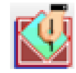
The original version of this file was an OS 9 stand-alone text application. The icon looked like this: 
It featured much colored text and other formatting fun, but this version is good-ol' black and white ASCII.
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The A-10 Thunderbolt II: A FAQ Sheet

Welcome to the FAQ sheet for the USAF A-10A ‘Warthog’! Although most FAQ (Frequently Asked Questions) sheets provide the answers to commonly asked questions about using a piece of software, this document is meant to serve as a ready source of background material for the A-10A aircraft itself. This document is truly a labor of love; we’ve collectively spent a lot of time on this documenting sources of information, and trying to present it so that you can not only look up something on the run via the Table of Contents (CMD-K), but also so you can take time to learn in depth just why the A-10 is such a special plane.

Dedication

Our goal in this document is to help you, the reader, understand that this is a real plane, in which, men in uniform have died in the service of their nation. These men left behind people who grieve for them, and families that are no longer whole. It is in the memory of these individuals that we wish to dedicate this document. Additionally, there are many more pilots who died flying the A-10; because of limited information access, we have not been made aware of these individuals. If you have information, please refer to the third-to-last chapter to contact the authors.

Fairchild (Republic division) chief test pilot
- Howard “Sam” Nelson, 6/3/1977 - Paris Air Show

353rd Tactical Fighter Squadron (Panthers)
- Capt. Steve “Syph” Phyllis, 2/15/1991 - Desert Storm

23rd Tactical Air Support Squadron, Forward Air Controllers (Nail)
- Lt. Patrick “Oly” Olson “Nail 69”, 2/27/1991 - Desert Storm
(Captain, posthumous award)

74th Tactical Fighter Squadron (Flying Tigers)
- Maj. Jeff Watterberg, 9/23/1991 - England AFB, LA
(Lt. Col, posthumous award)

76th Tactical Fighter Squadron (Vanguards)
- Lt. Eric “Boom” Miller, 9/23/1991 - England AFB, LA
(Captain, posthumous award)

333rd Tactical Fighter Squadron (Lancers)
- Capt. Ronald Truesdale 9/17/94 - Ft. Irwin, CA

NOTE: Squadron designations presented here represent the formal and composite unit designations at the time of Desert Storm (1991). Following their return from the Gulf, many units within all branches of the Armed Forces underwent decommision and reorganization. It has often been a policy for a decommisioned squadron, such as the Flying Tigers (who originally saw combat during WWII in China and Burma as the (AVG) American Volunteer Group), to host an auction to sell off the years of memoribilia collected by the squadron—done so with the proviso that upon squadron reactivation, these items will be returned. We hope that the squadron mementos from all such deactivations will one day return home to honor those who served before.

Version Updates - Revision Release 1.2

Since the 1.1 release, this FAQ has literally travelled around the world via the internet; comments from people in Europe and Asia so far are the most distant. This 1.2 release is a maintenance release to update the address for the primary author, and to correct and streamline some information. NO significant changes or additions to this FAQ are present in this release.

Version Updates - Revision Release 1.1

We would like to thank all of you who have taken the time to download the initial 1.0 release of this FAQ; the response to it has been unexpectedly overwhelming and very supportive. This 1.1 release truly indicates the extent to which it has become widespread electronically, as much of its contents has not only been greatly reorganized, expanded and corrected, but also some personal observations from people connected in different ways with the A-10A have been included. Thank you all for taking the time to make this a better and richer document: the ‘net truly works...

If errors exist in the information presented here, check the third-to-last chapter for the procedure to make corrections.

Future Plans

The strong and important role the A-10 played during the Gulf War is not presented in this document; it is a large enough topic that would be better presented in a future addition to the FAQ, or as a separate one. If enough time exists and enough requests are made, we will see what can be done. Including pictures, Quicktime clips or sounds will NOT be a priority, since they bring up specific copyright issues and increase download times. Specific anecdotes from military personnel, design notes from past Fairchild employees or anything that might be worthy of a greater audience are of course welcome, and will be duly referenced as your contribution if used. Properly defused CBU submunitions will be accepted as paperweights... <grin>

Functional Ancestry: The Douglas A-1 Skyraider

The history of the Fairchild A-10A Thunderbolt II follows many parallels with that of another long-lived and well-respected aircraft, the USN Douglas A-1 Skyraider. Originally developed late in WWII, this large and noisy, oil-dripping prop-driven airplane was mothballed at the close of the war, having seen very limited carrier-based service, but was resurrected during the Korean War for close-air support. The Skyraider has been aptly described as a legend in its own time, taking its first flight March 18, 1945, the project originating with the great aircraft designer Ed Heinemann 9 months prior out of the original US Navy BTD (Bomber, Torpedo Dive) contract. Designed to provide a superior carrier-based bombing platform, all ordnance and fuel was hung externally on 15 hardpoints, and featured a then unique downward vision angle of 15 degrees to the front and sides of the cockpit. An extermely rugged and clean design, it was also meant to survive 40g crash landing impacts. On the strength of the initial prototype and test flights, the US Navy ordered 500 of the BT2D (Dauntless II) aircraft, although they were not to see combat service before the end of WWII.

Between the end of WWII and the start of the Korean conflict, many other fighter or bomber models, such as the Republic P-47 Thunderbolt, North American Aviation P-51 Mustang and the Grumman F-4U Corsair were decommisioned, removed from inventories, and sold (more or less) as scrap metal. The Skyraider survived this fate by being born into battle essentially too late for the role it was designed for. At the end of the war, the Navy's designation system for aircraft changed: now it became the AD-1 Skyraider: A (for Attack); D (Douglas Aircraft); -1 (initial model/variant); "Sky_____" (Douglas was given this "Sky-" prefix for all of its subsequent designs). After serving well for the US Navy in Korea, inventories was mothballed again awaiting the possibility of future conflict, with the lesson of destroying perfectly servicable aircraft (as was done at the end of WWII) having been a costly one. In 1962, the US Navy once again changed its designation methods, and the "Able Dog" AD-1 now became the A-1 Skyraider series, with its variants renamed A-1E (formerly AD-5W); A-1G (AD- 5N); A-1H (AD-6); and the A-1J (AD-7). When A-1E models were appropriated by the USAF in 1964, this retired US Navy carrier fighter's ability to not only deliver a number of tactical munitions accurately, but its outstanding loiter time over an area made it an ideal choice for reconnaisance, interdiction and CAS missions, given the cold-war emphasis on faster, less fuel efficient jet fighters. This particular -E model had a wider fuselage with a two-seat side-by-side cockpit layout (much like the USN A-6 Intruder), a rear cabin area (12 passengers; 2,000 lbs freight; or 6 stretchers) and a larger vertical tail. Other Skyraider variants (-G, -H, -J) were single-seat aircraft. Skyraiders served well in search-and-rescue (SAR) missions, suppressing enemy forces away from downed pilots awaiting recovery. The Skyraider earned once again its widespread reputation in Vietnam, and a number of new nicknames. It has been often referred to as the "Spad", in acknowledgement of its gutsy performance and ability to handle battle damage, much as the original WWI Spads demonstrated; plus the name "Sandy" for its CAS role in SAR missions. Skyraiders were actively flown as an interservice airframe by the United States Navy and Marine Corps, with the USAF flying many Skyraider variants with the 1st Air Commando Group, and later the Special Operations Squadron. The Skyraider also became the favored attack aircraft of the South Vietnamese VNAF.

A particularly noteworthy example of this outstanding performance are documented in the events that occurred on June 20, 1965. Four A-1's from Squadron VA-25 (USS Midway) were on a ResCap (Rescue/Combat Air Patrol) mission, when they were jumped by two NVAF MiG-17's. The A-1's dived for the surface, and began defensive scissors maneuvers at treetop level in a dog fight lasting over five minutes, until two of the A-1's managed to turn inside the MiGs and brought one of them down with cannon fire, and badly damaging the other MiG. A 1/2 credit each was awarded to both Lt. Charles Hartman and to Lt. Clinton B. Johnson of VA-25. Also, on October 9, 1966, Lt(jg) William T. Patton of VA-176 downed a MiG-17 single-handedly while flying a A-1H. <<see NOTE below>>

Although a brilliant design that saw (interrupted) production until 1957 when the last of 3,180 Skyraiders rolled out, the stress and wear on this venerable airframe had begun to take its toll. Carrier-based US Navy A-1H and -J models that were in service in the Vietnam conflict through 1967 were beginning to be replaced by A-7 Corsair IIs. Indeed, the longevity of the Skyraider is often overlooked, with the last USAF A-1 Skyraider units decomissioned in 1974. No small tribute to all that flew the Skyraider is given by Colonel Robin Olds (USAF Vietnam MiG ace): "No Sandy (A-1) or Voodoo (RF-101C reconnaissance aircraft) pilot was ever allowed to pay for a drink at [our] O[fficer's] Club." The rescue support and CAS firepower provided by the Skyraider, and the respect it engendered, indeed made it a legend in its own time. That the A-10 would replace the Skyraider in its functional role gave the A-10 project big boots to fill.

NOTE: In the initial release of the FAQ, I stated that the first MiG kill mentioned above as the only time a prop plane destroyed a jet fighter in combat; although I intended to mean just during the Vietnam War, it was so poorly phrased that it caused much confusion. A number of folks reminded me of other incidents:

- August 16, 1944 - Lt. Col. John B. Murphy, USAF, of the 359th Fighter Group shot down a Messerschmitt Me163 Komet rocket-powered fighter while flying a P-51 Mustang.
- October 7, 1944 - Lt. Urban L. Drew, USAF, of the 361st Fighter Group flying the P-51D shot down two Me262s on takeoff from their base.
- September 10, 1952 - four North Korean (or Chinese) MiG-15s bounced a pair of Marine Corps F-4U Corsairs. One of the Corsairs flown by USMC Capt. Jesse Folmar nailed one MiG in a vertical turn with 20mm cannon fire.

Early German jets, although enjoying a 100 mph speed advantage against the P-51D, lost any tactical advantage in aerial combat manuevering, since the slower prop-driven plane could easily out-turn and target these jets in a dogfight. Successful attack strategies evolved to the point where US dive attacks were made on German jet airbases, since the jet's poor acceleration made them extremely vulnerable on takeoff and landing. Barring any challengers, these same jets could be easily strafed while on the ground. Nazi defenses quickly developed the strategy of placing a barrage wall of flak on either side of the runway, permitting their jets to enjoy a corridor of increased security until airborne with enough airspeed.

A-10A: Inception

For the A-10A, this large and distinctively quiet turbofan plane was first brought to life by the Close Air Support subcommittee of the Senate Armed Services committee (1967), which recognized and documented that high-speed aircraft (primarily jet aircraft such as the F-4 Phantom II, F-105 Thunderchief, A-7 Corsair II and A-4 Skyhawk) could not be fully effective in the close-air support role of ground forces. With piston-driven A-1 Spads currently fulfilling much of that role in 1967, it was also recognized that having operational airframes 15-20 years old such as these would not long remain servicable. The key for completing any successful CAS mission lay in the visual recognition of friendly and enemy forces—a fundamental requirement that precluded much of then current US inventory: Mach2 Phantom II pilots often were unable to fly slowly with any effectiveness at such low altitudes, and were poorly armored against intense light AAA fire from the ground; sturdier and heavier attack planes such as the Corsair II even had such high attack speeds that after a single target pass, would often find that the enemy had dispersed in the time it took for them to return.

Politically, a dedicated CAS aircraft was vital for the USAF, in order to prevent the Army and the Marine Corps from developing CAS aircraft and (gasp!) flying them independently of the USAF. Such opposition to other branches—particularly the Army—having operational flight squadrons were based on perceptions from the early inception and birth of the Air Corps and then the Air Force itself... suffice it to say that the modern Air Force struggled very hard to be born, and they weren't going to stand for any Army nonsense, even though the Air Force may have felt distinct pressure to develop just such an aircraft. The shotgun wedding of CAS support to the Air Force has not been necessarily a happy one, despite its recognition of the need for CAS aircraft. In fact, A-10s prior to Desert Storm were scheduled for decommission, retaining only a few for the Forward Air Controller role.

On March 6, 1967, a proposal was made available to 21 companies for design studies of a low-cost attack aircraft, the A-X (Attack-Experimental). The Air Force developed the original specifications for this aircraft, and based on initial reponses, awarded preliminary design contracts to Grumman, Northrop, McDonnell Douglas, and the General Dynamics (Convair division) one month later. The original USAF proposal was revised to include the following: turboprop engines; reductions in overall airframe size, weight and importantly, cost.

The USAF then sent Request for Proposals to 12 of the original 21 companies on May 7, 1970. By August 1970, McDonnell Douglas, North American Rockwell, Beech, Bell Aerospace, Grumman, and LTV declined to bid on the A-X because of the very low cost requirement (and profit margin) projected for the contract. A total of 600 A-X aircraft at a unit price of $1.4 million (1970) dollars each with a contigency inflation allowance of 15% were envisioned in the A-X proposal.

The revised A-X Proposal Requirements were as follows:

1. Ability to deliver highly acccurate weapons against targets with a prime objective to kill tanks.
2. Ability to carry large ordnance payloads and electronic and infrared countermeasures simultaneously.
3. It must have excellent range and loiter capabilities near the battle area.
4. It must be able to maneuver at low altitudes and low to moderate speeds.
5. STOL (short takeoff and landing) capability.
6. Maintain high sortie rates permitting rapid servicing and ease of repair of battle damage.
7. It must be able to survive intense anti-aircraft fire, surface-to-air missiles and attacks by other aircraft.
8. Ease of maintenance.
9. It must be affordable.

Mission criteria included:

1. Recommended use of turbofan engines of between 7,000 and 10,000 lbs of thrust for fuel economy and reduction of IR (heat) signatures.
2. Mission radius - 250 miles
3. Ordnance payload - 9,500 lbs
4. Take-off distance - 4,000 ft
5. Manueverability below a 1,000 ft cloud base.

Interestingly, although the proposal was made at the height of the Vietnam conflict, the proposal was focused on support for a European theater of operations against a (presumably) Soviet advance into NATO-aligned countries.

The remaining six companies returned design proposals: Boeing-Vertol, Fairchild Hiller (Republic division), Cessna, General Dynamics, Lockheed, and Northrop. Then Secretary of the Air Force, Melvin Laird, announced on December 18, 1970 that Fairchild Hiller (Republic division) and Northrop Corporation were the finalists in the A-X project, and invited them to participate in a fly-off. The use of competing prototypes had been uncommon previously, but the requirement for low cost and increasing Congressional disapproval of single source selections put Northrop and Fairchild in a head-to-head competition.

The Competitors: Eyeball to Eyeball

By March 1971, prototype designations were assigned: Northrop A-9, and Fairchild A-10, and two prototypes each were constructed: Northrop YA-9s 71-1367 & 71-1368, and Fairchild YA-10s 11369 & 11370. These four prototypes began their test evaluation on October 10, 1972 at Edwards AFB, CA for the USAF A-X Joint Test Force. The flight tests were to comprise 250 total hours for both models by 5 USAF TAC and Air Force Systems Command pilots over a two month period. These pilots had earlier knowledge and experience with these models to insure both fairness and full performance testing. The competing designs were flown in pairs for the trials to insure no variation in external temperature, wind or environmental factors. Prototypes were alternated for each company, and the pilots were alternated between aircraft models, in addition to alternating lead and wing positions.

Northrop YA-9: The Other Bird

Northrop maintains a long history of producing rugged and survivable aircraft, and its YA-9 design represented a more conventional design, with twin Avco-Lycoming YF102-LD- 100 turbofans (7,500 lbs thrust) mounted in fairings at the wing roots, landing gear that fully retracted, a single vertical stabilizer, and five pylon hardpoint locations on each straight shouldered wing.

Fairchild YA-10: What the Hell is That?

Fairchild (Republic)'s design represented a fundamental emphasis on survivability and redundancy at the expense of conventional design esthetics... plain and simple, this was the bird from hell. With straight wings and twin vertical tails, and twin General Electric TF34-100 turbofans (9,065 lbs thrust) mounted on fuselage pylons aft of the wings [the engines are also used on the S-3A Viking], eleven total hardpoints, and landing gear that partially retracted, the YA-10 easily could be distinguished from the YA-9.

The Competition: Fly Before You Buy

The tests in store for these four prototypes were strenuous, and sought to assess the performance of each design. The basic tasks and tests are described below:

Performance testing	50 hours
System checks	6 hours
Weapons delivery	54 hours
TAC mission suitability	20 hours

Recordings taken for all aircraft included full working cockpit instrumention with data readouts; radar tracking of weapons delivery (bomb and strafing runs); ground surveys of bomb tests for weapons delivery accuracy. Although 250 total hours were initially planned for evaluation, 328 hours were finally recorded on the YA-10s, and 307 hours on the YA-9s prototypes.

The Competition: Results

The test evaluations were completed on December 9, 1972, and on January 18, 1973, a contract was awarded to Fairchild Republic for an additional 10 aircraft for further research and development as winner of the A-X competition. The number of additional aircraft were later revised to include 8 Design Test and Evaluation (DT&E) airframes, 6 flight evaluation airframes, one static testing airframe, and one airframe for fatigue tests. A $159.2 million dollar contract was signed on March 1, 1973 for the airframes, and a simultaneous contract was signed with GE for the TF34 turbofan engines.

Factors that favored the Fairchild design over the Northrop proposal included the ease of access to underwing hardpoints, ease of engine maintenance, and the perceived easier path from prototype tooling to production airframe (given the high structural polish of the Fairchild prototypes). Higher flight hour-to-maintenance hour ratios, and the high level of redundancy within the design were additional factors. Yet the decision for selection of the YA-10 was not a foregone conclusion, as the Northrop design had superior handling characteristics and a unique side-force control system, linking speed brakes and the rudder. This yaw manueverability provided a level of ground target tracking independent of bank angle or fuselage axis direction.

In Harm's Way

Extreme survivability is the hallmark of the A-10. Designed from the ground up for redundancy protection to battle damage, the A-10 was envisioned to operate and survive the low-level world of high-intensity AAA gun barrages, IR and radar-guided surface-to-air missiles (SAMs), and the ever-present threat of enemy interceptors.

In such an environment, the pilot enjoys (and requires) the survivability built into the airframe: redundant hydraulic, electrical, and fuel lines in widely dispersed protected ducts; triple spars on wings and horizontal tailplanes; dual engines close to fuselage centerline, which were set high above the fuselage to limit FOD ingestion on primitive forward operating areas; self sealing fuel tanks; left-right parts interchangability; and most importantly, a direct mechanical cable linkage for redundant backup flight controls. Cables were chosen for this system backup due to the higher rate of failure (jamming) of control rods with battle damage. The high 85% bypass turbofan design directed cold bypass air upwards at a 10 degree angle to mix with and cool hot jet exhaust; further, the twin vertical stabilizers masked the heat signature of the aircraft from the sides, reducing the potential targeting threat from heat-seeking missile launches.

Former A-10A Flight Commander Ed Herlik relates a personal incident that illustrates the durability of this plane:
"From my own experience, the jet I inherited in England actually ran over and killed a motorized glider before I got my name on the

'Hog. The pilot knew he hit something but it wasn't until he got home and saw the paint and propeller marks on the belly that he knew he'd had a midair. The other plane didn't fare so well..."

The unswept straight wing incorporates a high lift camber, and permits increased strength. Good lookdown visibility is insured by a cockpit set high and forward on the fuselage; when threatened, the pilot finds ready comfort in the nearly three-quarter ton titanium "bathtub" armor surrounding the cockpit. Composed of alloy plates bolted together with a multi-layered nylon fiber shell, this tub can withstand direct 23mm projectile strikes from the Soviet-made ZSU 23-4 quad barrelled radar-guided AAA gun, and even 57mm projectiles <<see NOTE below>>. The titanium tub itself represents 47% of the total armor on the plane—a remaining 37% protects the fuel system. Even the ammo drum for the 30mm cannon has its internal helical ammo delivery system protected.

All this was accomplished in a cockpit that lacked even the simplest autopilot, requiring the A-10 to be flown hands-on at all times. Indeed, it has been said that a Republic F-84 pilot from Korea would feel right at home in the A-10 cockpit... however, the lack of such "typical" avionics on the A-10 is attributable more to the lack of adequate performance and reliability of such "advanced" devices during the 1970s, than a desire on behalf of the design team to return to the past. For targetting, a limited computing bombsight linked to the inertial navigation system was present. It would not be until after Desert Storm that the addition of low-altitude safety and targeting system (LASTE) modifications (begun in 1989) would be completed, providing (at last) an autopilot; a simple radar altimeter coupled to a voice warning system (Bitching Betty); nighttime formation ("slime") lights; cockpit lighting compatible with night vision goggles; and the same weapons delivery computer as found on the F-16, although the F-16's radar ranging was not incorporated. The strategic value, albeit late, of these modifications could be immediately seen at the 1991 'Gunsmoke' USAF bombing competition, where the Hogs of the 175th Tactical Fighter Group (Air Nat'l Guard) of Baltimore, MD—fitted with the LASTE mods—flew home with top honors. <<see NOTE below>>

Turn and Burn

The A-10 enjoys an extreme measure of agility and responsiveness that permits it to fly low and slow to employ terrain-masking techniques to thwart enemy defences. Its lower speed, combined with the higher lifting camber of the wing design, permits the A-10A to pull more g-forces at a lower given speed, making the A-10A highly maneuverable and agile. For comparison:

A-10: 3.5g, 180° turn, 320 knots
time to completion: 16 seconds
2,700 ft radius turn

F-16: 6g, 180° turn, 600 knots
time to completion: 17 seconds
3,620 ft radius turn

What these figures state clearly is that the A-10A can out-corner a F-16 Falcon in full afterburner (for ONE turn only!!), assuming similar "clean" underwing configurations, with air-to-air weapons only. This, of course, is not the primary role of the A-10A…

Within the performance envelope of that first turn outlined above, the high lift (high drag also) wing design permits the A-10 to enjoy a lower "corner" velocity—that is, a lower speed at which it can pull max g-forces—relative to the F-16.This higher rate of turn at lower speeds permits the A-10 to perform evasive jinking maneuvers mere feet above the ground, whereas other "fast mover" jets require a greatly elevated performance ceiling and higher g-force penalty. <<before yelling, please see NOTE at bottom of Chapter 12, "Counter-Air Tactics">>

Get Up and Go

In the event of hostilities, the A-10 has been exceptionally configured for rapid deployment in battle. The auxiliary power unit (APU) is built in, removing the need for external power carts and minimizing ground crew interaction. A single-point fuel receptacle, located in the leading edge of the left landing gear pod, permits not only refueling of the two integral wing tanks and the two tandem fuselage tanks, but also allows 'hot-pitting' of aircraft, where the pilot remains in the cockpit with engines running. Inflight refueling via a refueling slipway receptacle located on the fuselage in front of the cockpit permits "box and boom" fuel exchanges. Additionally, up to three external drop tanks can be carried.

Internal fuel capacity: 1,650 US gallons. Weight: 10,700 lbs
External fuel capacity (3 600-US gal ferry tanks): 1,800 US gallons. Weight: 11,700 lbs

NOTE: due to the increased form and interference drag penalty induced by the three ferry tanks, A-10As in Ferry configuration often only carry only two tanks.

Hard to Kill

Verification of survivability tests riddled a static A 10A airframe with over 700 rounds of 23mm armor piercing-incendiary (API) and high explosive-incendiary (HEI) shells, and over 100 rounds of other calibers, without causing critical subsystems damage(!). A summary of the survivability test is as follows:

Cockpit armor	430 rounds
GAU-8 Ammo Drum	58 rounds
Underwing Bombs	23 rounds
Wing Fuel Storage	172 rounds
Fuselage Fuel Storage	102 rounds
Aft/Tail Systems	6 rounds

Windshield Panels	24 rounds (NATO 7.62mm API)

NOTES:
Survivability of 57mm projectiles: even though this was specifically listed in the original assessment of survivability test results, a direct contact burst should indeed penetrate (and destroy) the armor of the cockpit and plane. It is more plausible to suggest instead that a proximity (close range) burst may be survivable; although this would, of course, depend on the circumstances…
2-seat Night Fighter Variant: the A-10 design had been designed from the onset by Fairchild to contain a second cockpit without major modification to the airframe, in the area covered by the rear cockpit “turtle” deck immediately behind the ejection seat. In 1978, Fairchild leased back the first of the DT&E aircraft back from the Air Force (serial number 75-01664) for conversion to a Night All Weather (N/AW) YA-10B prototype. The structural changes in this conversion provided the second cockpit, an additional 20 inch extension to vertical tail surfaces (increased stability with the now altered center of gravity), and relocated avionic access bays. No other major changes were required, validating much of the early design sophistication and anticipation for such future modifications. The first test flight occurred May 4, 1979. The N/AW concept sought to extend the A-10’s role beyond that of a pure daylight battlefield resource, providing battlefield commanders an additional capability in severe environmental and tactical conditions. The N/AW included avionics for low altitude penetration, target acquisition. Amazingly, this extended capacity and handling characteristics remained very close to the single-seat A-10, without loss of ammunition, payload hardpoints, or internal fuel capacity, although the titanium cockpit shielding was not extended to the second cockpit in the prototype.

The avionics suite would have been upgraded to include a forward-looking infra-red radar (FLIR) pod, radar-generated terrain contour map, terrain avoidance radar, and key ordnance delivery and flight symbology. The second-seat System Operator had duplicate displays and was responsible for searching targets with the FLIR, and coordinating targets to a moving ground map radar display. Moving targets could have been acquired, identified, and designated at a distance of eight miles in essentially instrument-flying conditions of night, clouds or rain. Initial target location was acquired in a momentary popup and linked via inertial navigation systems to establish a line-of-sight approach. The aircraft would then resume a terrain following mode for optimimum target penetration.

It is unfortunate to note that funding beyond the YA-10B prototype never surfaced, as the LANTIRN avionics system was slated for higher-priority F-16C and F-15E inventories. The lack of further development of the N/AW concept is a striking irony, since two squadrons during Desert Storm, the 74th TFS (Flying Tigers) and the 355th TFS (Falcons), had to develop their own program of exclusively night interdiction, without the benefit of any of the avionics mentioned here. Even the inclusion of the LASTE modification after the Desert Storm conflict did not included the FLIR designator. It is a tribute to the men of these squadrons that they fought as well as they did, using ingenuity and the trust they had in their abilities and aircraft to have performed so well.

An interesting sidenote about LASTE is the number of lives lost associated with its late implementation; the Air Force lost an average of 2.5 hog drivers each year to controlled flight into the ground. In other words, pilots who were task saturated, distracted—or just plain unlucky—flew perfectly good jets into the ground an average of 2.5 times each year before LASTE. Only one Hog driver survived such a mishap. Only one Hog driver has died this way in a LASTE jet.

The A-10 Thunderbolt II: ‘Hog’ to My Friends

When it comes down to it, the word “ugly” comes to mind when viewing the A-10 against the backdrop of sleek modern jets like the F-14 Tomcat, F-16 Fighting Falcon, F-15 Eagle, and F-1 Mirage. The A-10 was officially named the “Thunderbolt II” in a Fairchild Republic ceremony marking the delivery of the 100th production airframe in April, 1978. The parallel to the successful close air support role of the original Republic P-47 Thunderbolt was made in the naming of the A-10A, although much more descriptive names abound for the plane.

As early as 1973, an Air Force writer, pondering this well… "different" new addition to the USAF inventory, recalled the nickname for the Republic F-84 was the ‘Groundhog’, or ‘Hog’ (also ‘Lead Sled’), because of its difficulty to obtain takeoff lift on hot (or any other type) days; when the swept wing variant appeared, it was promptly named the ‘SuperHog’. In Vietnam, Republic’s F-105 Thunderchief became the ‘UltraHog’—although the F-105 is best known as the ‘Thud’... in any case, this AF writer paused, and mused (in print!) that perhaps this new mean, lean and well, special, new bird should be known as the ‘Warthog’. This unfortunate, well-intentioned but highly observant soul is credited therefore with the unofficial naming of the A-10... perhaps to the detriment of his career. Air Force leadership, in a fit of early political correctness, laziness, or momentary lack of imagination, rebelled against their new War Baby being known as a rather unappealing member of the porcine family; the official naming ceremony slapped a more sanitary name on the A-10—at least in official print.

Another version of the naming of the A-10A is told by former Ordnance Engineer at Aerojet-General (Chino, CA), William J. Bowser, when the ammunition for the GAU-8 was developed. During the first in-the-air test of the GAU-8 the pilot fired the gun and the smoke was so thick it extinguished the engine(s)! It also coated the nose with black soot. To fix this problem they added two shield deflectors on either side of the barrels. These gave the plane a ‘snout’ which prompted the sobriquet 'Warthog' from one of the pilots. The powder in the 30mm shells was reformulated to be smokeless, solved the flame-out problem.The shields were removed—but the name remained.

One will never know...

How to Piss an A-10 Pilot Off...

Go ahead. Ask your local A-10 pilot about his “Thunderbolt II”. More than likely, he’ll pause (repressing an urgent need to strangle you), and politely and firmly instruct you on the proper form of address for the A-10, and its pilot: “that plane there is the

‘Hog’, and I am a ‘Hog’ driver. Now stand directly in front of the nose sir, and I’ll demonstrate the gun on... er, for you...”

Score points and look real snappy if you can pronounce ‘Hog’ as ‘Hawg’. That is, more than one syllable. And be damned proud when you say it. Much like its unofficial namesake, the A-10 is rugged, dependable and quite dangerous.

Unfortunately, Fairchild (Republic) fell victim to the failing military aviation economy of recent years (Grumman is the current product support contractor)—yet they have left in this plane a legacy that recalls their strong and proud design history. Whatever you decide to call it, thank the men and women of Fairchild for creating a plane that does its job beyond the call of duty, strikes fear deep to its enemy—but more importantly, brings its pilot home.

The Gun

Because of the declared emphasis in the A-X Proposal for a tank-killing CAS aircraft, the choice of cannon received a separate Request for Proposal in July 1970. General Electric and Philco Ford presented two prototypes, and the GE cannon was chosen in June 1973. The original YA-10s used the 20mm M61A1 Vulcan cannon, and the first prototype was retrofitted to permit testing of the cannon itself, and of the YA-10 as gun platform.

The seven-barrelled General Electric GAU-8 Avenger 30mm cannon originally had firing rates of 2,100 or 4,200 rounds per minute. In the first second of fire, the barrel could only fire 50 rounds per second until it overcame inertia; then it fired up to 70 rounds per second. In 1989, however, the firing rate was fixed at a single speed of 3,900 rounds per minute. As the barrels spin, each barrel has its own breech and bolt action, creating in essence seven rotating 30mm rifles joined to a common axis with a common firing mechanism. Only one barrel fires, aligned and fixed along the long axis of the the aircraft to prevent any assymetric recoil force, while the other six barrels cool down and are fed ammo. The recoil force is tremendous: if the rounds were fired continuously in one burst, the cannon can produce 10,000 lbs of recoil, which is enough to actually cause the A-10 to slow in flight! The linkless feed and storage system of the A/A 49E-6 gun system can hold 1,174 rounds, sufficient for ten or eleven 2-second bursts. Unloaded, the gun system is about as long as a 1970’s Cadillac sedan, and weighs (loaded) 4,029 lbs. Empty, the drum weighs a mere 1,950 lbs. Each projectile on the feed belt recycles the cartridge casings back to the drum, to prevent a dramatic shift in the plane’s center of gravity.

The only specialized ground equipment required for the A-10 is, appropriately enough, used to load and unload the ammo drum in a mere 13 minutes. A typical combat ‘mix’ of ammo combines a single PGU-13 HEI round with five PGU-14 API rounds. The PGU-14 API round weighs (total) 1.77 lbs, surrounding a 0.94 lb depleted uranium (DU) penetrator. The choice of depleted uranium as the projectile was based on its atomic density, not as an ‘atomic’ weapon, as was then claimed by the Soviets. Each 30mm projectile leaves the muzzle at 3,280 feet per second (Mach3), seventy times a second... not bad for a shell the size and shape of an old-fashioned milk bottle. API shells are capable of killing a main battle tank by having enough mass and kinetic energy to cause the penetrator, upon impact, to translate its momentum into heat, permitting the DU to penetrate into the body of the tank. For the average strafing run (before LASTE mods), most attack runs began about 4,000 feet from the target, with a minimum acceptable standoff range of around 2,000 feet to avoid enemy fire. The impact on targets caused by these API shells, as replayed in field demonstrations, is devastating. The effect on the tank crew inside is, well... sudden and enlightening...

Ordnance Warloads

Weapons are hung from eleven possible hardpoints; these include the use of a single centerline mounting, or two (left and right) fuselage hardpoints. All eleven hardpoint pylons can be removed to enhance battlefield agility and decrease total combat weight. These pylon stations can hold between 1,000 lbs at the outermost stations, to 5,000 lbs at the centerline station. The total external ordnance payload is 16,000 lbs.

The A-10 is cleared for a huge assortment of weapons, including all the Paveway bombs, excluding the GBU-15 and GBU-28 ("Saddam Killer" 4,000 lb bomb); all of the Mk.80 series LDGPs; the M117 750-lb demolition bombs; cluster bombs; 2.75” rocket pods; ALQ-119 and -131 ECM pods; ALE-40 chaff/flare pods; and AIM-9 series Sidewinders. In practice, payloads are constrained by the mission and by performance requirements—just because the plane can carry 16,000 lbs of ordnance doesn’t mean that it will or should. Further, the A-10's tank-killing role and restricted battlefield environment often preclude the use of more expensive and sophisticated weapons. Predominant combat loads for the A-10A typically consist of Mavericks, iron bombs, and cluster munitions. For a plane to survive in any theater of operations, it must retain its maneuverability, and that in turn means relatively light payloads in combat. Where specific ordnance information has not been available, only the name of the munition is noted.

Laser Energy Detection

AAS-35 Pave Penny (TISL/Target Identification, Set, Laser)

GAU-8 Avenger 30mm cannon

PGU-13 HEI high explosive/incendiary shell

PGU-14 API armor piercing/incendiary depleted uranium shell

•Details about these projectiles have been discussed in the previous chapter.

AGM-65 Maverick series

•Originally developed by Hughes in 1965, introduced in 1972 for USAF use. Currently the smallest fully-guided air-to surface missile in US inventories. Highly respected as a fire-and-forget weapon. Weapons with the 300 lb (135kg) warhead are sometimes marked with a yellow band before the fin roots; 125 lb (57kg) warheads by a black band.

AGM-65B—electro-optical (EO) 125lb shaped HE charge

•Improved Scene-Magnification version of initial -65A TV Maverick, introduced in 1980. Doubles the image magnification of the 2.5° field of view of the -65A.

AGM-65D—imaging infra-red (IIR) 125lb shaped HE charge

•Imaging infra-red version, introduced in 1983. Capable of operating in adverse weather and night, the IR capability can be used in concert with both FLIR and LANTIRN target designators. The -65D is the most expensive and largest of the Maverick variants, but with exceptional range and target acquisition qualities.

AGM-65G—300lb explosive charge (non-shaped Avco penetrating blast fragmentation charge)

•Air Force equivalent to the -65E Maverick of the US Navy/US Marine Corps (250 lb shaped charge, inventoried for the F/A-18 Hornet and A-6 Intruder), it is designed for hardened targets such as aircraft shelters and bunkers, with the anti-tank capability intact. Features pneumatic controls and digital autopilot. The operator before launch can define what portion of a large target to lock on to, and the weapon features low altitude trajectories to prevent guidance errors due to clouds. Has been suggested that a tactical nuclear warhead may be developed for future use with this variant.

General Purpose (GP) Bombs

Mk.82 LDGP 500lb

Mk.84 LDGP 2000lb

-AIR (Air-Inflatable Retarder) System

•Loral Systems developed this balloon parachute derivative for low level, high speed munitions delivery. In a level pass at 200 ft AGL at a ground speed of 550 knots, the AIR system attached to any of the family of Mk.82, -83, -84 bombs provides a minimum aircraft separation of 1,375 ft from the impact point.

-Snake Eye (retarded air drop) metal Airbrake System

ANM47A4 Smoke Bomb

Guided Bomb Unit Designations and Status

PAVEWAY 1 SERIES MODS

GBU-1	Mk.20 Rockeye + KMU-420 Paveway 1 laser guidance kit
GBU-2	CBU-75 Pave Storm + KMU-351 Paveway 1 laser guidance kit
GBU-3	CBU-74 + KMU-422 Paveway 1 laser guidance kit
GBU-4	BLU-89 demolition bomb + KMU-355 Paveway 1 laser guidance kit
GBU-5	BLU-90 penetration bomb + KMU-353A Paveway 1 laser guidance kit
GBU-6	CBU-79 Pave Storm + KMU-351 Paveway 1 laser guidance kit
GBU-7	CBU-80 Pave Storm + KMU-351 Paveway 1 laser guidance kit
GBU-10A	Mk.84 LDGP + KMU-351B Paveway 1 laser guidance kit

•The Paveway I series were the first U.S. family of laser-guided bombs (LGBs). Introduced in 1967 during the Vietnam War, they were particularly effective against bridges and other high value targets in North Vietnam during the Linebacker 1 and 2 campaigns. Designed for release from high and medium altitudes, they had relatively small fins which restricted their range to about 8 km. No longer in service with the United States (except perhaps as practice bombs), they still may be active with a number of U.S. allies. The basic Paveway design has been widely copied, by Israel, Argentina, Brazil, Taiwan, China and the Soviet Union, among others.

Homing Bomb Systems (HOBOS) GBU-8

EOGB-1: Mk.84 LDGP + KMU-353A TV guidance kit, or KMU-390 Image Contrast seeker, or KMU-359 IR seeker GBU-9

EOGB-2: M118 3000-lb bomb + KMU-390C seeker

•Both of these configurations are known as HOBOS. They were used by the US with mixed results during the Vietnam War. Short-range (8km) direct attack weapons, they required the operator to lock onto a contast edge or IR source before releasing the weapon; unfortunately, the seekers frequently lost lock due to smoke, haze or obscuration. HOBOS is no longer used by the U.S. It was supplied to Israel and other US allies, which may still have some inservice. It was used by the A-10 during test and evaluation, but has never been a common payload.

(NON-OPERATIONAL LOAD)

GBU-15(V)1/B Mk.84 + Cruciform Wing + TV Seeker + AXQ-14 data link

GBU-15(V)2/B Mk.84 + Cruciform Wing + IIR Seeker + AXQ-14 data link

•The GBU-15 is the successor to the defunct HOBOS GBU-8, with much extended wings for longer range (10-15 km, depending on release speed and altitude). It is equipped with a 2-way video data link that allows the bomb to be controlled in flight by the launch aircraft or a third party. Thus it may be released beyond visual range of the target (hopefully beyond the range of its defenses as well), and locked onto the target in flight; it may also be steered manually. Adapted for use with the Mk.84 and the 3,000 lb M118E1 demolition bomb, target delivery accuracy is within 20 feet. Originally part of the Pave Strike program initiated in 1970, it was intended to be a modular “family” of weapons, including an airplane-like “planar wing weapon” (GBU-20) for use by B-52s. Due to rising costs, only the TV and IIR versions were produced. To extend range even further, a rocket-boosted derivative has been developed and fielded as the AGM-130. The GBU-15 has never been used by the A-10A, for several reasons. First, it is expensive ($130K each), and therefore not cost-effective against the A-10’s principal targets. Second, using the weapon requires carriage of a large data link pod, and ideally, the full attention of a dedicated weapon system operator (WSO). Third, given the A 10's low speed, it would not impart sufficient range to the GBU-15 to take advantage of the datalink feature. In US service, the GBU-15 is carried only by the F-111F and F-15E, for precision deep strike missions. The GBU-15 has been supplied to Israel, where it is carried by the F-4E Phantom.

PAVEWAY II SERIES MODS

GBU-10D   Mk.84 LDGP + KMU-351E Paveway II laser guidance kit
GBU-10E   Mk.84 LDGP + KMU-351E Paveway II laser guidance kit (mod)
GBU-10F   Mk.84 LDGP + KMU-351E Paveway II laser guidance kit (mod)
GBU-11   M118 demolition bomb + KMU-351 Paveway II laser guidance kit
GBU-12   Mk.82 LDGP + KMU-388 Paveway II laser guidance kit
GBU-13   SUU-51 dispenser + KMU-388 Paveway II laser guidance kit
GBU-16   Mk.83 LDGP + KMU-455 Paveway II laser guidance kit

•The Paveway II series was introduced in 1980 by Texas Instruments as a lower cost simple guidance system for the original Paveway concept. They were improved versions of the original LGB family featuring more reliable seeker heads and extended fins for longer range (10-15 km depending upon release speed and altitude). Of these, the GBU-10 and GBU-12 are by far the most commonly deployed laser-guided bombs employed by the A-10A; although the aircraft is also cleared for the GBU-16, this is primarily a Navy weapon (as used on the F/A-18 Hornet). The Paveway system typically comprises a set of add-on control surfaces with a marked target laser homing seeker head, which added about 30 lb to the weight of the standard low-drag Mk.82, -83, and -84 iron bombs. The GBU-10 is based around the Mk.84 2,000 lb general purpose bomb.

PAVEWAY III SERIES MODS

GBU-22   BLU-109 2000-lb penetrator + Paveway III laser guidance kit
GBU-24   Mk.84 LDGP + Paveway III laser guidance kit

•The Paveway III series are the latest US laser guided bombs. Also known as Low Level Laser Guided Bombs (LLLGBs), they have revised seekers (without the familiar "weathervane" head) and improved "proportional" (vs. "bang bang" or "on-off") control systems that allow them to be released at low altitude and "tossed" into a laser "basket". Paveway IIIs were introduced in 1987, and feature a digital autopliot with microprocessor controls for use in adverse weather, low-level flight. When fitted with high lift folding wings, this weapon can be released at angles ranging from level flight to dive release angles as steep as 60 degrees. They could have been used in the 1986 raid on Libya, but Paveway IIs were used instead to preserve the security of the Paveway III technology. This in turn necessitated a higher approach altitude and a closer approach to the target, which may have resulted in the loss of an F-111F to surface-to-air missile fire. Their sophistication has added considerably to their cost ($40k each); hence they are used only for deep strike missions.

Submunition and Cluster Bomb Units

•The designation BLU (Bomb, Live Unit) refers to a number of interchangeable and flexible munition packages and area denial munition types. These BLUs can be packaged for delivery by Cluster Bomb Units (CBUs) and Suspended Underwing Unit (SUU) dispensers, also known as Tactical Munitions Dispensers (TMDs). In instances where information is available, these munitions will be described; in cases where the A-10A is known to have carried the (typically older) munition, only the type designation will be listed.

Cluster Bomb Units

Avispa (Wasp) CBU canister (Chile)

•Although most cluster munitions are produced in the United States and Europe, other countries such as Israel (TAL-2 submunition dispenser) and Chile have developed CBU's. Chile's Ferrimar developed the 500 lb Avispa (or Wasp), which dispenses 248 bomblets of 1.43 lb each. It can dispense either an area-denial submunition with a preset time-delay between 30 seconds and 72 hours, or a shaped charge submunition that can penetrate 150mm (5.9 inches) of armor.

BL755 / HADES CBU canisters (Great Britain)

•Produced by Hunting Engineering since 1972, this dual-role submunition is the standard CBU of British forces, and is qualified for use in a number of NATO aircraft. Weighing 600 lb, it contains 147 bomblets wrapped in a notched steel wire for fragmentation purposes. One of four possible time delays is programmed into the canister before takeoff. Following release, a primary cartridge blows off the two-piece skin of the canister and fires the main cartridge, ejecting the minelets, which are fused by a piezo-electric crystal to a preset altitude. Each shaped-charge warhead thus is armed in free-fall and is able to penetrate (on impact) 9.84 inches of armor, in addition to scattering at least 2,000 lethal fragments. The Improved BL755 uses a more powerful warhead that features an extending nose probe and retarding parachute. The HADES variant contains 49 Ferranti HB876 area denial minelets (this minelet is also used in the JP233 system carried by the Panavia Tornado). These free-fall to the ground and orient themselves upright on radial spring legs, and trigger detonation via a proximity fuse. They too are rigged with an adjustable self-destruct timer fuse.

CBU-59/B Rockeye II

•Developed from the Navy's Mk.20 Mod IV "Rockeye" (247 M118 bomblets, 30,000 sq ft coverage @ 500 ft AGL release), the Rockeye II packs 717 PLU-77 bomblets in a Mk.7 Mod 3 dispenser. The PLU-77 bomblets are anti-tank fragmentation charges that can discriminate between hard and soft targets to provide a secondary anti-personnel function. Note: this is the only BLU-series submunition that is apparently mispelled, and is still referenced as such in US inventories.

CBU-52 fragmentation bomblets
CBU-58 anti-personnel bomblets
CBU-71 frag/incendiary cluster mines (anti-personnel role)

•A load of 670 BLU-86A/B bomblets is fitted inside the SUU 30A/B dispenser, where each bomblet is a steel-cased fragmentation warhead. 1,800 of these bomblets can also be substituted for BLU-63s in the CBU-75 (not carried on the A-10A).

CBU-87 combined effects munitions (CEM)

•Aero Ordnance began manufacture in 1983 of this dual purpose CBU, which houses 202 CEM BLU-97/B bomblets, fitted with a proximity fuse (FZU-39/B) for delivery at a preset altitude. Each bomblet combines a shaped charge for penetrating armor, a prefragmented case (for secondary anti-personnel effect), and a zirconium disk for incendiary effect. The CBU-87 is slated to replace both the 'Rockeye' series and the anti-personnel CBU-58/71 series, which have little anti-armor capabilities. Based on the SUU-65/B dispenser, the CBU-87 can be delivered at heights of 200 ft and at speeds of 805 mph. The fragmentation section of the BLU97/B bomblet can disable motor transport to 50 ft, and aircraft (presumably on the ground) at 250 ft. The CBU-87, along with the CBU-52 and CBU-58, are the three favorite gravity bomb loads for the A-10A.

CBU-89 Gator mines

•The Gator landmine system is part of the FASCAM (Family of Scatterable Mines) developed by the US Army's Armament Research and Development Center. The Gator dispenser system is known to the Air Force as the CBU-89/B, whereas the US Navy designation is CBU-78/B. This system embodies a unique tri-service relationship, in that the US Air Force is the lead service user, with the Army providing the BLU91 and -92 submunitions, and the Navy providing the mine-dispenser adapter. The weapon can be delivered between 200 and 40,000 ft, at speeds up to 700 mph, and the bomblets are triggered by a time fuse or a proximity-activated fusing. The CBU-89 carries 72 BLU-91/B Gator anti-tank bomblets with magnetic detector fuses, and 22 BLU-92/B anti-personnel bomblets with self-deployed tripwires within the 700 lb dispenser.

CBU-97 sensor fused weapon (SFW)

•Avco Systems/Textron developed an essentially 'guided' submunition delivery system in the CBU-97/B, which packages 10 BLU-108/B submunitions (each with four 'Skeet' smart warheads) inside the SUU-64/TMD dispenser. Each Skeet is a squat cylinder casing with a side-mounted IR sensor tube running parallel to the axis of the warhead. Each submunition is, upon release, suspended vertically by a parachute as a small retro rocket motor spins the armament upward and ejects the four Skeets outward. Spring-loaded arms on each Skeet impart a wobble on the spin of the Skeet, thus increasing the search pattern of the IR sensor to around 4,800 sq yd below it. Once the heat of a tank is identified, the Skeet warhead fires downward a unique self forging shaped charge, that transforms a dish of heavy malleable metal into a slender projectile, travelling at 9,000 ft/sec (6,100 mph)! The slug is capable of easily penetrating the thin armor at the top of the tank, resulting in tremendous kinetic forces upon impact, and often causing a secondary fire. If no heat source is detected, the Skeet detonates above the ground to cause blast and fragmentation damage in an anti-personnel role. Development of this submunition is under the supervision of the Wide-Area Anti-armor Munitions (WAM) and Assault Breaker programs which seek to provide US tactical aircraft with the ability to make direct attacks on armored formations. The WAM concept is itself an outgrowth of the Extended Range Anti-armor Munitions (ERAM) project of the USAF Armament Division at Eglin AFB, where Avco participated as a contractor.

Mk.36 Destructor mines

Sidewinder Air-to-Air Missile

AIM-9L infra-red heat sensing

•Arguably the most outstanding of the first postwar generation of air-to-air missiles, the Ford Aerospace/Raytheon Sidewinder AIM-9 was originally developed at the Naval Weapons Center, China Lake, and exists in multiple variants since its introduction in 1956. This missile inadvertently became the basis for its generation of missiles when one lodged in the rear fuselage of a MiG-17 when both its proximity and contact fuses failed. Examination of this missile once the MiG-17 landed resulted in Soviet-bloc and Chinese copies of the rocket motor systems. The AIM-9L 'Lima' (introduced in 1976) is the best-known of the current generation, with an all-aspect IR seeker head with double-delta canards. The Sidewinder series represents a design concept developed in the 1950s that the energy from a warhead could best be employed to create a moving ring of metal that expanded outward into the target. To that end, a series of rods were welded together in the warhead that would deform and break, but in the controlled pattern of an expanding circle or ring. The resulting contact with a target fuselage or control surface would be a linear set of slashes through the skin, resulting in significant strength damage to the structural components, with concomittant damage to electrical, hydraulic or mechanic connections. The preferred 6 o' clock target aspect for any missile shot increased the probability of successful damage to the engine and/or fuel systems by targeting the engine's heat signature; improved all-aspect missiles such as the AIM-9L meant that any firing aspect could be attempted, including head-on launches. Use of the AIM9 'Lima' model is believed to be minimal or discontinued for the A-10A, having been replaced with the improved 'Mike' model (see below).

AIM-9M all aspect

•Produced exclusively in the US, the AIM-9M features an enhanced guidance and target-acquisition, improved countermeasures resistance, and the smokeless exhaust of its Bermite/Hercules Mk.36 motor represents a significant tactical advantage to an already capable weapon.

Vought Hypervelocity Missile (HVM)

(CONCEPT WEAPON/NON-OPERATIONAL LOAD)

•This Vought/Loral system was developed as part of the Army’s Line-of-Sight Anti-Tank (LOSAT) program of the late 1970s. In 1981, the USAF awarded Vought a contract to develop an air-launched version under laser guidance, with the original specifications to use depleted uranium rods for maximum kinetic energy translation upon impact. Specifications for the USAF version call for a 66lb tungsten long-rod penetrator projectile of 3.8 inch caliber that can impact its target at 5,000 ft/sec (Mach 5). These would be fired from existing 40mm rocket pods. Such a kinetic force weapon would circumvent reactive (explosive) and composite (Chobham-type) tank armor plating that currently serves to reduce the effectiveness of tank damage and penetration by conventional high-explosive shaped-charge weapons. A FLIR sensor on the aircraft would track both target and missile location, and transmit guidance controls via a carbon dioxide laser data link. Testing of this weapon indicated that it was effective at a range of 6 km, roughly twice the range of the current Hydra 70 family of 2.75 (70 mm) folding fin aerial rockets (FFARs). Further, the HVM is designed to permit a single aircraft to engage up to 10 (ten) individual targets in a single pass. Operational cost of this system has been projected to be rather inexpensive, being $8,300 per missile in FY85 dollars. At present, however, the HVM is a purely Army program, and if the Air Force has retained any interest, it is mainly as a low-level technology demonstration program. From the Air Force perspective, the short range of HVM requires the launch aircraft to fly unacceptably close to its target. This would be no problem for the A-10A, for which HVM is an ideal weapon. But as current Air Force plans call for eventual elimination of the Warthog, there is obviously no programmatic justification (from their perspective) for the HVM.

Target Marking

•These items are most often carried by the OA-10A in its Forward Air Controller role, for target marking and designation, or as part of the standard operational load for Seaarch and Rescue "Sandy" missions. They should not to be considered part of normal combat ordnance loads or missions.

- Mk.156 White Phosphorus (WP) warhead / Mk.66 rocket motor assembly (‘Willy Pete’ Rockets)
- Mk.24 flare (3 min, 2 million candlepower)
- LUU-2 flare (5 min, 2 million candlepower)
- LUU-1 flare (red) (30 min, 1,000 candlepower)
- LUU-5 flare (green) (30 min, 1,000 candlepower)
- LUU-6 flare (fuschia) (30 min, 1,000 candlepower)

Primary Defensive Stores

- ALE40 chaff
- MJU3 IRCM (infra-red countermeasures) flare (modified LUU2)

Electronic Countermeasures

- ALQ-119(V)-15 (US-based aircraft)
- ALQ-131 (overseas-based aircraft)

•Because of its better performance, most A-10 units operating in Europe received the -131 model due to the higher threat level perceived in Soviet-aligned forces. It has a generally more squarish and chunky appearance in comparison to the ALQ-119 ECM pod.

- ALQ-131 Deep (provisional store)
- ALQ-184(V)-1 (provisional store)

A-10A: Mission and Threats

Mission Environment

The A-10A is a specialized close air support (CAS) aircraft. That is, it is designed specifically to act as "flying artillery" in support of ground troops in close proximity to the enemy—in general, within five miles of the front lines. Built around the awesome GAU-8A 30mm rotary cannon, the A-10's primary targets are enemy tanks and other armored vehicles. The big gun is backed up by other anti-armor weapons, most notably the AGM-65 Maverick missile, the GBU-12 Paveway 500 lb laser guided bomb (LGB) and the CBU-87 combined effects munition Other weapons, such as the Mk.82 Snakeye 500 lb retarded bomb, the (outdated) Mk.20 Rockeye cluster bomb (CBU), 2.75" rocket pods, and napalm bombs, can be used against trucks, troops and field installations.

In order to properly support ground troops, CAS aircraft must be able to stay on station, or loiter, near the front lines for extended periods. The A-10's high bypass TF34 turbofans were selected mainly for their excellent fuel efficiency, which together with the Warthog's internal fuel capacity of 10,650 lbs, allows the A-10 to loiter for nearly 2 hours over a radius of 250 n.mi., whereas high performance jets such as the F-16, can only loiter for 15-20 minutes at a similar radius.

Speed was definitely a secondary (or tertiary) criterion in the design of the A-10. More emphasis was placed on maneuverability in the horizontal plane; that is, the ability to turn quickly in a small radius. This allows the A-10 to fly very low, using terrain for cover, and to quickly bring its ordnance to bear on small, elusive mobile targets like tanks and troop positions. It also affords the Warthog pilot time to visually confirm friendly from hostile forces, which may be separated only by a few hundred yards.

To say that the forward edge of the battle area (FEBA) is a dangerous place is quite an egregious understatement, given the proliferation of light automatic anti-aircraft weapons, shoulder-fired surface to air missiles (SAMs) and larger, radar-controlled mobile SAM launchers. For any CAS aircraft, the danger is compounded first by the need to loiter over the battlefield (increasing exposure time); and second, by the high pilot workload (monitoring air-to-air and air-to-ground radio channels, trying to acquire the target, keeping track of friendly forces), which makes it difficult to see and evade many threats. For this reason, many air forces, including those of Germany, Israel and Russia, have relegated fixed-wing aircraft to a secondary role in CAS, placing their principal reliance on attack helicopters. The fixed-wing A-10 is something of an oddity, but it succeeds quite capably since its design stressed survivability through the protection of critical and redundant systems (widely separated hydraulic lines, a manual backup control system, widely separated engines to avoid total power loss from a single hit). Its effectiveness is due to it being a single mission, optimized platform. Even so, the A-10 can still be shot down, and special tactics have been developed to exploit its unique performance and design features and thereby improve its chances of survival.

Operational Threat Arena

Before one can understand the tactical repertoire of the A-10, one must understand the nature of the air defense threats that it faces in the performance of its primary mission. At the time of its design, the threat was defined as the air defenses of the Soviet Army on the NATO Central Front in Germany. Having suffered severely from German airpower in World War II, and recognizing that its own air forces were technically inferior to those of the NATO allies, the Soviet Army developed comprehensive and highly effective mobile air defense systems intended to protect its mobile forces from just the sort of threat posed by the A-10. The Soviet Union has been relegated to the ash heap of history, but the Russian Army remains, and its air defense systems remain the standard by which others are judged. In addition, many former Soviet client states and Third World countries are equipped with Soviet air defense weapons, and have air defense systems based on the Soviet model.

Soviet forward area air defenses are based on a layered concept of defense in depth, with multiple weapons of various types providing protection at different organizational levels. To begin within the tank and motor-rifle (mechanized infantry) battalions of the maneuver divisions, each tank, and most other armored vehicles, mount a heavy machinegun of 12.7 or 14.5mm bore. Visually aimed, each gunner has only a small chance of hitting an aircraft, but with 30-40 such weapons in the battalion, a wall of fire can be thrown into the path of an aircraft that is very hard to avoid. At the very least, these weapons exercise a deterrent effect on attacking pilots (forcing them to jink during their approach runs, thereby reducing bombing and strafing accuracy); at worst, a random hit (the notorious "Golden BB" can hit a critical component, bringing down a mult-million dollar fighter. The A-10's design largely negates this threat, allowing the pilot to concentrate on attacking with greater confidence of a successful mission profile through enemy air defenses.

Man-Portable Air Defense Weapons

Complementing the anti-aircraft machineguns are shoulder-fired SAM launchers, one of which is found in every motor rifle platoon (3-4 armored personnel carriers with 30-40 men). The oldest of these, the SA-7 Grail, is broadly similar to the U.S. FIM-47 Redeye. Armed with a 2kg high explosive warhead, it has a simple, uncooled infrared seeker that can only lock onto aircraft from the rear (i.e., hot engine nozzles), which in practice makes it a "revenge" weapon that can only be used on aircraft that have already made their attack. It has a range of 4-6 km, and a maximum ceiling of 2,500 meters. Now obsolete, it is still used in large numbers by Third World forces and terrorists.

The Grail has been superseded by the SA-14 Gremlin and the SA-16 Igla, both roughly comparable to the U.S. FIM-92 Stinger. Both have a range of 6 km, and a ceiling of 3 km. In contrast to the SA-7, they have much more sensitive IR seekers that can lock onto an aircraft from any aspect, including head-on, which makes them much more effective in disrupting an air attack. The SA-16 has a wide-angle seeker that allows it to track aircraft turning sharply.

All infrared missiles home on the heat generated by the target. The most common countermeasure against them are decoy flares, of which the A-10 can carry up to 480 in ALE-40 dispensers built into the wingtips and landing gear nacelles. The crude seeker of early missiles like the Grail simply homed on the hotest heat source in its field of view (sometimes including the sun or a hot chimney), so flares were very effective. Later missiles, like the SA-14 and 16, use seekers that operate in two frequency bands ("colors") in order to reject flares and other heat sources that do not closely resemble actual aircraft IR emissions. In response, flares have been developed that more closely match true IR signatures. Yet even these can be defeated. The latest models of Stinger, for instance, use the ultraviolet contrast between the target and the background sky to reject spurious emissions from flares. Nonetheless, individual shoulder-fired SAMs are not a serious threat; they can be spoofed, evaded or outrun, and a single hit from the small warhead may not cause fatal damage. Their true effectiveness lies in their ubiquity: passing over an enemy unit, a single aircraft may be attacked by upwards of a dozen missiles simultaneously, making a hit almost unavoidable.

SPAAGS

To the immediate rear of the front-line units one can find radar-directed self-propelled anti-aircraft guns (SPAAGs), six of which are commonly organic to each regiment or brigade. In the 1970s and '80s, the standard Soviet SPAAG was the ZSU-23-4 Shilka, many of which can still be found in Eastern Europe and the Third World. This formidable vehicle, with a tracked chassis and turret armed with four water-cooled 23mm cannon, was responsible for the majority of Israeli aircraft losses in the 1973 Yom Kippur War. Each gun has a cyclic rate of fire of 800-1,000 rounds per minute, for a combined rate of 1,600-2,000 rounds per minute. In operation, the guns are fired in bursts of 30 or 100 rounds. The guns are directed by a "Gun Dish" tracking radar, which passes range and range rate data to a fire control computer that accounts for lead and bullet drop in laying the gun. Typically, a radar directed burst has a 33% chance of hitting at a maximum range of 2,500 meters. The Gun Dish radar can be jammed, in which case an optical sight can be used with a corresponding reduction in accuracy.

Electronic countermeasures are one way to defeat the Shilka. Two others are to fly very low, using terrain masking to avoid detection by the Gun Dish; or to fly at heights abouve 6,500 feet, above the effective ceiling of the gun. To fly very low, an aircraft must either fly slowly (like the A-10) or have a terrain-following radar (like the F-111). In either case, it is extremely difficult to detect small targets like tanks unless one pops up to a reasonable height, which places the aircraft back in the vulnerable zone.

SHORAD

Aircraft attempting to fly over the Shilka's effective ceiling were normally engaged by a short-range air defense (SHORAD) missile system such as the SA-9 Gaskin or SA-13 Gopher. These are essentially enlarged versions of the SA-7 and SA-14, respectively, combined with infrared homing ranges of 9 km (SA-9) and 7 km (SA-13). Both have a ceiling of about 5,000 meters. The SA-9 is essentially a rear-quarter missile, but the SA-13 has a better seeker offering all-aspect capability. They have the same weaknesses as the shoulder-fired SAMs, but with greater range and larger warheads, they are significantly more lethal. Both the SA-9 and SA-13 are mounted on self-propelled chassis, wheeled in the case of the SA-9, tracked in the case of the SA-13. Target acquisition is visual in both, but the SA-13 has a range-only radar to assist the gunner.

In the Russian Army, both the SA-9/13 and the ZSU-23-4 are being replaced by a single combined gun/missile system, the 2S6 Tunguska, perhaps the most effective short-range air defense system in the world. Mounted on a large, tracked chassis, it combines on a single mount two 30mm water-cooled, high-velocity cannon and launchers for eight SA-19 Grisson short-range missiles. In addition, the 2S6 carries an integral target acquisition radar, a tracking radar, a laser rangefinder, and an electro-optical sight. In operation, the 2S6 would detect and engage targets first with the SA-19, a high-velocity missile with a range of 9 km. Relying on laser beam-riding guidance rather than IR, it is particularly difficult to defeat with countermeasures, and is too fast to evade easily. As a rule, two missiles are launched at each target. If the missiles miss, or if the target is detected inside of 4000 meters, it is engaged with the guns, the range and accuracy of which are significantly better than others of equivalent caliber. Not having been used in combat, the weaknesses of the 2S6 radar systems cannot be assessed, but later concurrently developed Soviet radars are very good indeed.

MSAMs

Overwatching the forward area air defenses are divisional air defenses based on short and medium range SAMs (MSAMs) such as the SA-6 Gainful and SA-8 Gecko. Both of these radar-directed missiles have been quite effective in combat, though their performance in the hands of Soviet clients like the Syrians and Iraqis might lead one to denegrate their capabilities. The SA-6 is an integral rocket ramjet missile with a maximum velocity of Mach 2.5, a maximum range of 24 km, and an effective ceiling of 11 km. A firing battery consists of four self-propelled triple launchers and a self-propelled "Straight Flush" engagement radar. The single radar represents the critical weakness of the system since only one target can be engaged at one time, and Israeli tactics in the Bekaa Valley in 1982 emphasized elimination of the radar in order to neutralize the battery.

The SA-8 Gecko's self-propelled launcher, in contrast, carries its own missile guidance radar, allowing a battery of four launchers to engage four targets simultaneously. Rather smaller than the SA-6, the SA-8 is a conventional solid-fuel rocket, with velocity of Mach 3, a range of 12 km, and a ceiling of 12.2 km.

Within the Russian Army, both SA-6 and SA- 8 have been replaced by the SA-15 Tor, a highly impressive weapon system featuring a self-propelled laucher with eight vertically launched missiles, an acquisition radar, a tracking radar, and a backup optical tracker. In contrast to earlier systems, each Tor launcher can engage two targets simultaneously. The SA-15 missile has a maximum velocity of Mach 3+, a range of 15 km, and a ceiling of 9 km. Used in conjunction with the 2S6, it gives the Russian Army the best short-range air defense in the world today. Both the SA-15 and 2S6 are being marketed quite actively by Russia in its quest for hard currency, so these weapons may pop up in many contingency theaters.

Overwatch

Behind all of the forward area systems, the Soviet and Russian Armies deploy MSAMs at the divisional and army levels. These included the SA-6, which has been superseded in that role by the SA-11 Gadfly. Mounted on a self-propelled launcher with four missiles and a guidance radar, the SA-11 has a maximum velocity of Mach 3, a maximum range of 30 km, and a ceiling of 15 km. It in turn is now being replaced by the SA-17 Grizzly, with even better performance. The divisional MSAMs overwatch the SHORAD and forward area systems, preventing the enemy from flying over or around them. Thus any attacker attempting to fly CAS against a Soviet-style air defense system would be confronted by a multiplicity of weapons, each with different and complementary characteristics, sited so as to provide mutual support and overlapping fields of fire. Small wonder, then, that the US places so much emphasis on "Suppression of Enemy Air Defenses" (SEAD) with specialized "Wild Weasel" aircraft to destroy SAM sites and radars, as well as on active and passive ECM. In this highly lethal environment, the A-10 must not only survive, but thrive.

A-10A Tactics—Root Hog, or Die!

Aside from its rugged construction, the A-10's survival in the forward area is abetted by its low-speed maneuverability, which allows it to fly safely as low as 100 feet above ground level. Flying at low altitude conveys two main advantages: first, radar has trouble detecting the aircraft against background clutter; second, the pilot can exploit the air defense concept of "intervisbility" by means of terrain masking tactics.

Terrain-Masking

What is intervisibility? This concept simply put, defines how neither radar, optical systems, nor the naked eye can see through solid objects like hills, or even dense foliage. Though air defense units are normally posted on hilltops or ridgelines that provide long lines of sight, in rolling hill country (such as is found in Germany) the chances of detecting a very low-level target exposied for a brief instant (say, an A-10A at 100 feet) are very small indeed. Statistical analyses done in the Fulda Gap area (the principal Soviet invasion route into the US sector of the NATO Central Front) indicate that the median unmask range for an aircraft flying at 30 meters (100 feet) is on the order of 5 km. Of equal or greater importance, statistics show that even at that range a target normally remains unmasked for less than 10 seconds. Because all existing air defense systems require an uninterrupted line of sight, this means that even if an air defense weapon does acquire and track a target, it will not have time to launch its weapon; even if it does, that weapon will not have the time to cover the distance to the target before the aircraft remasks by passing behind another hill.

Consider the following example: an air defense missile system detects an aircraft at 5 km range and 30 meters height, flying towards the launcher at 400 km/hr. (110 m/sec). It has a radar with a 2-second scan period, and requires two scans to establish a track. Its fire control system requires another 2 seconds to establish a solution and present it to the operator. The launcher takes another second to slew onto the target and launch the missile. The missile, with an average velocity of 700 m/sec., requires 5 seconds to fly 3,500 meters. Total system reaction and flyout time is therefore 4+2+1+5=12 seconds. Under average conditions, therefore, there is a 50% chance that the missile system will never be able to launch, and an almost 100% certainty that if launched, the missile will lose lock before intercept (when the target re-masks). This is, of course, a very sterile example; in reality, many different systems with interlocking fields of fire would increase significantly the chances of a successful engagment. Still, the use of low-level terrain masking allows an aircraft like the A-10 to approach quite close to its targets without being observed or engaged, and then to escape destruction after its attack run.

As originally conceived (in the mid-1970s), the A-10's basic mission profile was derived from World War II "Cab Rank" close air support tactics as used by the RAF and USAAF in 1944-45. Flights of four aircraft would loiter at medium altitude (5,000-10,000 feet) just behind the front lines, until called upon by a Forward Air Controller (FAC) on the ground or in a spotter aircraft. They would then strike those targets using low-level strafing, bombing or rocket attacks. Using this type of mission profile, the A-10 would take off from a base perhaps 250 n.mi. behind the front, cruise to the battle area at high altitude (25,000 feet) to conserve fuel, then loiter for as long as 2 hours at medium altitude over or just behind the FEBA. The primary weapon would be the GAU-8, supplemented by up to 18 Mk.82 500-lb HE bombs, or a similar number of Mk.20 Rockeye cluster bombs.

By the time the Warthog entered service in the early 1980s, the forward area threat had become far more severe, necessitating a reevaluation of tactics. The current mission profile for a high-threat environment calls for takeoff some 250 n.mi behind the front, followed by a 25,000 foot cruise to an initial point approximately 40 n.mi. behind the front. At this point, the A-10 descends to a height of less than 250 feet (often less than 100 feet) above ground level for penetration of the forward area. Any loitering is done at this height, which reduces time on station to approximately 30 minutes. The A-10 then exits the battle area at very low level before climbing to 25,000 feet for the return to base. Flying for such extended periods at near-zero feet requires considerable agility, as provided through low wing loading and a reasonable thrust-to-weight ratio. This can only be achieved by reducing the payload to much less than the theoretical maximum. A typical loadout for this mission profile would be the GAU-8 with 1,174 rounds, and up to 6 AGM-65 Mavericks, plus an ALQ-119 jamming pod. Much more emphasis is placed on standoff weapons in order to avoid the lethal envelopes of air defense weapons systems like the Shilka, Tunguska, Gecko and Tor.

Attack Strategy Profiles

Cannon Attack Profile

In a typical strafing attack, the A-10 approaches the target obliquely at about 30 meters (100 feet) and 300 kts. At that height, the Warthog pilot cannot see the target, so its location must be provided by a FAC using smoke marker rockets, smoke rounds from artillery or mortars, or a laser designator keyed to the A-10's Pave Penny laser spot tracker. In reality, a "mark" is a real luxury, not often provided to A-10 operators. More commonly, a set of briefing coordinates and a lot of in-cockpit map reading determines the success of hitting the attack objective. Warthog pilots will fly to an identifiable point (a river bend or town) and then pop up (hopefully) to where the target was said to be. At roughly 4-6 km (2-3 n.mi) from the target, the pilot pops up briefly to a height of 150 meters (500 feet), acquires the target either visually (or by a target mark), rolls into a shallow dive, lines up, fires a 1-2 sec. burst, then rolls away from the target, diving back to 30 meters. He may then use terrain masking to approach the target from a different angle before repeating the pop-up attack. Because of the high threat environment of the FEBA, target designation—by a FAC aircraft, or by other assets such as an Army Fire Support Team Vehicle (FISTV), or helos such as the AH-64 Apache or OH-58D Kiowa Warrior—is often just a practice exercise. In most combat situations, target coordinates would be provided by artillery or tank fire, or from the initial mission briefing.

IIR Maverick Attack

The AGM-65D and -G use imaging infrared guidance. That is, the seeker in the nose of the missile provides a TV-like picture of the target, but based on the infrared (thermal) emissions from the target itself. The image is projected on the A-10's multi-functional display (MFD), allowing the pilot to select the target by placing the cursor over it. The missile seeker then locks onto the thermal signature of the target, and, when fired, homes autonomously to the kill. When using the IIR Maverick, the pilot flies an attack profile broadly similar to that used with the GAU-8, except at much greater standoff range, perhaps 8-10 km (4-5 n.mi.). As soon as the missile is launched, the pilot dives back to 30 meters, ducking behind whatever cover is available, then proceeding to the next target waypoint.

Laser-Guided Attacks

Because the USAF never provided the A-10A with its own laser designation capabilities, and it lacks the necessary speed for correct release, use of laser-guided weapons like the USN/USMC AGM-65E Maverick missile and Paveway-class bombs is not known to be a common payload. The AGM-65E Maverick would be a relatively expensive weapon to use against the primary target class (tanks) of the A-10A. The A-10 is capable of tracking laser energy from a variety of designators (land-based or otherwise) with its AAS-38 Pave Penny laser spot tracker, a sensor similar to the seeker on the AGM-65E and laser guided bombs. It detects coded laser emissions from a designator, and projects a target indicator symbol in the HUD to provide the pilot with the target location. Tactics are therefore sketchy, but delivery of LGBs is certainly within the mission capacity of the A-10A. Theoretically, A-10s flying at medium altitudes could loiter near a battle, and deliver LGBs on demand from a designating party. But due to the A-10's basic mission design and the low-level high-threat battlefield environment, other allied assets are much better suited to deliver laser-guided munitions.

Unguided Rocket Attack

Unguided 2.75” (70mm) FFAR rockets, carried in 7-and 19-round pods, are useful against soft vehicles, artillery positions, and exposed troops. The attack profile for rockets is similar to that for the GAU-8, with different ballistic characteristics fed into the attack system.

Free-Fall Weapons

In the high threat environment, use of free-fall bombs such as the Mk.82 LDGP bomb or Mk.20 Rockeye is fraught with extreme peril, because they require the aircraft to directly overfly the target, thus passing through the heart of the air defense envelope. If they are employed, either a low-level (laydown) or shallow dive attack profile is used. In the laydown, the aircraft approaches at 30 meters, pops up to perhaps 100 meters, acquires the target, and flies level right over it. In the shallow dive, the aircraft pops up, and then rolls in on the target in a 15-20 degree dive, releasing somewhat short of the target and breaking away. To ensure that the weapons are released at the proper moment, the A-10 attack system provides the pilot with a Continuously Computed Impact Point (CCIP) in the HUD. With LASTE, a Bomb Fall Line with its "death dot" at the bottom end of the line is displayed in the Bomb mode. The pilot then puts any part of that line on the target and flies the "death dot" to the Bomb Release Point. Once the dot is over the target, the pilot "pickles" the bomb release, and gravity takes over…

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Defensive Strategy Profiles

Tactics have also been developed specifically to defeat the ZSU-23, 2S6, SA-8 and SA-15. All tactics are based on the ability of the A-10 to avoid the lethal envelope of each weapon.

ZSU-23/2S6

To counter the ZSU-23 (and by extension the 2S6), the A-10 exploits the systems' reaction times and the "dead time" while the shells are in flight. Approaching at low level, it pops up to 170 meters (500 feet) at a range of 2 km, acquiring the target and lining up in roughly 1.5 seconds. It then fires a 1.5 second burst and breaks down and away to 30 meters (100 feet). The ZSU-23 has a reaction time of the roughly 4 seconds, starting from the time the A-10 unmasks during the pop-up. By the time the ZSU-23 opens fire, the A-10 has already completed its run and is beginning its break. By the time the ZSU's shells reach the predicted intercept point, the A-10 has already re-masked. Of course, it takes a lot of training to acquire, track, and shoot a very small target in 3 seconds or less. Against the more powerful 2S6, the pop-up range would have to be extended by as much as 1,000 meters.

SAMs

Tactics against the SA-8 and SA-15 also exploit system reaction time, as well as the considerably slower flyout time for guided missiles. Again, the A-10 approaches mased, pops up (height is dependent on whether the GAU-8 or Mavericks are being used), then dives back to the deck to re-mask. Again, the challenge is acquire, track and engage the target in the brief time window available.

JAWS (Joint Attack Weapons System) / JAATS (Joint Air Attack Team)

Another tactics used to defeat intense air defenses, originally called the Joint Attack Weapons System (JAWS), or the Joint Air Attack Team (JAATS) concept, involves coordination between A-10s and the Army's AH-64 Apache attack helicopters. Flying "Nap of the Earth" (NOE) (which is actually below the tree line), AH-64s are generally immune to air defenses at all but the shortest ranges. This allows them to stalk enemy armored formations, achieving ambush positions on the flanks of their advance. JAWS would exploit this capability by using the Apaches specifically as precursors to an A-10 attack. Their primary mission would be to identify and destroy all forward area air defense systems supporting the targeted enemy unit, using laser-homing AGM-114 Hellfire anti-tank missiles. Once the ZSU-23s and SA-8s were destroyed or suppressed, the A-10s would be free to make repeated attacks on the enemy armor, using Mavericks, Rockeyes, and of course, the GAU-8. After the A-10s are finished, the Apaches would move in to mop up the survivors. Attacks usually alternated between Warthogs and Helos, thus providing enemy defenses the impossible task of switching tactics every minute or so while trying to survive the attack, with each aircraft covered the repositioning of the other. In Red Flag exercises, JAATS has been absolutely devastating, but it still has never been used in combat, not even in Desert Storm (for lack of opportunity). The critical key to success here is absolutely perfect coordination between the Warthogs and the Apaches, which may have been difficult to achieve in the confused air over the NATO Central Front.

Counter-Air Tactics

In earlier wars, specialized tank killer aircraft (like the Ju-87G Stuka) were "easy meat" for enemy fighters, unless absolute air superiority could be assured. Thus there was considerable concern about the survivability of the relatively slow A-10 in contested air space. This fear has been greatly, if not completely alleviated by the results of Red Flag exercises, which have shown that the A-10, by virtue of its low-speed agility and inherent toughness, could potentially hold its own against aircraft of much greater raw performance.

In the first place, few high performance aircraft can even attempt to maneuver at the A-10's preferred height of 100 feet; thus any attempt to engage with either IR or radar-homing missiles must be made in a "shoot-down" mode into severe ground clutter. While a few of the most modern aircraft have true look-down/shoot down capability, most do not; and even with look-down/shoot down capability, the probability of kill is reduced by as much as half. The A-10 can reduce this even further through the use of radar jamming and the release of chaff and flares. Gun attacks would be equally problematic, because the enemy fighter would have to make its pass in a very shallow dive to avoid flying into the ground.

Assuming that an enemy fighter did come down on the deck to dogfight the A-10, it would soon find that it had bitten off more than it could handle. For shear instantaneous turning performance at low speed and low altitude, nothing can match the A-10 (in its first turn towards the enemy—that is, before it 'bleeds off' its energy). For example, at 300 kts, the A-10 has an instantaneous turn rate of 25 deg/sec, and a turn radius of only 1,200 feet. At 150 kts, the instantaneous turn rate is reduced to 15 deg/sec., but the turn radius is also reduced to a mere 900 feet. Because of its low air speed, the A-10 can sustain very high turn rates without incurring the high g-loads associated with higher airspeeds, while conversely, high performance fighters such as the F-16, with higher wing loading and aerodynamics optimized for higher speeds, cannot match the A-10A's turning performance without pulling much higher g-forces. <<see NOTE below>>

Tactically, this level of horizontal turning performance allows the A-10 to dodge air-to-air missiles and prevents enemy fighters from pulling sufficient lead for a guns attack. Conversely, the A-10 is able to put its nose on an attacking fighter very quickly indeed against any jet stupid enough to drop down to engage it. And while designed to punch holes in tank armor, the GAU-8 cannon could easily shred a thin-skinned fighter with one or two hits--a real deterrent to a persistent opponent. Since the mid-1980s, the A-10 has been wired to carry a twin AIM-9 Sidewinder launcher on one of the outboard pylons (the other usually carried an ECM pod), for primarily air-to-air attacks on enemy helos, and secondarily for counter-air defense. The all-aspect AIM-9L and -M models can engage targets approaching head on at ranges up to 10 n.mi. Thus, when bounced from the rear, an A-10 will typically break horizontally to force the (much faster) enemy fighter to overshoot. If the fighter is detected soon enough, the Warthog might even have a chance for a quick, head-on "lip shot". If that missed, the A-10 could continue turning inside the fighter, taking snapshots with the GAU-8 until the enemy is either destroyed, discouraged, or out of fuel. Even when a fighter jet disengages, the A-10 can quickly reverse its turn for a snap Sidewinder shot at the receding enemy fighter, in the few seconds while it was still in range. It would require several very well piloted fighters to kill one A-10, and Warthogs typically fly in mutually supporting pairs; for instance, even while on landing approach, a wingman flies cover.

NOTE: I am anticipating a number of responses to this topic; to begin with, I have nothing against Viper drivers, or anyone else of the fighter jet community. Honest! The figures quoted here represent the instantaneous turn rate of the A-10A in the first turn towards an attacking (Falcon) jet; the reality of such an event is quite remote. Although the A-10 may enjoy the privilege of a higher g-force loading at a given lower velocity, it would lose any energy advantage against its opponent after the first or second pass. The tactics described here are for illustration of the potential turning ability against an unprepared jet opponent in a principally guns-only engagement. Several experienced aviators and others with better language skills than I helped to review drafts of this section… any confusion or errors that remain are my responsibility. <E Pak>The Sukhoi Su-25: Comparative Assessment

The Sukhoi Su-25 (NATO Codename Frogfoot) is often identified as a direct counterpart of the A-10 Warthog. Indeed, the two share many of the same design criteria (both are slow, maneueverable, and heavily armored), and many have noted the superficial similarities between the Su-25 and the Northrop YA-9A, loser of the A-X competition. A more comprehensive analysis of the Su-25 will, however, reveal that it was designed quite a different mission than "tank busting"—which is the raison d'etre of the A-10A. First, a bit of background...

The Soviet Air Force during World War II developed a line of specialized close air support aircraft. Heavily armored, and armed with cannon, bombs, and unguided rockets, these Shturmoviki (specifically the Ilyushin Il-2 and Il-10) served as flying artillery in support of fast moving tank columns, and as fire brigades to seal off advances by German Panzer formations. The Il-10 Shturmovik served through the middle 1950s, and saw action in the Korean War. But the advent of Khrushchev's "Revolution in Military Affairs", and its emphasis on nuclear warfare, saw the demise of the Shturmovik in Soviet service.

By the early 1970s, Soviet doctrine had come to recognize the possibility of protracted conventional (non-nuclear) war in Central Europe, and renewed interest was given to the use of airpower in direct support of the ground forces. This was provided either by obsolescent fighters like the MiG-21 (NATO Codename Fishbed), specialized attack aircraft like the Su-7/-17 Fitter, or ground attack variants of front-line fighters like the MiG-27 Flogger. Only after the US initiated the A-X competition did the Soviet Air Force show real interest in a specialized, heavily armored attack aircraft--a "Bronyirovanni Shturmovik" (armored assaulter). The project was pushed forward by the Sukhoi design bureau, despite a relatively low priority. The T-8-1 prototype aircraft first flew in February 1975, and available pre-production aircraft were used in Afghanistan in 1979-80. Production aircraft were then manufactured at a low rate, and the first service squadrons were formed in 1984. These were formed into 3-squadron Otdelnyi Shturmovoi Aviatsionnaya Polki (OShAP), or Independent Storm Aviation Regiments. Several of these saw active service throughout the Afghan War, suffering several losses to US Stinger missiles in the hands of Mujahidin guerrillas.

Surprisingly, the Su-25 was acquired only by three of the Warsaw Pact nations—Bulgaria, Czechoslovakia and Hungary—none of which would be major players in the Central Front confrontation for which the aircraft was designed. It may be that Warsaw Pact air staffs had the same reservations about the survivability of a slow jet as their USAF counterparts. Export sales were also limited; few were picked up by Iraq and North Korea, but many were transferred to Afghanistan after the USSR withdrew from that country in 1989.

By all accounts, the Su-25 was a very successful design, faster than the A-10, highly maneuverable, and very rugged. Many were damaged in Afghanistan, but only a handful were actually shot down. Why, then, was this aircraft relegated to relative obscurity?

The answer may lie in the evolution of Soviet military doctrine regarding what the U.S. calls close air support (CAS); i.e., the use of aircraft to attack targets in direct contact with friendly ground forces. The turning point may have been the 1973 Yom Kippur War, in which the Israeli air force suffered heavy losses to battlefield air defenses while trying to repeat its 1967 performance as "flying artillery". After that war, the Israelis reconsidered their CAS philosophy, concluding that the pilot workload in the face of serious air defenses was simply too great to ensure survival. Instead, Israel began to place much more emphasis on the attack helicopter armed with anti-tank guided missiles. Helos, it was felt, could coordinate directly with the ground forces, and were inherently more effective and survivable by virtue of their ability to maneuver "nap of the earth" (NOE). Coming to similar conclusions were the West German Luftwaffe and the staff of the Soviet Air Force, both of which began to downplay fixed-wing CAS in favor of a rotary wing approach.

To this end, the Soviet Union transferred most light, medium and attack helicopters out of Frontevaya Aviatsiya (Frontal Aviation-FA) of the Soviet Air Force, and into Armeskaya Aviatsiaya (Army Aviation-AA) units controlled directly by ground force commanders. With this decision, much of the rationale for a Shturmovik seemed to disappear.

In USAF doctrine, tactical air-to-ground operations fall into three main battle area categories: CAS, performed within 1-5 km on either side of the Forward Edge of the Battle Area (FEBA); battlefield interdiction (BAI), attacks on tactical and operational targets such as enemy artillery and second echelon formations (from 5-50 km behind the FEBA); and deep interdiction, attacks on enemy logistic and transportation infrastructure, carried out more than 50 km behind the FEBA.

Soviet doctrine appears to have been somewhat different, in that there are four separate attack zones. CAS (in the US sense) is generally performed by helicopters. In between the CAS and the BAI zones was an intermediate zone in which the main targets are enemy battlefield forces not in direct contact with Soviet forces. Behind that are the traditional BAI and deep interdiction zones. While BAI and deep interdiction could be performed quite well by specialized high-speed strike aircraft such as the Su-24 Fencer and MiG-27 Flogger, and CAS was assigned to helicopters, the area between the CAS and BAI zones seemed to require a different sort of aircraft. In that region, air defenses would be as dense as in the forward area, and targets dispersed and difficult to spot. Aircraft operating in that zone would therefore have to loiter a relatively low speeds, be highly maneuverable (to avoid defenses and engage fleeting targets), and, obviously, be able to sustain considerable damage and return to base. In short, this was a mission ideally suited to the Su-25.

Su-25 Design Analysis

The main operational variant, Su-25 "Frogfoot-A", is a twin-engine, single-seat aircarft with an unswept, tapered, shoulder-mounted wing. The pilot sits in a heavily armored cockpit behind a bullet-proof windscreen. The clamshell canopy is faired into the spine of the slab-sided fuselage, limiting visibility to the rear (unlike the A-10, which has a bubble canopy for 360° vision). In contrast, the pilot's view forward is exceptional because of the downward-sloping nose profile (known in Russian as the "Utka", or duckbill. The same basic nose design is also used on the MiG-27 Flogger ground attack variant of the MiG-23 fighter. In the tip of the nose is an electro-optical sensor package that includes a low-light television, a laser spot tracker (like Pave Penny), and, in contrast to the A-10, a laser rangefinder / designator. Thus, unlike the A-10, the Su-25 has a modicum of night attack capability, is able to launch laser-guided weapons without external designation, and conversely, can also designate targets for other aircraft.

The engines, two 9,925-lb. st. thrust Turmanskiy R-195 turbojets, are buried in the wing roots, much like the Northrop YA-9A prototype. This configuration provides low drag, and makes for easy access and maintenance, but is more prone to foreign object damage (FOD) and presents a higher infrared (IR) target than the high-mounted engine pods of the A-10A. The choice of engine types in the two aircraft is in itself enlightening. The 9,065-lb st. thrust TF-34 of the A-10A is a high-bypass turbofan, selected for its fuel efficiency and cool efflux (to minimize vulnerability to IR-guided missiles). In contrast, the R-195 is low bypass ratio turbojet, generating more thrust, but at a cost of much higher fuel consumption and a hotter exhaust plume.

As in the A-10, most of the fuselage is occupied by fuel tanks and avionics compartments; other fuel tanks are located in the wings. In addition to the cockpit, the engine compartments and at least some of the fuselage fuel cells are armored. The degree of armor protection in general seems to be inferior to that of the A-10, but the threat against which the Su-25 was designed (20-35mm cannon) was less potent than the 23mm cannon of the Shilka.

As in the Northrop YA-9A—but in marked contrast to the A-10—the Su-25 has a conventional single-rudder tail. The twin rudder configuration of the A-10 was chosen to enhance survivability through redundancy, and also to mask the engines from IR missiles from the sides and below. With its low-mounted engines, this was not necessary in the Su-25. The overall effect, then, is a more streamlined design that emphasizes speed and power over endurance and survivability.

The defensive systems of the Su-25 are considerable, but not nearly as extensive as those of the A-10A. The standard radar warning receiver is the Sirena-3, which provides 360° detection of ground and airborne radars. A cockpit display shows bearing and approximate range based on signal strength, plus an identification of threat by type using simple warning lamps. As initially delivered, the Su-25 had only a small number of chaff/flare dispensers. As a result of Afghan war experience, two 128-cartridge dispensers were added to the upper surfaces of the air intakes (published reports indicate that the upward ejection of countermeasures improves the chances of seducing a missile away from the low-mounted engines). However, in the basic Su-25, the Sirena-3 is not linked to the countermeasures dispenser; the pilot must decide when and how many cartridges to pop on his own.

In addition to passive countermeasures, the Su-25 was designed from the start with two dedicated air-to-air missile pylons. Initially, these carried the IR-homing R-60 (AA-8 Aphid), a short-range missile roughly comparable to the second-generation AIM-9J/P Sidewinder. There is reason to believe that it is also capable of launching the newer R-73A (AA-11 Archer), a highly advanced IR missile considered superior in most respects to the latest AIM-9M Sidewinder. Thus the Su-25 has considerable ability to defend itself against enemy fighters, should these care to get into a dogfight.

Offensive Systems

The primary weapon of the A-10 is the GAU-8A Avenger 30mm cannon; the aircraft is in fact built around the gun. The Su-25 does indeed carry a twin-barrel 30mm gun with 250 rounds, built into the left side of the fuselage, but it has a much lower rate of fire and muzzle velocity than the GAU-8, and does not fire specialized armor-piercing ammunition like the PGU-14 API round. Thus the gun is more of a general purpose strafing weapon than a dedicated tank killer.

The principal weapons of Su-25 are carried on its eight underwing pylons, which have a total capacity of 9,700 lbs. (seldom carried operationally). Whereas the most common ordnance carried by the A-10 (AGM-65 Maverick missiles and Mk.20 Rockeye cluster bombs) are primarily oriented towards the anti-armor mission, the Su-25 generally carries a more general-purpose load. Most commonly carried stores include:

- FAB-100 220-lb general purpose bomb
- FAB-250 550-lb general purpose bomb
- ZAB-100 220-lb incendiary bomb
- ZAB-250 550-lb incendiary bomb
- RBK-180 & RBK-250 submunition dispensers (similar to the Mk.20 Rockeye)
- UV-16 and UV-32 57mm rocket pods
- S-24 240mm unguided rockets

The Su-25 is also cleared to carry the Kh-66 (AS-7 Kerry) air-to-surface missile, an command-guided weapon similar to the U.S. AGM-12 Bullpup; it is no longer in front-line service with the Russian air force, but may be used elsewhere. Note that none of these can be considered precision, standoff tank-killers in the same league as Maverick. Rather, they are general purpose weapons intended to deal with the broad range of materiel and personnel targets found in the area 5-50 km behind the FEBA.

Su-25 / A-10 Performance Comparison

The performance envelopes of the A-10 and the Su-25 differ substantially, a further reflection of their different design philosophies. The Su-25 is substantially lighter than the A-10, and has nearly 2,000 lbs more thrust, in addition to being aerodynamically "cleaner". No surprise, then, that the Su-25 is very much the faster, with a maximum speed (clean) of 527 kts. (606 mph), as compared to 397 kts (456 mph) for the A-10A. Clean speed, however, is a rather meaningless. Far more relevant are basic attack speeds: 372 kts (428 mph) for the Su-25, and about 300 kts (345 mph) for the A-10A. This indicates that the Su-25 is far closer in design to a conventional strike fighter than the A-10; the latter is far better optimized for the CAS mission as commonly defined in the West.

Though exact performance comparisons are not available, it is possible to say that the A-10, with a wing loading of only 99 lbs/sq ft vs. 107 lbs/sq ft (assisted by very large decelerons and a high-lift wing), has superior instantaneous turn performance. On the other hand, with its higher power loading (0.61 vs. 0.45), the Su-25 has better sustained turning performance, as well as much better rate of climb, and better overall performance in hot-and/or-high environments (like Afghanistan and Kuwait).

Variants

Though production of the Su-25 ended in 1989-90, further development of the type has continued. The first variant was the Su-25K (for Kommercheskiy), an export derivative generally similar to the basic Su-25, with certain Soviet systems deleted. The Su-25UB (Frogfoot-B) is a 2-seat operational trainer with full combat capability. It features a raised rear seat (displacing some fuel and/or avionics) under an enlarged canopy. To compensate for increased keel area forward, the vertical stabilizer has been greatly enlarged, but otherwise the airframe is similar to Frogfoot A; the Su-25UBK is the export version. The Su-25UT is an primary trainer lacking combat systems, but otherwise similar to the UB. The Su-25UB was navalized as the Su-25UTG, with a tail hook, to serve as a carrier-based trainer and possible attack aircraft for the Admiral Kuznetsev class full-deck carrier. Approximately 12 were produced, but at present it appears that the Kuznetsev air group will be limited to Su-27K Flanker multi-role fighters.

As a private venture, Sukhoi developed the Su-25T (for Tank), a dedicated anti-armor Shturmovik similar in concept and mission to the A-10A. Based on the Frogfoot-B airframe, the Su-25T replaces the rear seat with an enlarged dorsal spine for additional fuel and the avionics associated with the Shkval electro-optical sight system. Ordnance options have been expanded to include a number of modern tactical standoff missiles, including the TV-guided Kh-25ML (AS-10 Karen), laser-guided Kh-29L (AS-14 Kedge), and the anti-radiation Kh-58 (AS-11 Kilter) and Kh-31R (AS-17 Krypton), and KAB-500 laser guided bombs. However, the primary weapon appears to be the laser beam-riding AT-12 Vikhr anti-tank missile, of which upwards of 16 can be carried. According to US sources, these have an effective range of some 8km (probably more), and, like the AGM-114 Hellfire, can penetrate all known tank armor. Thus the Su-25 has an standoff anti-tank capability roughly comparable to the A-10A.

Because of its higher speed and inferior maneuverability, its tactics would probably require somewhat higher pop-up approaches, with concommitantly longer periods of exposure. This may be acceptable, however, because of the paucity of forward area air defenses in Western armies. The Su-25T would not have to face the redundant, interlocking, and mutually supportive layered system used by the Soviet Army. Its main threat would be the FIM-92 Stinger, a man-portable shoulder-fired IR missile with a maximum range of around 6 km, or similar missiles such as the French Mistral or British Javelin. Longer-range systems positioned further back, such as the German Roland, British Rapier, or French Crotale, lack the range to overwatch units in the forward area. In addition, with its E-O sight system, the Su-25T can acquire targets at much longer ranges than A-10s relying on visual acquisition. It can, therefore, exploit the longer ranges of missiles like the AS-14 (not to mention ARMs like the AS-11 and AS-17) to avoid or destroy longer-range air defense systems. Working in conjunction with the latest Russian attack helicopters (Mi-28 Havoc and Ka-50 Hokum), the Su-25T could become part of a Russian JAAT concept that at least in theory , can be as effective as the A-10A/AH-64 Apache combination.

As of 1995, the Su-25T has been offered for sale to several countries, but none have been exported to date. A limited production batch have been accepted by the Russian air force for evaluation purposes (and to underwrite the development of the aircraft).

A-10A Warthog and Su-25 Frogfoot-A

Comparative Specifications

	A-10A	Su-25A
Length (ft,in)	53'4"	50'11"
Span (ft,in)	57'6"	14' 1"
Height (ft,in)	14'8"	11' 9"
Wing Area (sq ft)	506	362.7
Wt, Empty (lbs)	24,200	20.95
Wt., Loaded (lbs)	38,136	32,190
Wt, Max TO (lbs)	50,000	38,800
Wing Loading (lbs/sq ft)	99	107
Engines (2x)	GE-TF34	R-195
Thrust, st. (lbs), each	9,065	9,920
Fuel, Internal (lbs)	10,725	(N/A)
Fuel, External (lbs)	7,800	(N/A)
Fuel, Max (lbs)	18,525	(N/A)
Pylons	11	10
Max Payload (lbs)	16,000	9,700
Speed, SL, Clean (kts)	397	527
Speed, Attack (kts)	300	372
Speed, Cruise (kts)	286	(N/A)
Init. climb (ft/min)	6,000	9,000 (approx)
Service Ceiling (ft)	33,400	23,000
Combat radius (n.mi):		
Lo-Lo-Lo	250	162
Hi-Lo-Hi	401	400
Ferry Range (n.mi)	2,450	(N/A)
Loiter time (min)		
@250 n.mi. radius	120	(N/A)

OA-10A: Forward Air Control Hogs

In the late 1980s, some 150 Warthogs were modified to OA-10A standard in order to replace the OA-37A Dragonfly and the OV-10 Bronco in the forward air control (FAC) mission. Only a minimal conversion was undertaken, limited mainly to installation of VHF and UHF radios to permit direct communications between the OA-10A and ground units. No attempt was made to fit any sort of night sensor or laser designator system—or even a high-frequency shortwave radio—which places serious limits on the effectiveness of the Warthog in the FAC role.

The job of the forward air controller is to spot, identify, and mark targets for close air support aircraft. In Vietnam, this mission was generally undertaken by the Cessna O-2 Skymaster, a militarized light civil aircraft, and the OV-10 Bronco. These had little chance of survival over North Vietnam, so the "Fast FAC" was conceived: a 2-seat jet fighter (usually an F-100F Super Sabre) equipped with smoke rockets and sometimes a hand-held laser designator known as Pave Nail. "Nail" has remained a standard FAC call sign ever since. In the 1970s, these were replaced by conversions of the A-37B Dragonfly (itself a modified Cessna T-37 "Tweet" jet trainer), but by the 1980s these were themselves not considered survivable against the modern air defense threat, so the USAF turned to the rugged A-10A.

The easiest way to locate enemy ground forces is to fly in their vicinity and draw their fire. Thus OA-10s fly in pairs, with one acting as bait while the other watches for enemy fire, as was done in some of "armed reconaissance" patrols during Desert Storm.

Armament is generally limited to 7- and 19-round rocket pods armed with 2.75” marker rockets. These have white phosphorus (WP) warheads that form a thick white cloud when detonated (they are also very effective incendiary devices in their own right). The A-10’s maneuverability enables it to roll in quickly against any target that reveals itself, and then evade return fire at low altitude. Even with the A-10’s survivability features, this is a very dangerous mission that would only be used when most of the enemy’s air defenses have already been beaten down, or in a dire emergency (an enemy breakthrough, or friendly units being overrun).

The lack of a laser designator is a serious handicap, because OA-10s cannot illuminate targets for other A-10s (or for Marine Corp F/A-18s with AGM-65Es). Given current budget constraints and the US Air Force's committment to more exotic aircraft, it is a fundamental weakness that doubtfully will ever be rectified.

A-10: Basic Specifications

		(Northrop YA-9 prototype) for comparison
Wingspan	57' 6"	(58')
Overall Length	53' 4"	(53' 6")
Overall Height	14' 8"	(16' 11")
Wing Area	506 sq ft	(580 sq ft)
Empty Weight	21,541 lbs	(26,000 lbs)
MaximumTakeoff Weight (MTOW)	50,000 lbs	(42,000 lbs)
Maximum Speed	439 mph	(449 mph)
Maximum Ordnance	16,000 lbs	(16,000 lbs)
Internal Fuel	10,700 lbs	(N/A)
Maximum Ordnance w/full internal fuel	14,341 lbs	(N/A)
Forward Staging Area (Combat) Weight	32,771 lbs	(N/A)

Takeoff Distances: 4,000 ft @ MTOW
1,450 ft @ Combat Weight
Landing Distances: 2,000 ft @ MTOW
1,300 ft at Combat Weight
Ferry Range: 2,134 n.mi. (with 2 ferry tanks, no in-air refueling)

Original Mission Specifications & Design

•Battlefield Air Support Mission Characteristics (Standard Day)
252 mi cruise @ 5,000 ft to Initial Point (IP);
40 mi ingress/egress to target;
30 min. Combat Time over Target (ToT);
20 min. landing fuel reserve loiter.
Full Internal Fuel: 10,700 lbs
Ordnance Loading: 6 Mavericks, 1 ALQ-119 ECM pod, Full Ammo, 480 M-206 Flares/Chaff, Full gun ammo (variable on projectile mix)
Takeoff Gross Wt: 42,071 lbs
Combat Gross Wt: 34,400 lbs (assume 50% ammo, weapons, combat fuel load)
Maximum Speed: 368 knots
Sustained g-load @ 300 knots - 3.4
Instantaneous g-load @ 300 knots - 6.5

•Close Air Support Design Mission Characteristics (Tropical Day)
Ingress Cruise @ 25,000 ft, 296 knots;
Weapons Delivery 10 mins, 300 knots;
Single Engine ToT Loiter @ 5,000 ft, 174 knots;
Egress Cruise @ 35,000 ft, 286 knots;
20 min landing fuel reserve loiter.
Full Internal Fuel: 10,700 lbs
Ordnance Loading: 18 MK-82 LDGP bombs, Max. load Combat Ammo mix
Takeoff Gross Wt: 46,196 lbs

•Ferry Mission: 50 knot headwinds (Tropical Day)
Initial climb to 25,000 ft @ 304 knots;
Climb to 30,000 ft @ 289 knots;
Cruise to 35,000 ft @ 286 knots;
20 min. landing approach and fuel reserve loiter.
Full Internal Fuel: 10,700 lbs
External Fuel: (3) 600-gal ferry tanks

Takeoff Gross Wt: 48,728 lbs
Maximum Distance: 2,240 mi
A-10A Loading and Performance-Typical Missions

	CAS	Recon	Escort	Ferry
Takeoff Weight (lbs.)	45,071	45,071	40,269	46,786(*)
Fuel (lbs)	10,650	10,650	10,650	22,350
Bombs (lbs)	9,540	9,540	4,240(4x)	none
Ammunition (lbs)	1,170	1,170	2,105	none
Wng Loading (lbs/ft2)	89.1	89.1	79.6	92.5
Vstall, Power Off (kt)	103.8	103.8	98.1	105.7
Takeoff Run, SL (ft)	1,905	1,905	1,480	2,075
Run to Clear 50' (ft)	2,760	2,760	2,120	3,025
Rate of Climb (fpm)	3,290	3,290	3,975	3,160
RO Climb, 1 eng (fpm)	1,115	1,115	1,520	1,055
Time to 10,000 ft (min)	<N/A>	<N/A>	2.9	<N/A>
Time to 15,000 ft (min)	<N/A>	5.9	<N/A>	<N/A>
Time to 25,000 ft (min)	14.0	<N/A>	<N/A>	14.6
Service Ceiling (ft)	30,500	30,500	34,400	29,900
Service Ceiling (1 eng)	14,500	14,500	19,100	14,000

	CAS	Recon	Escort	Ferry
Combat Range (N.mi)	<N/A>	<N/A>	<N/A>	3048
Avg. Speed (kts)	<N/A>	<N/A>	<N/A>	296
Init. Altitude (ft)	<N/A>	<N/A>	<N/A>	25,000
Final Altitude (ft.)	<N/A>	<N/A>	<N/A>	35,000
Tot. Mission Time (hr)	<N/A>	<N/A>	<N/A>	10.3
Combat radius (n.mi)	250	401	243	<N/A>
Avg. Speed (kts)	286	217	173	<N/A>
Init. Altitude (ft)	25,000	15,000	10,000	<N/A>
Final Altitude (ft)	35,000	35,000	25,000	<N/A>
Tot. Mission Time (hr)	3.9	3.8	3.9	<N/A>
Loiter Time (min)	116	<N/A>	60	<N/A>

(*) weight with 3 x 600 gal ferry drop tanks. This appears to be more of a theoretical configuration, given the high drag penalty during flight. Operationally, 2 x 600 gal ferry drop tanks are more common.Typical Desert Storm Ordnance Configurations

Close Air Support/RESCAP
- 2 x AGM-65 Maverick
- 4 x Mk.82 LDGP or
- 4 x Mk.20 Rockeye
- 2 x AIM-9L
- 1 x ALQ-119 ECM Pod

Scud Hunt
- 2 x AGM-65 Maverick
- 4 x GBU-12 500-lb LGBs <<see NOTE below>> or
- 4 x Mk.20 Rockeye
- 2 x AIM-9L
- 1 x ALQ-119

Night Attack
- 2 x AGM-65G IIR Maverick
- 4 x GBU-12
- 2 x Flare dispensers
- 2 x AIM-9L
- 1 x ALQ-119

Forward Air Control (FAC)
- 2 x Mk.82 LDGP or
- 2 x Mk.20 Rockeye
- 2-4 LAU-3 7-round rocket pods w/WP smoke rockets
- 2 x AIM-9

1 x ALQ-119

NOTE: a careful reading of the use of the GBU-12 LGB on Desert Storm A-10s indicates that "someone" was able to provide laser target designation for accurate delivery of this munition. Official USAF records substantiate the use of a small quantity of the laser-guided GBU-12 by the A-10 during the Allied operations in the Persian Gulf. Public domain information is NOT available as to the details of its use by any A-10A squadron or any target designation provider.

Current A-10 Squadron Roster (circa January 1995)

•Air Combat Command (ACC)
20th FW Shaw AFB SC
  55th FS OA-10A
23rd Wing Pope AFB FL
  75th FS A/OA-10A
355th FW Davis Montham AFB AZ
  333rd FS OA-10A
  354th FS OA-10A (McChord AFB, WA)
  357th FS A-10A
  358th FS A-10A

•Pacific Air Forces (PACAF)
51st Wing Osan AB Korea
  25th FS OA-10A
354th FW Eielson AFB AK
  355th FS OA-10A

•US Air Forces in Europe (USAFE)
52nd FW Spangdahlem AB Germany
  81st FS A/OA-10A

•Air Force Reserves (AFRES)
442nd FW Whiteman AFB MO
  303rd FS A-10A
917th Wing Barksdale AFB LA
  47th FS A/OA-10A
434th Wing Grissom AFB IN
  45th FS A/OA-10A

•Air National Guard (ANG)
  CT ANG - 118th FS A-10A
  MA ANG - 131th FS A-10A
  MD ANG - 104th FS A/OA-10A
  MI ANG - 172nd FS A/OA-10A
  PA ANG - 103rd FS OA-10A

Total Air Force Inventory as of 1/1/95
  A-10A: 251
  OA-10A: 133

Corrections/Comments?

It is possible that we, or most accurately I, have misrepresented some technical information regarding the A-10 itself, or its many operational munition types. If there is a specific correction or addition you would like to notify me of, please do so in the following fashion:

•email AFC Spad@aol.com directly to inform the primary author of your comment or correction. I will then provide you with a mailing address to send:
  -a copy of the source you are using;
  -the information that is incorrect;
  -your name, mailing address, and any email address you prefer.
All attempts will be made to verify your correction and to include it in any future revision of this document.

•any comments (good/bad) can also be directed to AFC Spad@aol.com, who will share them with the rest of the group (see next chapter). Be kind or else be brief <grin>.

Missing Info...

•Call signs of Lt. Colonel Jeff Watterberg and Captain Ronald Truesdale.
•Names, Squadrons, and dates of death and location for any other A-10 pilots not listed.
•current operational stores as of Spring 1995 (or more current) for the A-10.
•operational details/anecdotes of A-10 performance and cockpit avionics, although this may not exist in the public domain. Discretion is assured otherwise...

Legal Stuff (Whew)

Who Wrote This Stuff?

We did! Although I take primary responsibility/blame for setting this document in the form that you see, and for writing most of it, this FAQ is the collective work of a group of aviation fans who thoroughly enjoy and respect the capabilities of the A-10A.

We are listed (hopefully) alphabetically by email address, with our respective backgrounds...

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•tv toon@aol.com - Tyler Gee. Former USAF instructor Pilot, 2600 hours multi-engine jet time. Now flying simple puddle jumpers (Cessnas).

Sources of Information

A number of public domain resources were consulted in the preparation of this document (listed alphabetically by author):

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•A good source of many of these books is Zenith Books, an imprint of Motorbooks International in Osceola, Wisconsin. Zenith Books covers most civilian aviation and military topic areas and periods. Nice stuff. They can be reached at: 800/826-6600.

•Another valuable resource is the US Naval Institute, and its book division, Naval Institute Press, which publishes a number of noteworthy titles related to aviation and particularly, US naval history. Based in Annapolis, Maryland, the Institute also publishes two separate journals that are great sources for naval warfare topics. A very nice organization to join, or at least to find out more about, since members get discount pricing on book purchases. They can be reached at: 800/233-8764.

•The World Air Power Journal is a very polished softcover publication that deals with a specific aircraft in each quarterly issue. Each issue also highlights current world aviation news and reports on a number of interesting airbases and aircraft histories. Quality four-color printing throughout. Both back issues and current subscription inquiries can be answered at: 800/359-3003.

•Time-Life Books in Richmond, Virginia publishes the "Wings of War" series, which reprints the original editions of a number of autobiographies and personal accounts of combat pilots (of all countries) from WWI onward. Although the series appears heavily weighted to WWI memoirs, volumes such as Richard Drury's "My Secret War" Vietnam experience would not otherwise be available. For subscription inquiries, call: 800/621-7026.