Introduction

The cannon fighter gained the interest of Mr. Mel Buck of the USAF Flight Dynamics Laboratory. In 1997 a technology evaluation contract[i] was awarded to Advance Concepts Section of the Advanced Engineering Department, with the writer as Study Manager. Because of the writer's re-assignment to the low-observable team in a remote site, the Cannon Fighter project was never completed as intended. Some of the information provided in this report is based on "Work-in-Progress" results that have never been published.

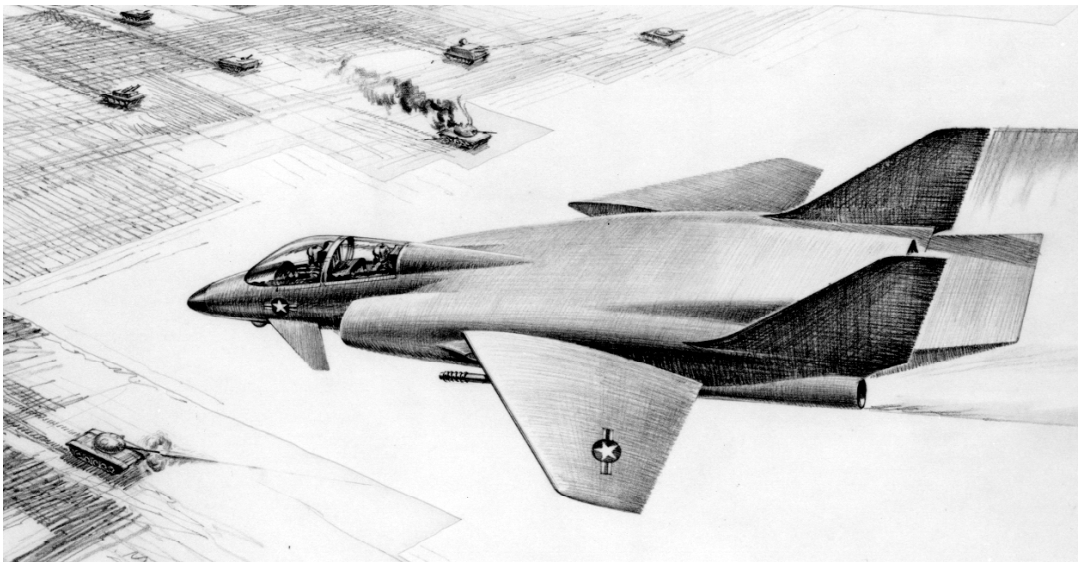

FIGURE 1, OAS Cannon Fighter for USAFFDL circa 1977.

Figure 1 shows the configuration that emerged from that study. It carried two General Electric, Armament Division 105 mm recoilless cannons with 56 Texas Instruments 105 mm guided tank projectiles. The aircraft configuration was the McDonnell Aircraft developed from the Vectored Lift Fighter concept and as depicted, the fuselage could be independently aimed in elevation and azimuth while the vectored wings maintained the flight path angle. The targeting was based on advanced sensors and the integrated flight and fire control concept that always maintained the target spatial location in the fire control system and provided the pilot with targeting information on his helmet sight based on the aircraft current location and the stored target location. In Red Flag and Maple Flag exercises, returning to re-acquire a passed target was not successful without such an aid. Projectiles were capable of servicing either surface or airborne targets.

Mr. Richard D. English on the Operations Analysis group in Advanced Design developed a Monte Carlo approach to address the targeting and attacking of large arrays of targets. This was used to evaluate the Cannon Fighter against a conventional F-15 using AGM-65 Maverick missiles and 20mm cannon. In another comparison, the Cannon Fighter was compared to the A-10 in a tank attack role with TGM munitions and the GAU-8. The advantage of the Cannon Fighter was that it did not attack the tank under direct visual attack.

The advantage of the cannon system is that the disposable load is much less than the disposable missile payload. There is a significant advantage in disposable armament weight for the gun launched projectile over rocket-powered missiles, in the number of weapons and warhead selections carried. The next two figures will illustrate that and quantify that in terms of current and study missile systems and the OAS General Electric gun system.

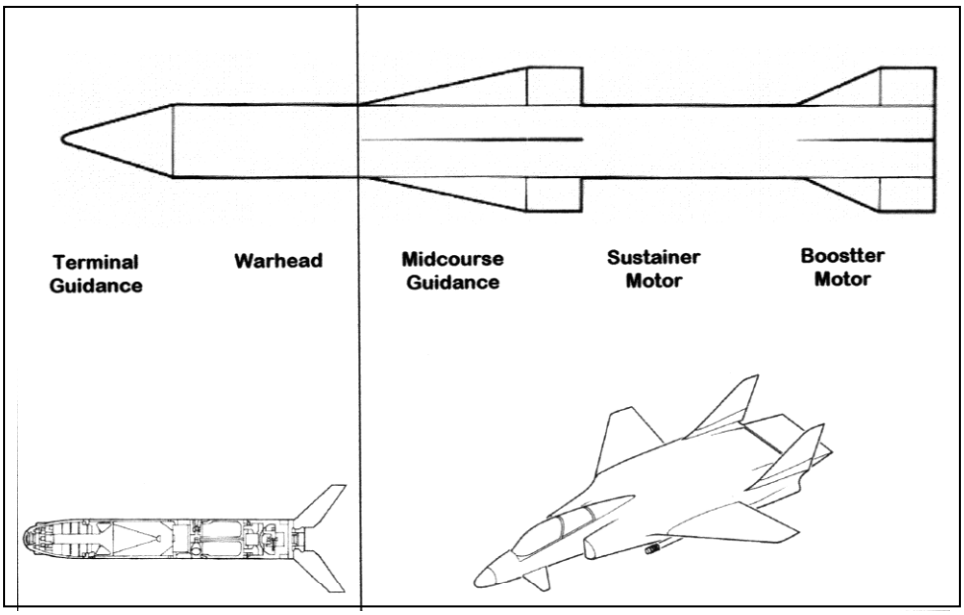

FIGURE 2 Airborne Cannon Carries Less Disposable Hardware and Payload and Lessens the Logistic Chain

System	Diameter	Velocity	P/B**	Total Weight
Mod AIM-7 Folding fin	8.0 inch	3,050 ft/sec	0.55	438 lbs
Mod AIM-7 Dual Pulse	8.00	3,038	0.61	380
AMRAAM	7.00	3,100	0.61	335
GE gun Liquid.	4.134	3,302*	0.75	62.0
GE gun Solid-Cased	4.134	3,302*	0.75	75.0
Study Gun	3.00	3,302*	0.65	36.8

* With 700 ft/sec (415 knots) flight speed
** Propellant to launched projectile weight ratio

FIGURE 3 The gun disposable weight is at least 5 times less than AIM missiles

The next figure shows the attack scenario for the Cannon Fighter. In the original study the target location hardware and displays was located in the fighter. In today's combat situation an observation aircraft such as AWACS, Joint Stars, Joint Rivet or ground observer can provide

targeting information to the pilot in terms of GPS coordinates and the motion vector. In this case the IFFC system would work out firing solutions for the targets within range and determine the appropriate attack flight path. The aiming and firing of the cannon is automatic with the pilot concentrating on flight path and threats.

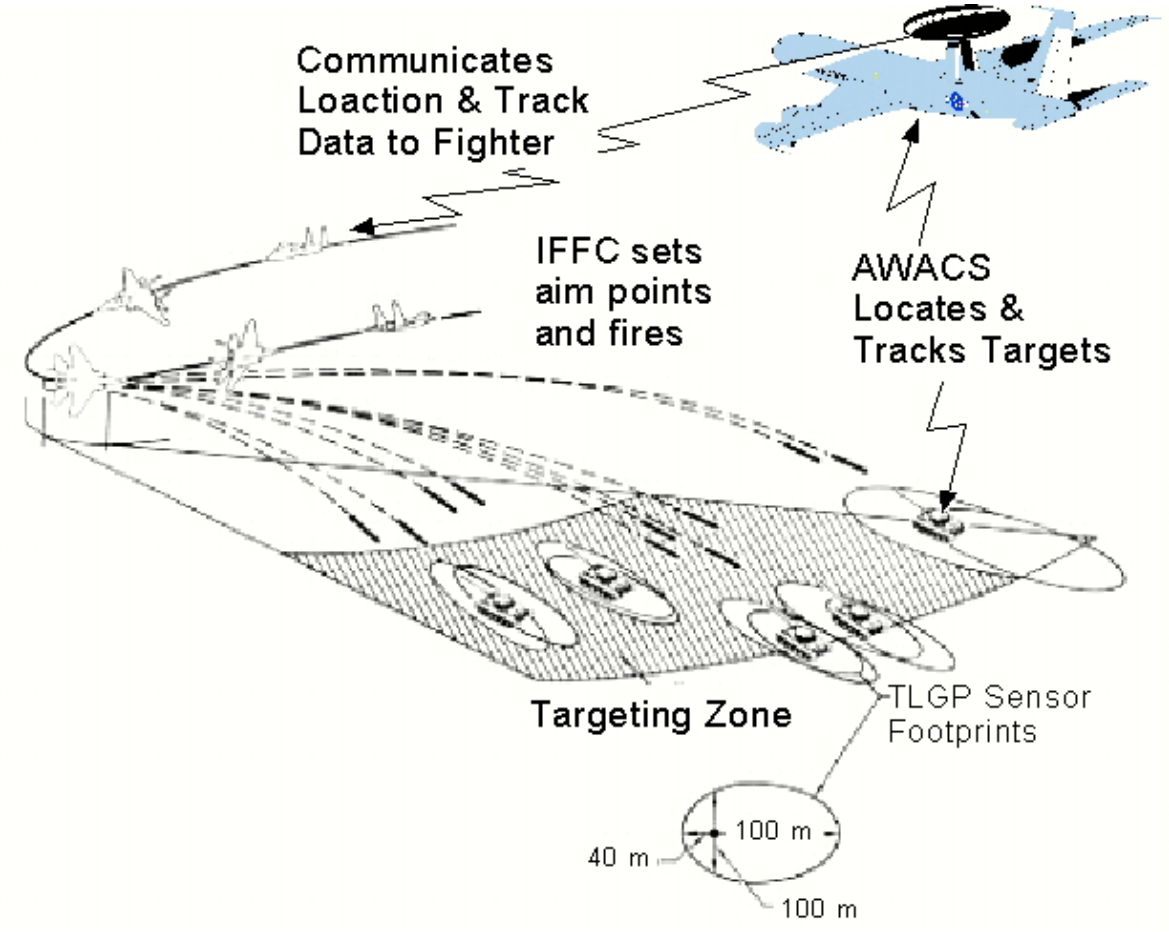

FIGURE 4 Cannon Fighter Attack Scenario

Using a Monte Carlo approach there are times some of the destroyed targets are hit more than once, some projectiles do not function, sometimes there is no target in the filed of fire, even with these statistical variations, the Cannon Fighter is very effective. About six targets are attacked per sortie, and about one-half destroyed. In World War II, the best armor killers were the British Tempests/Typhoons with one vehicle kill every 20 sorties! The next figure summarizes the Monte Carlo attack results using the F-15 and Maverick missiles. This work was done is conjunction with the OAS study, but not included in the final report. It is for a series of Monte Carlo runs for 200 available aircraft attacking an advancing army of 25,000 targets (3,600 are tactical targets), re-supplied daily, over a 10-day period. Forces attrition was made up from the number of 200 aircraft held in reserve. The first set or results is for the *OAS II* aircraft armed with two GE 105 mm recoilless cannon versus an F-15 with Mavericks.

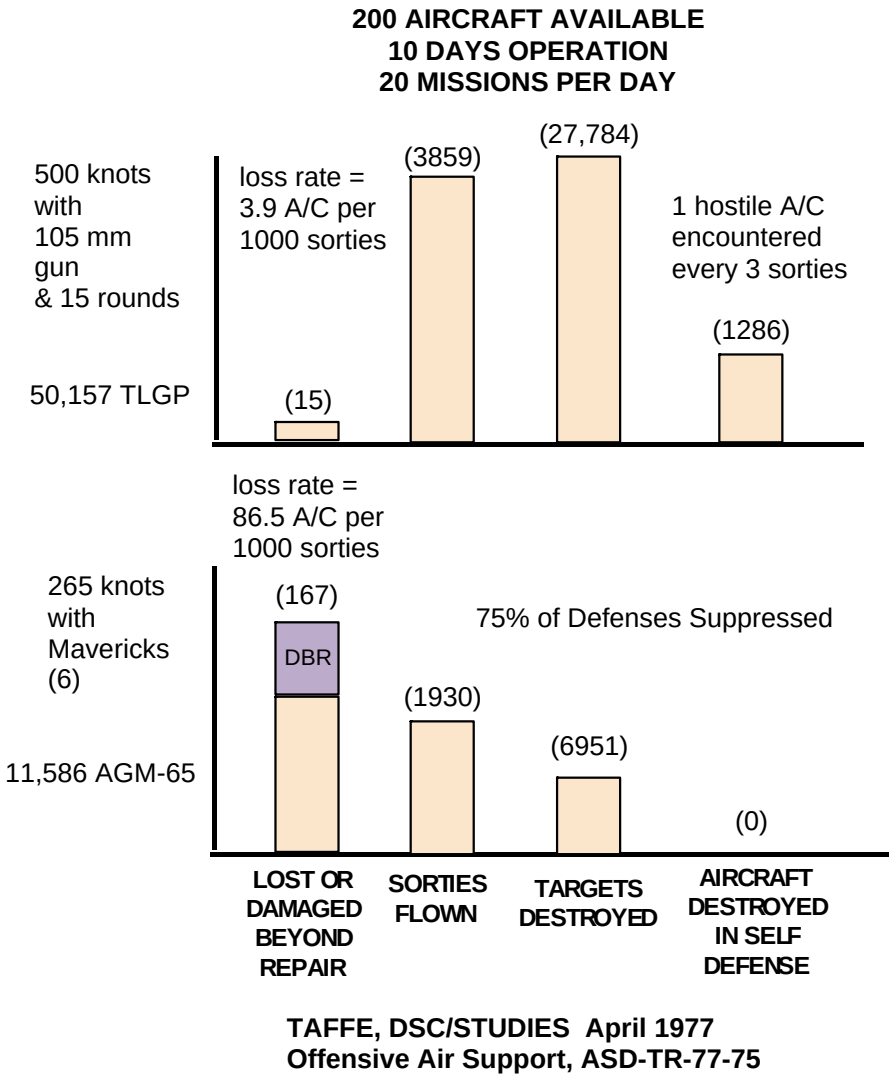

FIGURE 5 Monte Carlo Results Summary Shows Advantage Recoilless

In both cases the enemy defenses have been suppressed by 75%. The loss rate for the F-15 averaged 86.5 aircraft per 1000 sorties. The largest reported losses in SEA were 20 to 30 aircraft per 1000 sorties. The loss rate for the *OAS II* Cannon Fighter was 3.9 per 1000 sorties. These aircraft encountered a hostile aircraft or helicopter on the average of once every three missions, even with the defenses suppressed. Because it had the capability of self-defense without changing its attack pattern (using anti-aircraft rounds carried in the magazine), the Cannon Fighter generated a significant number of hostile aircraft kills. Even though the number of Tube launched Guided Projectiles (TLGP) is large, so are the targets destroyed. In terms of 1977 US dollars, the estimated cost of munitions, replaced aircraft and fuel was $262,000 per target for the F-15 with AGM-65's and $25,200 for the Cannon Fighter.

In a second comparison an A-10 armed with TDM's (Tactical Dispenser Munitions) and the GAU-8 was compared to a smaller fighter armed with a single 105 mm recoilless cannon, *OAS*

I (see Figure 6). For the A-10 the majority of the kills were with the AGM-65 not the GAU-8, as shown in the following tables. In this case there were 3 missions of 18 aircraft per day (54 sorties) targeting 350 targets in the attack zone on each mission.

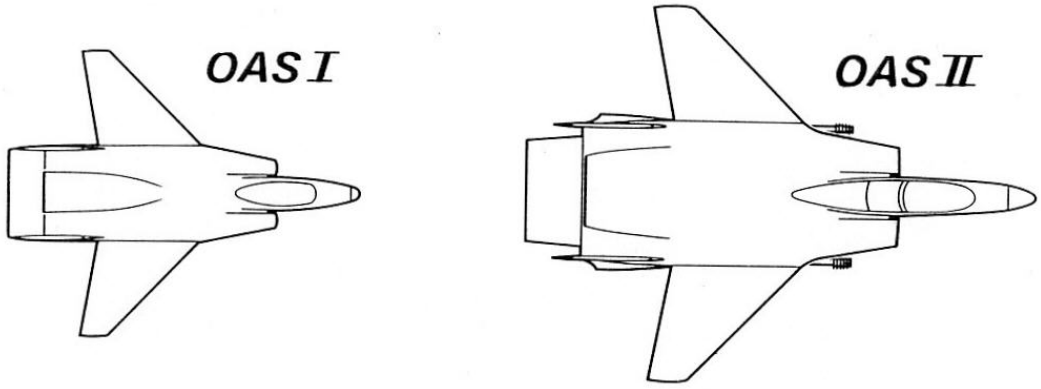

Figure 6 *OAS I* and OAS *II* Cannon Fighters

*Burst = 135-30 mm rounds	A-10 Class	*OAS I* Class
Weight of Resources per Target Destroyed		
Fuel ……(lb).	5,160	466
Ordnance ……(lb)	9,020	187
Total ...……(lb)	14,180	653
# Weapons/Bursts* per Target Destroyed ….	15.9	3.06
Resources to Destroy 100 Targets		
Fuel ……(lb)	516,200	46,600
Ordnance ……(lb)	902,300	18,700
# Friendly Aircraft Lost …….…….	26	1
# Friendly Aircraft Damaged …….….	53	2
# Bursts*/Weapons ……..	1,590	306

Figure 7 Relative Combat Effectiveness of Spent Resources

The relative effectiveness of the cannon fighter compared with the conventional armor attack aircraft shows clearly the advantages of precise aiming, long range, and a guided, maneuverable projectile. So the combination of more kills and fewer losses gives the Cannon Fighter over a 20:1 advantage! The operational advantage of the Cannon Fighter is that the resources required to achieve a given number of kills are less than for any other system

The net result in terms of cost is summarized in Figure 8. The cost of a conventional direct attack kill in a defended zone is significant, and driven by the cost of lost and damaged beyond repair aircraft. If the losses for the A-10 in direct attack would have been as low as for the indirect attack Canon Fighter, the cost per kill would have been $320,900 not $2,7300,000. A ratio to the Canon Fighter of 2.4 not 20.3! In this analysis now of the aircraft had any low observable treatments. In Appendix F a comparison is made for a specific reduction in radar

cross section, based on an assessment of the reduction possible for an operational USAF fighter, against the same target array.

*Burst = 135-30 mm rounds	A-10 Class	*OAS I* Class
Resource Weight per Target Destroyed ….(lb)	14,800	653
# Burst*/Weapons per Target Destroyed ..…	15.9	3.06
Cost per Target Destroyed (1977 Dollars)		
Weapons ……($)	200,700	28,700
Fuel ……($)	15,500	1,400
Destroyed Aircraft ……($)	1,508,800	71,400
Damaged Aircraft ……..($)	1,005,900	33,300
TOTAL ……($)	2,730,900	134,800

Figure 8 Relative Cost Effectiveness of Spent Resources

The specifics for each aircraft are given in Figure 9..The key to reducing friendly losses is the increased targets killed per sortie, reducing the exposure to hostile defenses for a given number of targets. The total weight of resources is 964,575 pounds for 68 targets or 14,185 pounds per target destroyed. For *OAS I* the total weight of resources is 287,750 pounds for 441 targets or 653 pounds per target destroyed.

*Burst = 135-30 mm rounds	A-10 Class	*OAS I* Class
# Targets Destroyed ……	68	441
# Friendly Aircraft Destroyed …… ……	18	5
# Friendly Aircraft Damaged ……..……	36	7
# Targets Destroyed per Sortie ……	1.26	8.17
# of TMD with ACM ……...…	540	
.Weight of TMD ……(lb)	486,000	
# 30 mm GAU-8 Gun Bursts* ……..……	540	
Weight of 30 mm Rounds ……..…..(lb)	127,575	
# TLGP Fired ……..		1,350
Weight of TLGP Fired ……....(lb)		47,250
Weight of OTTO Fuel … ……....(lb)		35,100
Weight of Fuel ……(lb)	351,000	205,400

Figure 9 Resource Utilization to Accomplish Mission (54 Sorties)

Figure 10 graphically points out the supply chain for conventional armed systems. As effective as they are, they demand a prodigious supply chain and supply effort. The gun ammunition is not the greatest supply effort but the TDM's (Tactical Dispenser Munitions) are as these provided a majority of the vehicle kills. In Figure 5 there is a 5 to 1 kill ratio for the Cannon Fighter over a conventional aircraft armed with AGM-65's and a 1 to 8 loss rate advantage. In this example in absolute terms, not rate, there is a 1 to 4.5 loss advantage and a 6.5 to 1 kill advantage.

An important characteristic of the Cannon Fighter is that it need not disengage the attack mission to service attacking hostile aircraft. As Figure 11 shows it is capable of addressing

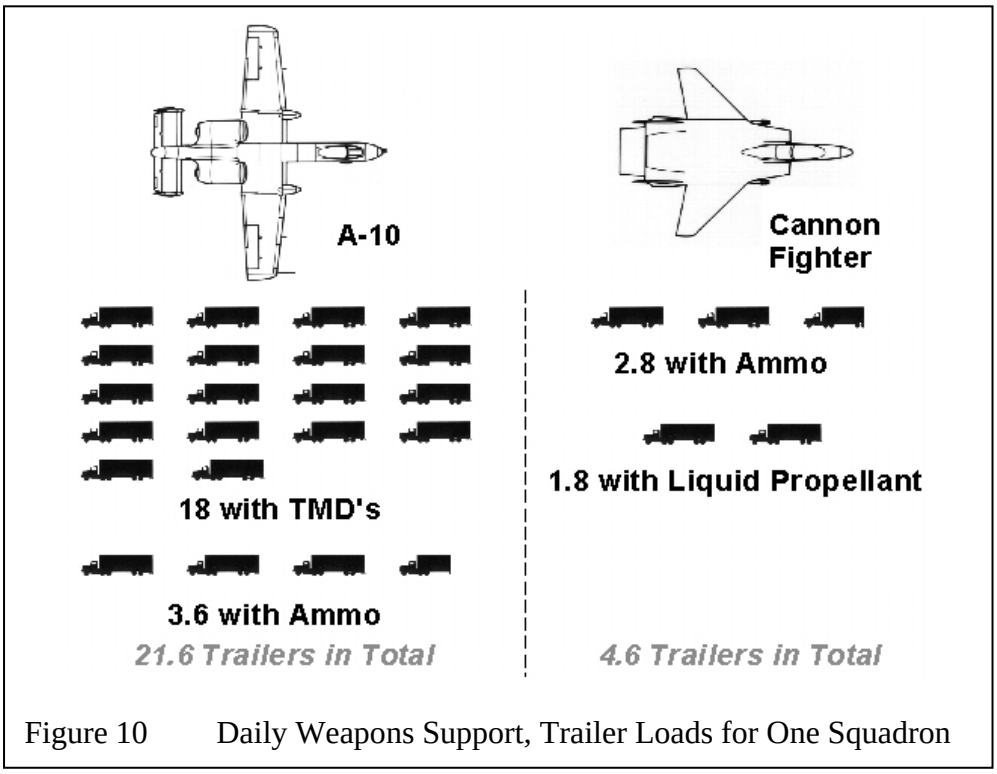

Figure 10 Daily Weapons Support, Trailer Loads for One Squadron

either an attacking missile or aircraft without diverting its mission or dropping its surface attack armaments. In fact the concept was that the cannon fighter would not attack a benign hostile aircraft.

The cannon can service airborne threats, either aircraft, aircraft intercept missiles, or surface to air missiles with a guided flechette round. The key capabilities are a target acquisition system that tracks incoming missiles and the General Electric remote setting fuse that times the flechette spread and impact time. Advanced seekers can detect and track any of these threats, and since the attacking threat is flying a predicable intercept course (usually proportional navigation) the intercept point can be well predicted based on both flight paths. With the current advanced digital aircraft, engine, flight, fire and weapon control a mechanism for lethal engagements against high speed missiles is available with the cannon. In 1977 the concept included a flechette round that included General Electric remote set fuse concept to disperse the flechettes at the proper time. Figure 11 presents such an engagement.

As in the key battles of the Hundred Years War, Crecy, Poiters & Agincourt, the British Yeoman armed with long bows and unmanned, aimed missiles were more lethal in indirect attack than the French knights direct close-in combat. So one-on-one close in combat is not the determining factor. Even if close in air combat does not result in a lost friendly aircraft, it can mean aborting the attack mission, and that means the enemy was successful. The determining factor is the ability to service intercept aircraft and anti-air missiles, whether airborne or surfaced launch, without mission interruption. That was the focus of the Cannon Fighter.

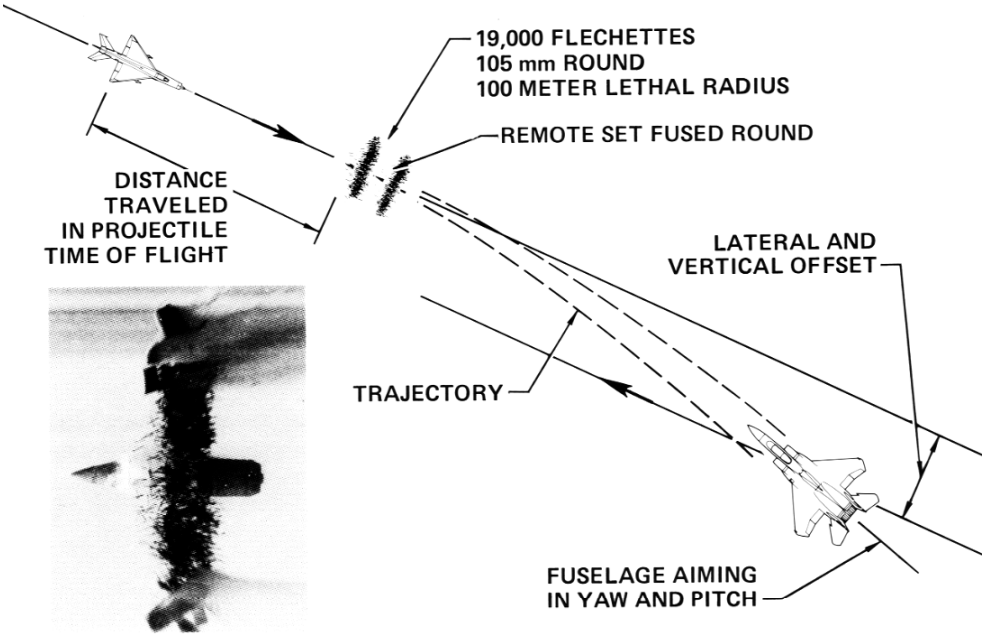

Figure 11 Cannon Fighter Can Provide Air-to-Air Superiority

[i] McDonnell Aircraft Company,, "Technology for Offensive Air Support, European Scenarios and Threat for Offensive Air Support," ASD-TR-77-35, December 1977.