2006 - 2007 AIAA Graduate Team Aircraft Design Competition –Modified RFP

SUPER CAS

BACKGROUND

The A/OA-10 is a Close Air Support (CAS) and battlefield interdiction aircraft. Originally designed to satisfy an anti-tank role on an anticipated Western European battlefront against Warsaw Pact forces, the A-10 has continued to remain an essential military asset as proven in Operation Desert Storm, Operation Enduring Freedom and throughout the ongoing War on Terror. Although a variety of studies have been undertaken to consider successors to the A-10, including GPU-5/A 30mm gun pod equipped F-16s, the A-10 remains in service today due to its unique ability to serve as a heavily armored, highly maneuverable, low-level attack aircraft with significant warload.

Recent USAF plans have most of the A/OA-10 Thunderbolt II remaining in the USAF circa FY 2015, provided the existing aircraft receive a Service Life Extension to approximately 16,000 hours total time per airframe. After 2015, however, the USAF may require a dedicated, next generation aircraft to replace the 2005 Total Active Inventory of 356 A-10s in USAF service, especially if the JSF slips IOC and JSF costs continue to escalate. Although the F/A-35 JSF was originally anticipated to serve as a suitable A-10 successor, Some USAF leaders have recognized that the JSF will lack the armor, firepower, low level performance, simplicity and reliability necessary to adequately replace the A-10 in a wide variety of Close Air Support and attack missions. This RFP focuses upon the conceptual design of a dedicated A-10 successor/CAS JSF alternative for 2015 and beyond designated SUPER CAS.

Intended to replace the A-10, SUPER CAS is also perceived as a platform which not only satisfies the A-10 mission, but will bridge current F-16 and potentially F/A-18 attack capabilities. The SUPER CAS aircraft is to be a manned military air vehicle of fixed wing or powered lift type.

SUPER CAS is a new type of requirement which greatly expands upon the traditional role of CAS. Conceived to address the evolving needs of 21st century tactical air warfare, SUPER CAS is a Close Air Support aircraft which must travel quickly to the combat zone, operate at low level/low speed in the combat zone and engage the enemy with a high degree of maneuverability and precision. Upon mission conclusion, SUPER CAS must promptly exit the combat zone. SUPER CAS must be capable of providing Close Air Support to special operations forces which may be deployed deep within enemy lines, as far as 750 nm to 1,000 nm from forward positions (or from the nearest "safe" in-flight refueling zone). In this scenario, a CAS aircraft capable of penetrating enemy territory to provide close air support for previously covertly inserted, ground based special operations forces, must fly at high subsonic speeds to the target zone, engage enemy ground assets at low speed/low level with precision target dispatchment being facilitated with a 30mm internal gun. The CAS aircraft must then exit the combat zone at high altitude/ high subsonic speeds.

Such mission profiles require a SUPER CAS aircraft: a platform which cannot only perform low speed/low level CAS missions, but offer high subsonic penetration and dash speeds.

An all-weather, day/night aircraft (designed for the weather conditions associated with Western Europe, the Middle East and Philadelphia, PA) capable of satisfying low-level attack missions, SUPER CAS is a quasi A-10/F-105 class aircraft. Although not a nuclear fighter/bomber, lessons learned from the F-105 may be considered highly relevant to SUPER CAS.

PROJECT OBJECTIVE

Overall Objectives

The objective of the SUPER CAS program is to develop a new, next generation Super Close Air Support aircraft specifically designed to succeed the A-10 while significantly expanding upon A-10 to the extent of bridging F-16 capabilities.

SUPER CAS must function as an all-weather, day/night attack aircraft. Focused upon low-level attack with specific emphasis placed upon anti-armor and providing air support for urban warfare, the primary lethal mechanism for SUPER CAS will be at minimum a 30mm cannon of the GAU-8 class. Additionally, the low-cost aspects of the A-10 are desirable, so much effort should be made to minimize the acquisition and life cycle cost of the design.

MINIMUM PERFORMACE REQUIREMENTS/CONSTRAINTS

General Configuration & Design

1. Design a SUPER CAS platform for IOC in 2015.

2. SUPER CAS must be a fixed wing aircraft.

3. SUPER CAS must be a manned aircraft.

4. <u>PROPULSION:</u> SUPER CAS must be powered by a powerplant(s). A requirement for a specific type or number of powerplants is not specified. While multi-engine designs are encouraged to ensure survivability, single engine designs are acceptable provided adequate provisions are made to ensure overall improved reliability, maintainability and survivability. Selected powerplant(s) must be in current service or anticipated to enter service within the next 8 years. The powerplant(s) may be of U.S. domestic or allied foreign/international origin.

5. <u>PRIMARY WEAPON:</u> The primary weapon system for SUPER CAS must be a fixed, large caliber cannon system or Directed Energy Weapon for air-to-ground and secondary air-to-air engagements. Minimum cannon size is 30mm. The cannon must be capable of delivering the PGU-14 series of ammunition or equivalent. Selection of the GD GAU-8 30mm cannon system as principal aircraft armament is encouraged. If selected, the GAU-8 will be provided as Government Furnished Equipment (GFE). Minimum ammunition capacity for GAU-8 ammunition drum is 2,000 rounds in the SUPER CAS application. Data describing the GAU-8 is provided in Appendix A.

6. <u>INTERNAL STORES:</u> SUPER CAS must feature internal weapons carriage capacity such that at minimum 5,000 lbs of stores may be carried internally in the clean configuration.

7. <u>EXTERNAL STORES:</u> SUPER CAS must be offer a high degree of stores carriage flexibility including accommodations for the installation of external stores hardpoints for missions which do not necessitate Low Observability. Minimum external stores load must exceed 12,000 lbs.

Performance & Systems Design

1. <u>MISSION PROFILES:</u> SUPER CAS must satisfy one specific Combat Mission Profile (CMP) as specified in Appendix B.

2. <u>ACCOMODATION:</u> SUPER CAS must incorporate provisions for single pilot operation, a zero-zero escape system, bullet resistant/bird strike resistant canopy, armored cockpit. Crewmembers ranging from 1st percentile female through the 99th percentile male (5 ft 4in/100 lbs through 6 ft 4 in/250 lbs)

must be accommodated. For planning purposes, assumed standard crew-member weight is 280 lbs, including survival equipment.

3. STRUCTURE: SUPER CAS Design limit loads are +8 and -3 vertical g's at MTOW with 100% internal fuel and 100% payload. SUPER CAS structure must be capable of withstanding a dynamic pressure of 2,140 psf (M=1.2 at SL). A safety factor of 1.5 must be used in the analysis of ultimate design loads.

4. FUEL SYSTEMS:
   SUPER CAS fuel systems must be of survivable configuration. The aircraft must facilitate ground refueling and must maintain provisions for in-flight refueling via a standard USAF Flying Boom Refueling Systems. Provisions for external fuel tanks of 370 and 600 USG capacity must be included. Primary design fuel is JP-8 with a density of 6.7 lbs/USG.

5. SENSORS, AVIONICS, DISPLAYS & ECM: SUPER CAS must feature an integrated comprehensive sensor, avionics, display and ECM suite. Desired sensors, avionics, displays and ECM systems to be incorporated in the aircraft conceptual design are specified, along with their associated weight, in Appendix C.

6. STALL SPEED: SUPER CAS must demonstrate a level stall speed in the landing configuration of no greater than 100 kts at SL/MTOW.

7. CORNER SPEED: SUPER CAS must demonstrate a standard level attack/combat entry corner speed no greater than 275 kts at SL/MTOW.

8. MAXIMUM LEVEL SPEED: SUPER CAS must demonstrate a maximum performance level speed no less than 550 kts at optimum performance altitude.

9. RATE OF CLIMB: SUPER CAS must demonstrate a maximum initial rate of climb of at least 10,000 ft/min at SL/MTOW.

10. CEILING: SUPER CAS must demonstrate a maximum service ceiling of no less than 45,000 ft at MTOW.

11. RADIUS/RANGE: SUPER CAS must demonstrate a tactical radius of at least 800 nm on internal fuel in a Hi-Lo-Hi mission carrying (4) GBU-31 JDAM. SUPER CAS must demonstrate a range in excess of 2,500 nm on internal fuel. SUPER CAS must demonstrate a Ferry Range in excess of 3,500 nm on maximum internal and external fuel.

12. SUSTAINED TURN RATE: SUPER CAS must be capable of a sustained turn rate of 12 deg/sec at 15,000 ft and 75% MTOW.

13. FIELD LENGTH: SUPER CAS must be capable of operating from austere, unprepared forward airstrips with field lengths of 2,000 ft x 75 ft or shorter at MTOW. SUPER CAS must feature retractable landing gear capable of withstanding a 18 ft/s vertical descent rate. SUPER CAS takeoff and landing cycles must handle a 30 kts/90 degree cross wind component.

14. COSTS: Acquisition and life-cycle costs should be reduced wherever possible. All monetary values are to be calculated in 2007 United States Dollars.

ANALYSIS QUESTIONS

In addition to discussion of how your design point was selected and which requirements were active constraints, discussion should include answers to the questions below. Provide the supporting quantitative analysis to answer these questions where necessary.

1. In a hard-to-penetrate combat zone, the military decides to use SUPER CAS as a stand off weapon instead of for close air support. In order to do this, the low altitude loiter and combat segments of the mission are replaced by a 1 hour loiter at 5,000 ft. At the end of this loiter, half of the payload is released. Based on your chosen design point, could SUPERCAS perform this new mission? If yes, evaluate the performance in this mission. If no, discuss what constraints are preventing the mission from being completed, and by how much they would need to be relaxed in order to meet them.

2. Comment on the effects that the sustained turn rate will have on the aircraft structure.

3. If the field length requirement were to be relaxed from 2000 ft to standard NATO runways, how would this change the design point, if at all? Also, discuss how austere operations might impact the aircraft design.

4. If SUPER CAS were deployed to Afghanistan where the temperature is routinely 110°F at sea level, how would the take-off and landing performance be impacted? Would the aircraft still be able to meet the 2000 ft requirement? If not, what would the field length need to be?

5. If the total weight of internal stores that needed to be carried were doubled, how would this affect the design point? How might this affect other aspects of the internal design, such as the internal layout and structures?

6. A new technology is introduced that reduces fuel consumption in all mission segments by 15%. Resize the aircraft, and redo the constraint analysis. What implications does this have on empty weight, fuel weight, total weight, and wing loading? Does this change which requirements drive the design point? What are the pros and cons of adding this technology to the aircraft design?

7. A study is done showing that departure speed from the combat zone has a significant impact on survivability. In response to this, the military adds a 200 nm dash segment at the end of combat. The required dash speed is M=0.87. This means that the return cruise radius is then reduced to 600 nm. How does this affect your design point? Discuss how this might affect your wing planform.

APPENDIX A:

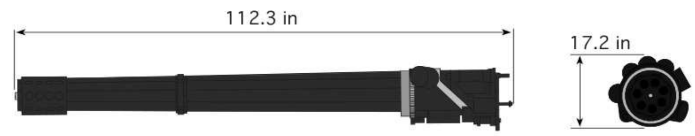
General Dynamics GAU-8/A 30mm Cannon

General Arrangement, Dimensions & Specifications

GAU-8/A SPECIFICATIONS

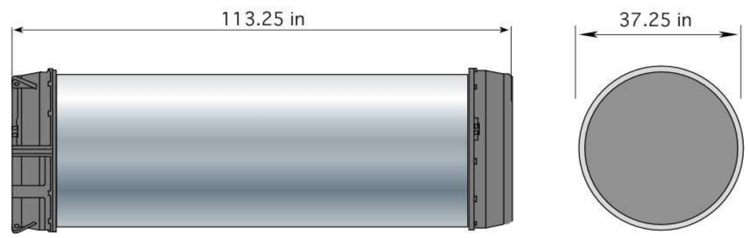
Gun Designation	GAU-8/A
Gun Caliber	30mm
Gun Barrels	7 Barrel
Gun Type	Gatling Gun
Gun Weight (Gun Only)	620 lbs
Gun Length (Gun Only)	112.3 in
Gun Height (Gun Only)	17.2 in
Maximum Rate of Fire	4,200 rds/min
Muzzel Velocity	3,400 ft/sec
Average Recoil Force	10,000 lbs
Drive System	Hydraulic, Electric or Pneumatic
Feed System	Linkless
Ammunition Designation	PGU-14/B
Ammunition Caliber	30mm
Ammunition Type	API
Ammunition Length	11.4 in
Ammunition Weight (total)	1.62 lbs
Projectile Weight (average)	0.94 lbs

GAU-8/A Cannon
Profile/Front Views



Profile View Front View

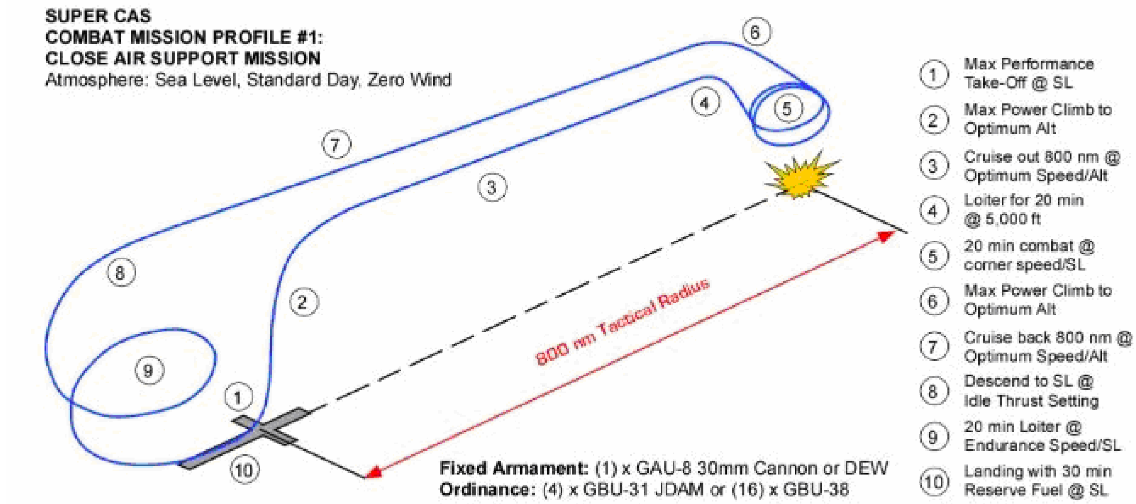
GAU-8/A 2,000 Rd Drum
Profile/Front Views



Profile View Front View

Appendix B

SUPER CAS COMBAT MISSION PROFILES (CMPs)



APPENDIX C:

SUPERCAS DESIRED SENSORS, AVIONICS, DISPLAYS & ECM

SUPERCAS DESIRED SENSORS, AVIONICS, DISPLAYS & ECM		
UNIT TYPE	**UNIT MANUFACTURER & MODEL NUMBER**	**UNIT WEIGHT (lbs)**
RADAR		
Multi-Mode Fire Control Radar	Raytheon Systems AN/APG-79 AESA	437.0
Multi-Mode Terrain Following Radar	Raytheon Systems AN/APS-174/186	240.0
MISSION COMPUTERS		
Advanced Mission Computer	General Dynamics GD 3000	13.2 Unpopulated
Multi-Mission Display Processor	CMC FV-4000 MMDP	27.7
NAVIGATION SYSTEMS		
Embedded GPS/INS Unit	Northrop Grumman LN-100G GPS/INS	21.6
Anti-Jam GPS Receiver	Raytheon DAR GPS Anti-Jam Receiver	11.0
TACAN	DRS Technologies AN/ARN-136A Tacan Receiver	7.0
VOR/ILS	Honeywell AN/ARN-127	8.8
Radar Altimeter	Honeywell HG9550 LPI Radar Altimeter	9.75
ADF	Honeywell KR 87 ADF	5.0
COMMUNICATION SYSTEMS		
Multi-Mode Communications System	Rockwell Collins AN/ARC-210(V) VHF/UHF COMM	30.8
IFF Transponder	Raytheon APX-119 Digital Transponder	10.0
Secure Voice System	Raytheon KY-58 Secure Voice/Data System	4.9
Link 16 Data Link	Rockwell Collins Link 16 Data Link	15.4
HEAD UP DISPLAYS (HUDs)		
Helmet Mounted Display (HMD)	Vision Systems International F-35 JSF HMDS	21.0 (Includes Helmet & Display Processor)
Head Up Display (HUD)	CMC Sparrow Hawk HUD	17.3
MULTI-FUNCTIONAL DISPLAYS (MFDs)		
Multi-Functional Display (MFD)	L3 Actiview 104P 6 x 8 in LCDs	8.0
COCKPIT VOICE DATA RECORDER		
Cockpit Voice/Data Recorder	Smiths 3253F Series VADAR	8.0
INTERNAL ECM SUITE		
Internal ECM System	Northrop Grumman Integrated Defensive Countermeasures[1]	200.0 (Combined LRUs)
MISSILE APPROACH WARNING RECEIVERS		
Missile Warning System	Northrop Grumman AN/AAR-54	25.9 (Including 4 Sensors)
CHAFF/FLARE DISPENSERS		
Chaff/Flare Dispenser	BAE Systems AN/ALE-47(V) Dispenser Suite	62.3 (Including 8 Dispensers)

1: Next generation Northrop Grumman integrated Radar Warning Receiver and Defensive Countermeasures System that is approximately 2 cu ft and weighs 200 lbs as quoted by William Hawk of Northrop Grumman.