aircraft have been shot down in recent conflicts? How many have been shot down by ground-based air defenses? Because SEAD missions are designed ultimately to protect U.S. aircraft, combat attrition provides some insight into the effectiveness of SEAD efforts. As indicated in Table 1 below, from World War II to the present, the loss of U.S. combat aircraft has steadily declined, both in absolute terms, and relative to the number of combat sorties flown. While these numbers do not prove that SEAD is solely responsible for this very favorable trend, it is clear that SEAD is an important contributor to aircraft survivability.

Table 1. Estimates of Combat Aircraft Losses

Conflict	Combat Sorties	Total Combat Losses ^a	Attrition Rate
World War II ^b	2,498,283	19,030	0.76%
Korea ^c	591,693	1,253	0.2%
Vietnam ^d (AF data only)	219,407	1,437	0.65%
Desert Storm (Iraq) ^e	68,150	33	0.04%
Bosnia ^f	30,000	3	0.01%
Kosovo ^g	21,111	2	0.009%
Northern/Southern Watch ^h	268,000	0	0.0%
Iraqi Freedom ⁱ	20,733	1	0.004%

Notes:

^a Other losses, either due to pilot error, accident, or unknown enemy action not included.

^b *Army Air Force Statistical Digest: World War II*. Prepared by the Office of Statistical Control. December 1945. p220, Table IIB. *Naval Aviation Combat Statistics: World War II*. Air Branch. Office of Naval Intelligence, Office of the Chief of Naval Operations. Washington, DC. 17 June 1946. p. 51-59.

¹⁰ Benjamin Lambeth, *NATO's Air War for Kosovo* (RAND, 2001), p. 142.

Greene, Terrell. "Surviving Modern Air Defenses." *Aerospace America*. American Institute of Aeronautics and Astronautics. August 1986. p.14.

- ^c Robert Futrell, *The United States Air Force In Korea*. Office of Air Force History, US Air Force. Washington, 1983, pp. 689-692.
- ^d Wayne Thompson, *To Hanoi and Back: The USAF and North Vietnam, 1966-1973*, Air Force History and Museums Program, USAF, 2000, pp. 304, 311.
- ^e *Gulf War Air Power Survey*, vol. v.: Statistical Compendium and Chronology. Washington, 1993, pp. 232, 641. US and coalition partners.
- ^f John Tirpak, The NATO Way of War. *Air Force Magazine*. December 1999. p. 24. Figures represent coalition combat sorties and losses.
- ^g Correspondence from Lt.Gen. C.W. Fulford, (USMC) Director, Joint Staff to Mr. Daniel Mulhollan, Director, Congressional Research Service. October 19, 1999.
- ^h Gen Walter Buchanan, *Air Force Current Operations*. Briefing to Congressional Air Power Caucus. Bolling AFB. Mar. 12, 2001. According to USCENTCOM Press Release (8/10/01) Iraq has conducted over 1,000 attacks against U.S. and Allied aircraft since December 1998.
- ⁱ *Operation Iraqi Freedom — By the Numbers*. Assessment and Analysis Division. USCENTAF Lt. Gen. Michael Moseley, Commander, Apr. 30, 2003.

MOE 2: Effort Expended. Another factor that can be considered when assessing U.S. SEAD capabilities is the amount of effort that is expended to protect U.S. aircraft. How onerous a mission is SEAD? As Table 2 below suggests, twenty-to-thirty percent of all combat sorties in recent conflicts were devoted to SEAD, while historically, this ratio is much lower. While this increase in SEAD sorties could be attributable to a number of factors, it appears that SEAD is a growing mission area.

Table 2. Estimates of SEAD sorties and Total Combat Sorties

Conflict	Combat Sorties	SEAD Sorties	%
Vietnam ^a	219,407	11,389	5.2
Desert Storm (Iraq) ^b	68,150	4,326	6.3
Bosnia ^c	2,451	785	32.0
Kosovo ^d	21,111	4,538	21.5
Northern/Southern Watch ^e	268,000	67,000	25.0

Notes :

- ^a Conversation with Dr. Wayne Thompson, Center for Air Force History, Bolling AFB, Aug. 9, 2001. Figure includes 8,669 F-105 Wild Weasel sorties, and 2,720 "Flack Suppression sorties. Figures include USAF sorties only. Does not include 24,278 EB-66 or 11,732 misc. EW sorties.
- ^b *Gulf War Air Power Survey*. vol. v: *Statistical Compendium and Chronology* (Washington, 1993), p. 232-233. Figures include coalition partners. Does not include 2,918 EW sorties.
- ^c *Deliberate Force: A Case Study in Effective Air Campaigning*. Final Report of the Air University Balkans Air Campaign Study. Edited by Col. Robert C. Owen, USAF, Air University Press, Maxwell Air Force Base, Alabama, Jan. 2000, p. 334.
- ^d Fulford, Mulhollan correspondence, op. cit.
- ^e Maj. Gen. Walter Buchanan, *Air Force Current Operations*, Briefing to Congressional Air Power Caucus, Bolling AFB, Mar. 12, 2001.

MOE 3: Efficiency. By some measures, U.S. SEAD efforts have been effective. However, other observations suggest that efficiency could be improved. For example, one MOE pertains to the destruction of enemy air defenses (DEAD). While suppressing enemy air defenses through electronic warfare (EW) or intimidation can effectively

protect U.S. aircraft, the effect is ephemeral. Destroying enemy air defenses is generally preferred to suppressing them, because of the enduring effect that destruction has on military capabilities. As Table 3 suggests, U.S. air forces have had mixed results in recent conflicts destroying enemy air defenses. In some cases, such as in Iraq, U.S. destructive SEAD efforts have been somewhat successful. In other cases, such as Kosovo — where the Serbs employed a variety of challenging tactics — efforts were less successful.

Table 3. Destructive SEAD: Some Estimated Results

Conflict	Estimated Results
Desert Storm ^a	35 of 120 fixed SAM batteries destroyed
Bosnia ^b	52 of 70 air defense targets destroyed
Kosovo ^c	3 of 25 SA-6 batteries destroyed, 10 of 41 SAM radars destroyed
N./S. Watch ^d	33 of 35 air defense targets damaged, but many rebuilt and improved

Notes:

^a *Gulf War Air Power Survey*, vol. v., op. cit., p. 19.

^b *Deliberate Force Case Study*, op. cit., p. 342.

^c Benjamin Lambeth, “Kosovo and the Continuing SEAD Challenge,” *Aerospace Power Journal*, Summer 2002, and interview with personnel involved in Operation Allied Force.

^d Iraq Improves in Face of Bombs, *New York Times on the Web*, Aug. 30, 2001.

Another measure of efficiency pertains to tactics. One SEAD tactic to fire numerous HARM missiles preemptively — that is, in the direction of a SAM that is suspected to exist, but which hasn’t turned on its radar. Thirty three of 56 HARMs used in Operation Deliberate Force were fired preemptively.¹¹ Over 1,000 HARMs in Operation Allied Force were fired at only a handful of SAMs, suggesting many preemptive shots.¹² While using HARMs in this way may effectively deter adversaries from shooting at U.S. aircraft, it also poses two problem areas. First, preemptive HARM use can be expensive since HARMs cost approximately \$250,000 per missile. Second, preemptively fired HARMs present a fratricide risk. If there are no enemy radar emissions for the HARM to guide on, the missile could lock-on to friendly emissions and destroy the wrong target. At least six HARMs shot during Kosovo ended up by accident in Bulgaria.¹³ While launching HARMs preemptively may be effective and necessary, it not efficient. The Navy’s Advanced Anti-Radiation Guided Missile (AARGM) program, may reduce the need for or the potentially negative effects of preemptive missile launches (\$75M requested in FY2006). The AARGM program is pursuing a number of improvements to HARM, including adding a radar that can detect enemy radars after they have turned off, and hardware and software improvements that limit the areas in which the missile can fly when searching for a target.

¹¹ *Deliberate Force Case Study*, op. cit., p. 315.

¹² Rep. Randy “Duke” Cunningham, *Suppression of Enemy Air Defenses: Improvements Needed*, EW Working Group Issue Brief #7.

¹³ Gert Kromhout, “From SEAD to DEAD,” *Military Technology*, Apr. 2001.