USAF MANNED AIRCRAFT COMBAT LOSSES 1990-2002

Executive Summary.

Weak air defenses in Afghanistan during Operation ENDURING FREEDOM in 2001 and 2002 failed to down a single United States Air Force (USAF) aircraft. In operations between 1990 and 2000, however, the USAF lost 17 airplanes in combat, including 14 over Iraq and three over the former Yugoslavia. Thirteen USAF airplanes fell to Soviet-designed surface-to-air missiles (SAMs): seven to heat-seekers (infrared) and six to missiles guided by radar. Antiaircraft artillery (AAA) downed three airplanes. One other aircraft maneuvered out of control after falsely perceiving enemy aircraft fire.[1] Allied air superiority assured that no USAF airplanes were lost to enemy aircraft, either in aerial combat or because of enemy raids on friendly airfields.

Given the number of sorties flown, the number of aircraft lost is miniscule. For example, during Operation DESERT STORM against Iraq in 1991, the USAF lost a total of 14 aircraft after flying more than 29,300 combat sorties, or .048 percent. This was against an enemy with 16,000 SAMs, 7,000 antiaircraft guns, and 750 combat aircraft. During Operation ALLIED FORCE against Serbia in 1999, the USAF lost one F-16 after more than 4,500 F-16 sorties, or .02 percent.[2]

Analysis of the aircraft losses suggests effective countermeasures. Superior fighters and destruction of enemy airfields suppresses the threat of interceptors. Stealth technology provides protection against both radar-guided and heat-seeking SAMs. Flying high, fast, and at night reduces the risk of destruction by relatively small heat-seeking SAMs or AAA. For aircraft that fly slow and low during daylight, flares and armor provide some protection respectively against heat-seekers and AAA. High-speed

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
09 DEC 2002		**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
USAF Manned Aircraft Combat Losses 1990-2002	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Historical Research Agency,Maxwell AFB,AL,36112**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**18**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

anti-radiation missiles (HARMs), electronic jamming, destruction of enemy command and control centers, dispensing chaff, and launching decoys counter larger radar-guided SAMs. Flying unpredictably and using stand-off weapons, unmanned aircraft, and cruise missiles also reduce manned aircraft losses.

Table I: USAF Manned Aircraft Combat Losses 1990-2002[3]

Date	Type	Enemy Weapon	Guidance	TIME
17 Jan 1991	F-15E	AAA		Night
19 Jan 1991	F-15E	SA-2E	Radar	Night
19 Jan 1991	F-16C	SA-6	Radar	Day
19 Jan 1991	F-4G	AAA		Night
19 Jan 1991	F-16C	SA-3	Radar	Day
31 Jan 1991	AC-130H	SA-16	Infrared	Day
2 Feb 1991	A-10A	SA-16	Infrared	Day
13 Feb 1991	EF-111A	(maneuver)		Night
15 Feb 1991	A-10A	SA-13	Infrared	Day
15 Feb 1991	A-10A	SA-13	Infrared	Day
19 Feb 1991	OA-10	SA-9	Infrared	Day
22 Feb 1991	A-10A	SA-16	Infrared	Day
27 Feb 1991	OA-10A	SA-16	Infrared	Day
27 Feb 1991	F-16C	AAA		Day
2 Jun 1995	F-16C	SA-6	Radar	Day
27 Mar 1999	F-117	SA-3	(Radar?)	Night
2 May 1999	F-16CG	SA-3	(Radar?)	Night

Enemy Methods

The Iraqis and Serbs both used Soviet-designed and supplied antiaircraft missiles and artillery. Both missile types that shot down USAF airplanes over the former Yugoslavia had also destroyed USAF airplanes over Iraq. Although the hardware was basically the same, the Iraqis and Serbs used different methods. The Iraqis more often used the systems as originally designed, sending radar signals constantly to the aircraft

they intended to shoot down. This made successful targeting more likely but also rendered the systems more vulnerable to HARMs. The Serbs used the signals less, scoring fewer hits but preserving their air defense threat until the end of the hostilities.[4] The Taliban air defense system did not seriously threaten USAF aircraft, partly because of its initial weakness and also because of effective USAF countermeasures. Early cruise missile and air raids on Afghan airfields at Kabul, Kandahar, Jalalabad, Shindand, and Herat destroyed the Taliban air force on the ground and many of its SAM and AAA air defenses. Just ten days into Operation ENDURING FREEDOM, the threat was low enough to allow AC-130 flights over Afghanistan.[5] The threat of man-portable SAMs kept transports flying high and at night until the end of 2001.

Table II: USAF Manned Aircraft Combat Losses 1990-2002 by Cause[6]

CAUSE	NUMBER LOST
Surface-to-air missiles (SAMs)	**13**
Antiaircraft artillery	**3**
Direct enemy action-other	**1**
Enemy aircraft	**0**
TOTAL	**17**

The Most Serious Threats.

Between 1990 and 2002, enemy forces used three primary methods to attempt to destroy USAF aircraft over their territory: surface-to-air missiles (SAMs), antiaircraft artillery (AAA), and enemy aircraft. The most successful of these, by far, was the use of SAMs. Thirteen of the seventeen aircraft lost, or 76 percent, fell to missiles. AAA downed only three, or 18 percent, the last in 1991. Enemy fighters failed to shoot down a single USAF aircraft between 1990 and 2002. This is not to say they were no danger but that countermeasures succeeded. In the same 13 years, USAF airplanes shot down 48

enemy airplanes, including 39 over Iraq and nine over Yugoslavia.[7] Allied warplanes destroyed greater numbers of Iraqi and Serbian on the ground than in the air. In 1991, for example, coalition air strikes destroyed more than 200 Iraqi combat aircraft on the ground and 37 in the air.[8] The twenty-odd fighters available to the Taliban in 2001 were destroyed on the ground and not in the air.[9]

Table III: Enemy Surface-to-Air Missiles That Destroyed USAF Manned Aircraft, 1990-2002[10]

No. of USAF aircraft Shot Down	SA-	NATO Name	MACH	Max. effec-tive range	Max. Effec-Tive Altitude	Launcher	Guidance	Warhead
4	16	Gimlet	2+	5 km	3.5 km	Man-portable	Infrared/ Ultra-violet	HE 2 kg
3	3	Goa	3+	25 km	25 km	Static	Radar	HE 60 kg
2	6	Gainful	2.8	24 km	12 km	Mobile	Radar/ Optical	HE 59 kg
2	13	Gopher	2.0	10 km	5 km	Mobile	Infrared	HE 6 kg
1	2E	Guide-line	4.5	50 km	40 km	Static	Radar	HE 200 kg
1	9	Gaskin	1.8	4.2 km	3.5 km	Mobile	Infrared	HE 2.6 kg

Ranking the Missiles.

Iraqi and Serbian forces launched a great variety of Soviet-designed SAMs at USAF aircraft, but only six types brought down any airplanes. The most successful of these was the SA-16 (NATO nickname: Gimlet), which destroyed four aircraft. A man-portable missile, it has the smallest warhead. Lacking much range, speed, or the ability to reach a high altitude, the Gimlet brought down no fighters. SA-16s destroyed two A-

10 close air support airplanes, shot down an AC-130 propeller gunship, and forced an OA-10 to crash. The AC-130 gunship loss resulted in the greatest loss of lives (14).

The second most successful enemy SAM was the SA-3, which brought down three USAF airplanes, an F-16 over Baghdad in 1991, another F-16 over Serbia in 1999, and, most notably, an F-117, also over Serbia in 1999. The stealthy F-117 was supposed to be almost invisible to enemy radar and infrared tracking systems, making it virtually immune to antiaircraft systems. The Serbs managed to bring one down anyway, probably by focusing on the aircraft's expected path and time.[11] A very fast missile with a relatively large warhead, the SA-3 is vulnerable to countermeasures because it is usually launched from a fixed position rather than a vehicle.

Two enemy SAM types, the SA-6 (Gainful) and the SA-13 (Gopher) each shot down two USAF airplanes since 1990. Both are launched from vehicles capable of moving soon after firing, thus reducing their vulnerability to counterstrikes. An SA-6 destroyed an F-16 over Iraq in 1991. In 1995, Captain Scott O'Grady, who was rescued after nearly a week eluding the enemy in the former Yugoslavia, also fell to an SA-6.[12] Guided by radar, armed with a relatively large warhead, and with moderate range and altitude, the SA-6 is a formidable antiaircraft weapon. The SA-13 has a smaller warhead and less range and altitude, but in 1991, this SAM type destroyed two A-10 airplanes over Iraqi-occupied Kuwait. Like the SA-16, the SA-13 is a heat seeker.

Two other enemy SAM types each destroyed one USAF airplane between 1990 and 2002. One was the SA-2 (Guideline), the oldest of them all. Famous for bringing down a U-2 over the Soviet Union in 1960 and for its success against USAF airplanes over North Vietnam in the mid 1960s and early 1970s, the SA-2 is the enemy SAM with

the greatest speed, range, and altitude.[13] Guided by radar and launched from a fixed platform, the SA-2 also has the largest warhead. On the third day of DESERT STORM, an SA-2 brought down an F-15E. It was the only enemy missile ever to down an F-15. Despite its formidable reputation, the SA-2 is an old system fired from a static platform vulnerable to HARMs. The only other enemy SAM type that brought down a USAF airplane was the SA-9. In February 1991, an SA-9 (Gaskin) shot down an OA-10 over occupied Kuwait. Launched from a vehicle, the Gaskin is a heat-seeking missile with a small warhead and relatively short range and altitude. It is also the slowest of the enemy SAMs that destroyed USAF aircraft and would not be very successful against fighters.

Table IV: SAM Missile Classes[14]

SAM CLASS	ADVANTAGES	DISADVANTAGES	COUNTER-MEASURES
Larger radar-guided missiles	1. longer range 2. higher altitude 3. greater lethality 4. greater speed	1. high cost 2. easier to find 3. signals may be used for targeting 4. Signals may be jammed 5. signals may be absorbed or deflected	1. jamming 2. HARMs 3. stealth technology 4. destruction of command and control facilities 5. chaff or decoys
Smaller infrared-guided missiles	1. low cost 2. easy to move 3. easy to hide 4. fewer personnel to operate 5. require less infrastructure	1. shorter range 2. lower maximum effective altitude 3. less lethal warhead 4. slower speed	1. flying at high altitudes 2. flying at high speeds 3. flares 4. stealth technology

Strengths and Weaknesses of Various SAMs.

Enemy surface-to-air missiles (SAMs) may be divided into two broad classes, the larger radar-guided types and the smaller infrared-guided types. The advantages to the

enemy of larger radar-guided SAMs are their greater ranges and maximum altitudes, the lethality of their larger warheads, which can more easily destroy aircraft near their detonations, and their greater speeds. Most of them are also usually more accurate because of their radar guidance. This advantage, however, is the first of its disadvantages. The radar signals such systems emit for guiding to their targets make them vulnerable to high-speed antiradiation missiles (HARMs), which home on these signals. The radar can also be jammed electronically or evaded with stealth technology. The larger radar-guided missiles are also more costly, depending on more infrastructure and command and control facilities whose destruction often renders the missile sites inoperable.

The smaller infrared-guided missiles have become more of a threat in recent years because they cost much less and depend on fewer personnel and infrastructure to operate. Not needing radar systems with which to guide, some can even be carried by individuals and fired from the shoulder. Such weapons are easy to move and hide. Their small size also has disadvantages. They lack the range, altitude, and speed of the larger missiles and have smaller, less lethal warheads. By flying high and fast, friendly aircraft can avoid them. Aircraft that must fly lower and slower can use flares to divert the missiles because they depend on infrared signals from the target for guidance. Stealth aircraft disguise both their radar and infrared signatures, making them almost immune from both classes of missile.

Antiaircraft Artillery

Only three of the 17 USAF airplanes shot down in combat between 1990 and 2002 fell to antiaircraft artillery (AAA). They were an F-4G, an F-15, and an F-16. All

of these went down after having been hit by Iraqi artillery during Operation DESERT STORM in January and February 1991. The F-4G Wild Weasel aircraft was hit while flying against air defense sites in Iraq and as a result lost fuel. The two crew members were rescued because they ejected after returning over friendly territory. The F-15 crashed southwest of Basra during a mission to strike Iraqi targets, and both crew members perished. The F-16 crashed over Iraq and the pilot was taken prisoner. All three of these aircraft were flying against enemy targets at a relatively low altitude in regions of dense flak.[15]

Antiaircraft artillery can influence the routes and altitudes of raiding airplanes, forcing them to fly along certain corridors vulnerable to SAMs and interceptors. The chief advantage of AAA as an air defense weapon is its ability to fill a given air space with inexpensive projectiles that can hit any airplane in that space at that time, regardless of how fast or stealthy that airplane might be. The chief disadvantages are that the projectiles, once fired, lack guidance and therefore accuracy, and rarely reach high altitudes. Two of the most common AAA types used by Iraq during DESERT STORM were the ZPU-2 and the ZPU-4. Each gun in these systems could fire 600 rounds per minute, but their effective range was only 5,000 feet. The ZPU-4 had four such guns, so the system could fire 2400 shells per minute.[16] The Soviet-made ZSU-23-4, which Iraq also used in 1991, fired 23 millimeter shells that could reach an altitude of more than 16,000 feet.[17] Individually, the small size of the shells cause less damage than most SAMs. Returning to earth after exploding, the projectiles and flak often cause as much damage to the side that fired them as to the enemy airplanes. One countermeasure is armor-plating. AAA accounted for none of the six armor-plated A-10 and OA-10

airplanes lost between 1990 and 2002. Other countermeasures against AAA include flying at high altitudes, at night, and less predictably.

Multiple Threats

At the beginning of Operation DESERT STORM against Iraq in 1991 and Operation ALLIED FORCE against Serbia in 1999, the U.S. faced a formidable set of air defenses that included a combination of several kinds of SAMs, AAA, and interceptors linked by an integrated command and control system. Launches of air and sea-based cruise missiles and the use of stealth aircraft (F-117s against Baghdad and Belgrade and B-2s against Belgrade) knocked out the most dangerous and heavily defended command and control facilities. This made the skies over enemy territory safe enough for formations of non-stealthy attack planes with HARM-carrying and radar-jamming escorts. As raids degraded enemy systems further in the course of the operations, fewer escort sorties were needed.[18] Despite the weakness of Taliban air defenses in 2001, Central Command also launched cruise and stealth attacks at the opening of Operation ENDURING FREEDOM to assure that no friendly aircraft would be shot down in Afghanistan.

Table V: Types of USAF Aircraft Lost in Combat Since 1990[19]

TYPE OF AIRCRAFT	NUMBER LOST	ENEMY WEAPON USED
A-10 and OA-10	**6**	**SA-16 (3), SA-13 (2), SA-9 (1)**
F-16	**5**	**SA-6 (2), SA-3 (2), AAA (1)**
F-15E	**2**	**SA-2 (1), AAA (1)**
AC-130	**1**	**SA-16**
F-4G	**1**	**AAA**
F-117	**1**	**SA-3**
EF-111	**1**	**(falsely perceived enemy fighter attack caused maneuver accident)**

Vulnerability of USAF Aircraft Types

Seven USAF aircraft lost to enemy action were non-fighter types that generally flew slow and low. Every one of these was shot down by a relatively small heat-seeking enemy SAM with a small warhead, short range, and low altitude. Such missiles' small size and mobility makes them difficult to find and destroy. Guided by the infrared signatures of their targets, they produced no radar signals on which to home. Six of the non-fighter USAF aircraft shot down were A-10 types. One of the non-fighter USAF aircraft lost in combat was the propeller-driven AC-130, vulnerable because of its large size, slow speed, and lack of armor.

Of the ten fighter-type USAF aircraft lost in combat, five were F-16 Fighting Falcons. Statistically the F-16 appears more vulnerable than the others, but only because F-16s flew many more sorties over enemy territory than other types. Radar-guided SAMs brought down four Fighting Falcons. The F-16 downed by AAA was flying at an altitude of only about 8,000 feet.[20] During Operation DESERT STORM, F-16s were less vulnerable to enemy SAMs when escorted by F-4G Wild Weasels armed with HARMs and by radar-jamming EF-111 Ravens, but the escorts themselves were vunerable.[21] Iraqi AAA downed an F-4G flying at relatively low altitude, and an EF-111 crashed while maneuvering wildly to escape what the crew falsely perceived to be an enemy fighter attack. Both the F-4G and EF-111 have been dropped from the USAF inventory, but their roles have been filled by the F-16CJ and the EA-6B Prowler.[22] Of the two F-15Es shot down in Iraq in 1991, one was lost to a radar-guided SAM and one to AAA. Despite its near invisibility to radar, one F-117 fell in 1999 to an Serbian SA-3

missile, probably because the stealth fighter's flight path and time were predicted correctly by the enemy.

Methods For Reducing USAF Aircraft Lost in Combat

From statistics and tables on the combat destruction of USAF aircraft, one may develop a list of methods that would reduce the risk of loss. Certain tactics have worked in the past. Simply **flying at altitudes beyond the range of enemy AAA and SAMs** with relatively low maximum engagement altitudes has protected many pilots and aircraft. The drawback is that the same high altitudes that protected attacking aircraft also reduced their ability to find and destroy enemy targets. In DESERT STORM, A-10s found it difficult to hit targets accurately after the altitude of their flights was raised to protect them from ground fire.[23] During Operation ALLIED FORCE, the rules of engagement forced many USAF fighter aircraft to fly at altitudes of 15,000 feet or more.[24] Such tactics contributed to the low aircraft combat attrition but also limited the destruction of Serbian targets such as moving tanks. Transports dropping food over Afghanistan in the first few months of ENDURING FREEDOM flew at altitudes over 25,000 feet so that they could avoid antiaircraft fire. This taxed the loadmasters physically (rapid decompression and cold), decreased the accuracy of the drops, and increased the risk the packages would be damaged when they hit the ground.[25]

The AC-130 that the Iraqis shot down in January 1991 was hit partly because it had lingered in the target area as the sun came up.[26] Fourteen crew members died in that crash. **Flying at night** is another method of avoiding aircraft losses due to enemy fire, especially if the aircraft flies relatively low and slow. Eleven USAF airplanes lost in combat between 1990 and 2002 were hit during the day, and only six at night. Operation

ENDURING FREEDOM in 2001 and 2002 experienced no USAF aircraft combat losses to enemy SAMs, AAA, or fighters. The transport pilots flew over and landed in Afghanistan initially only at night without lights. This forced crews to wear night-vision goggles and increased the risk of accidents.[27] One other tactical method for reducing aircraft attrition in Afghanistan was to **fly varied routes and schedules** to reduce predictability. The predictability of the F-117 flight over Serbia on 27 Mar 1999 might have contributed to its loss.[28] If the enemy knows where an aircraft will be at a certain time, his radar and infrared sensors are less necessary.

Other methods that can reduce the chances of losing aircraft to the enemy involve the use of **diversions** or decoys. Dispensing **chaff** has been a practical method for confusing enemy radar since World War II. Chaff is a collection of small metal strips that, when released from an airplane, tempt the radar to follow it instead of the aircraft. On the other hand, chaff is not effective against heat-seeking missiles.[29] According to Major Steve Janeczko, chief of the tactics division of the Air Mobility Warfare Center in 2000, "the biggest threat against military aircraft are Man-Portable Air Defense Systems because they are inexpensive, easily concealed and easy to operate."[30] To divert such infrared-guided missiles away from C-130 and C-17 transports, which fly relatively low and slow in a combat theater, the Air Force has equipped the airplanes with **flares**.[31] The Air Force is testing longer-lasting alternatives to flares that would have the same purpose of confusing heat-seekers. These include dispensing a rapidly-oxidizing material from an airborne pod or arming transports with lasers.[32] During the Cold War, B-52s carried **decoy aircraft or missiles** such as the Quail to confuse enemy radar and provide an alternative target.[33] During Operations DESERT STORM and ENDURING FREEDOM,

coalition forces used such unmanned decoy aircraft to reduce the risk of their manned aircraft being shot down by enemy antiaircraft systems depending on radar. For example, B-1Bs operating from Diego Garcia towed decoys that transmitted signals to attract radar-guided SAMs. The decoys are designed to force the enemy to waste SAMs.[34]

Stealth technology has allowed USAF airplanes to be less vulnerable to enemy fire. No stealthy F-117s were lost over Iraq, although they were used extensively against some of the most heavily defended sites around Baghdad. The shape and materials of such aircraft reduce their radar and infrared signatures enough to make them almost invisible to enemy detection systems. Despite the F-117 loss over the former Yugoslavia in 1999, stealth technology will guard increasing percentages of USAF combat aircraft in the future. Stealthy B-2s and F-117s took part in the initial bombing of Afghanistan during the opening of Operation ENDURING FREEDOM in October 2001.[35] The F-22 and F-35, the newest USAF fighter types, both incorporate stealth technology.[36]

During Operation DESERT STORM, the initial air attacks on Iraq involved the use of flights with several different types of aircraft (referred to as "packages"). F-15s cleared the skies of enemy fighters, aided by circling E-3 airborne warning and control aircraft. EF-111 Ravens and EC-130s protected attacking F-16s by **jamming enemy radar**. F-4G Wild Weasels destroyed enemy SAM sites by firing high-speed anti-radiation missiles (**HARMs**) at them. Such packages undoubtedly reduced USAF aircraft combat attrition. One of the F-16s lost near Baghdad in 1991 had been escorted by F-4Gs, but they had already fired all of their HARMs when the F-16 was hit by an SA-6.[37] EA-6Bs jammed enemy radar during Operation ALLIED FORCE over Serbia in 1999 and even more during Operation ENDURING FREEDOM.[38] Future packages will

include F-16CJ for suppression of enemy air defenses (SEAD) and EA-6Bs for jamming. Technology will allow attacking aircraft increasingly to carry their own electronic jamming systems and their own HARMs.[39]

Besides attacks on enemy SAM and AAA sites, **strikes on enemy command and control** facilities have successfully reduced the threat to USAF aircraft in combat. During ten years of patrol flights over northern and southern Iraq (Operations NORTHERN WATCH and SOUTHERN WATCH), the USAF lost no aircraft, although a great many SAMs and artillery shells were fired at them. Coalition aircraft homed on targeting beacons and subsequently destroyed most sites from which the missiles and shells came. More recently, the trend has been to attack command and control centers. Destroying the centers will disable the connected sites as surely as eliminating the head of an octopus will make its tentacles useless.

Unquestionably one of the greatest successes in combat operations between 1990 and 2002 has been the loss of no USAF aircraft to enemy aircraft. Technological superiority of USAF fighters over their opponents in both Iraq and Yugoslavia in the 1990s coupled with superior pilot training contributed to the ability of USAF aircrews to shoot down 48 enemy airplanes in aerial dogfights while losing none. In 2001-2002, the Afghan air force was too weak to even engage USAF fighters in aerial combat. If there were any Taliban-operated mission-capable fighters, they did not even get into the air. Between 1990 and 2002, attacks on airfields and aircraft on the ground contributed to the inability of enemy fighters to take off in Iraq, Bosnia, Serbia, and Afghanistan. **Destruction of enemy airfields** and the addition of the **F-22** to the USAF inventory should assure that the threat of enemy fighters will continue to be low.[40]

The use of precision-guided **standoff weapons** is another method for reducing or eliminating the loss of USAF aircraft in combat. Such weapons as the Hound Dog missile of the 1960s and air-launched cruise missiles of the 1980s were designed to allow B-52s to strike enemy targets without having to fly over them.[41] Modern technology allows similar weapons to be more accurate than ever before and to be launched from a variety of aircraft, enabling those aircraft to stay outside the range of AAA and SAMs. Surface-launched cruise missiles such as **Tomahawks** fired from ships can destroy enemy targets without putting any pilots at risk.

During Operation ENDURING FREEDOM, the USAF began to **arm unmanned aerial vehicles** with missiles to destroy enemy targets.[42] The Predator (RQ-1) was originally designed only for reconnaissance but has become an attack vehicle as well. Predators, however, fly low and slow, making them extremely vulnerable to enemy antiaircraft fire. Some can be destroyed by a helicopter flying alongside. The USAF is considering the use of new unmanned aerial vehicles designed specifically to attack enemy targets. They will be able to fly higher and faster and carry more ordnance. Manned or unmanned, aircraft will continue to be vulnerable to enemy antiaircraft fire, whether it be from SAMs, AAA, or enemy interceptors. So far, manned USAF aircraft have been more successful at both destroying enemy targets and avoiding enemy antiaircraft fire than unmanned systems.

Finally, **armor-plating** offers some protection to aircraft that must fly relatively low and slow over enemy territory where they are in range of AAA and heat-seeking SAMs. Man-portable air defense systems lack large warheads, and sometimes cause damage but not destruction to attacking aircraft if those aircraft are sufficiently armored.

During Operation ENDURING FREEDOM, small SAMs, antiaircraft artillery, and automatic weapons posed a greater threat to USAF aircraft then enemy fighters or radar-guided SAMs, but they failed to down a single USAF airplane, partly because slower and lower-flying airplanes such as the A-10 carried armor plating.[43]

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9 December 2002

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