Chapter 8

Example Point Design - Suppression of Enemy Air Defenses

In order to quantify the sensitivity of UAVs to potential technological advances and to define promising UAVs as precisely as possible, several preliminary design analyses were carried out during this study. One of the most important of these, SEAD, is described in this section, which is intended to serve as a departure point for more detailed examination.

8.1 Specific Tasks and System Definition

A SEAD mission was selected to serve as a basis for preliminary combat UAV sizing studies. The mission goals were 800 nm of penetration with a 6 hour loiter capability. The mission profile is shown in Figure 8-1.

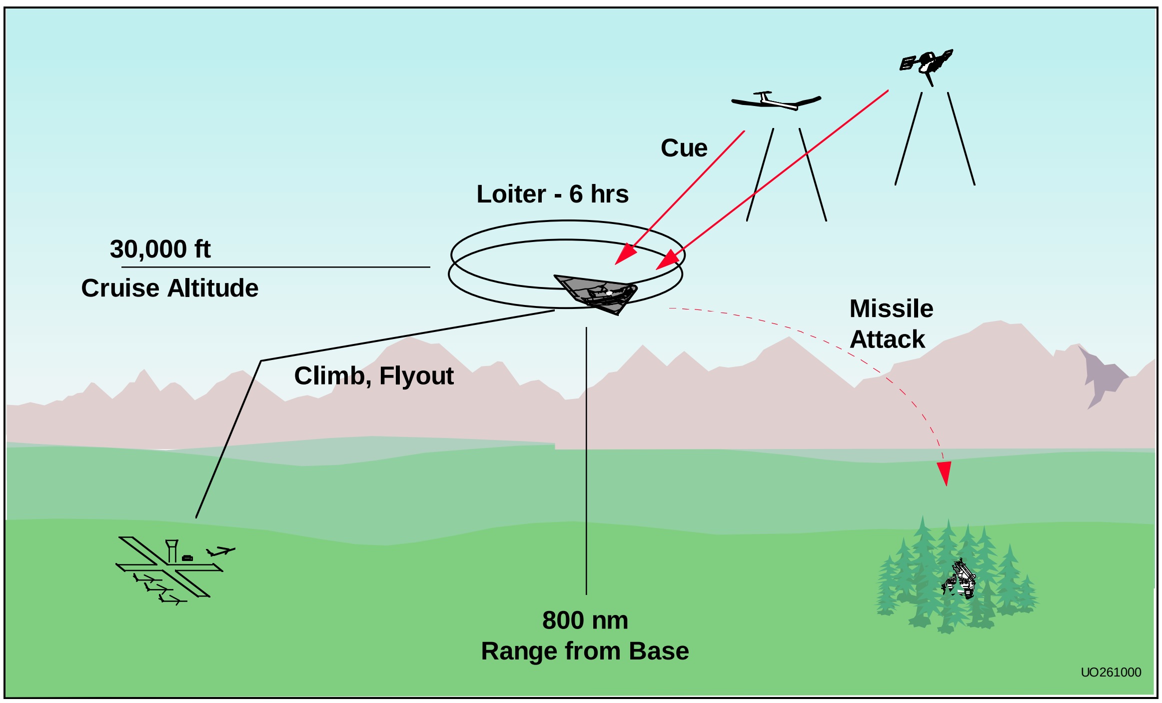

Figure 8-1. *SEAD Profile*

The mission is a cooperative one, with an ISR UAV providing the data so that target locations (GPS coordinates) are communicated to the SEAD UAV. The SEAD UAV cruises 800 nm to the target area and loiters for up to 6 hours, during which time it is cued to target(s) and launches a missile or missiles as authorized by the appropriate C^2 activity. The missiles have a range of approximately 5 nm. Eight 100 lb (see Volume 1, Chapter 6) missiles are carried on the UAV so that several targets can be destroyed. The UAV incorporates low-observable antennas on both wings for communication and control and carries onboard electronic countermeasures (ECM).

Provisions for a limited number of expendable decoys are also included. The UAV has the capability to descend to 200 ft for attack if needed, at the expense of some loiter time.

8.2 Design Description

Based upon the preliminary studies, a wing loading of 90 lb psf was chosen. Two weapon bays are located on either side of the engine, incorporating four advanced missiles in each. The main landing gear is located outboard of the weapon bays. Avionics compartments are located out on each wing: they are 5 in. deep for the electronic receivers and transmitters as well as the antennas. The engine has cycle characteristics similar to the existing Allison 3007 but scaled to the thrust necessary to carry out the most demanding phase of the mission.

The configuration selected has a trailing edge sweep of -15^{o} and a leading edge sweep of $+45^{o}$. While this moves the trailing edge radar spike close to the flight path, it is felt that adequate mission flight planning will make it acceptable. Good balance and volumetric efficiencies are possible with this design. Both the inlet and nozzle are on the bottom with serpentine ducts for low observability. The top surface is smooth for signature treatment. The vehicle cruises and loiters inverted to shield inlets, doors, and exits from ground radar. Note that the wing span of 22 ft was chosen to allow the UAV to be transported on existing aircraft, thus simplifying its deployment. Figure 8-2 below shows the notional configuration.

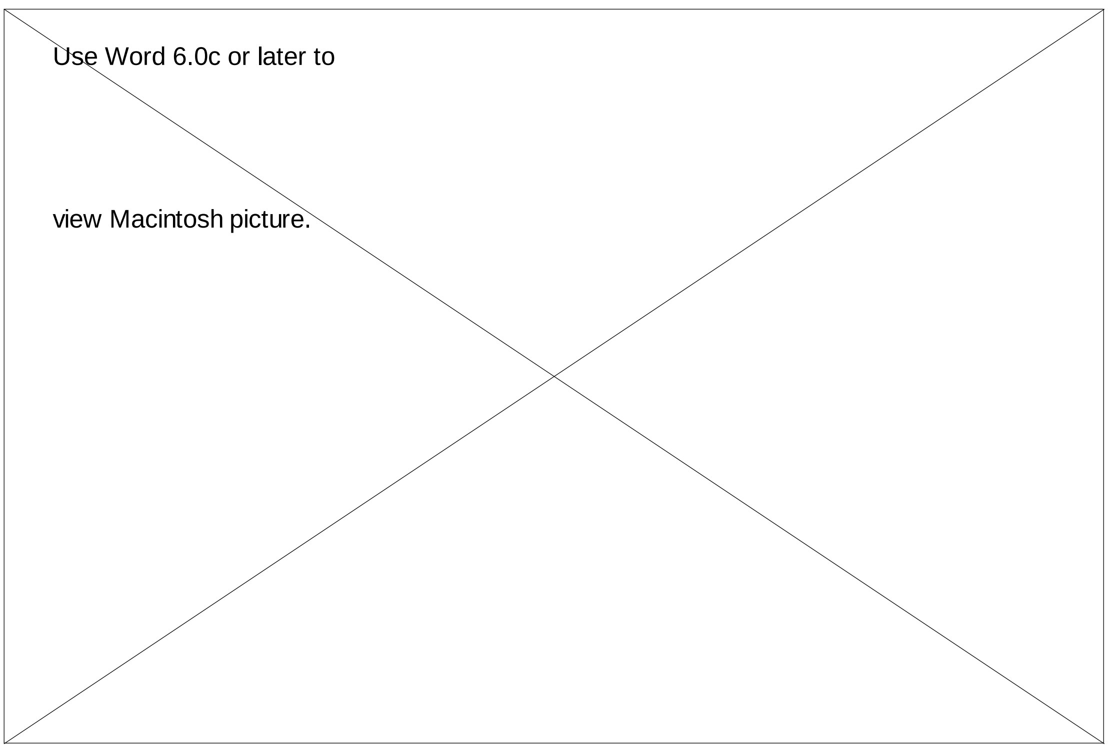

Figure 8-2. *SEAD UAV Configuration (Notional)*

8.3 Technical Analysis

Aircraft. With respect to the small missiles, it was initially assumed that the vehicle would have a 7,000 lb takeoff weight. However, this vehicle achieved just over 3 hours of loiter at 800 nm radius. Larger vehicles were designed with loiter times shown in Figure 8-3 as a function of takeoff gross weight. The vehicle weighing 13,500 lb provided the desired 6 hours loiter time. (The shape of the curve indicates that this is pushing the state-of-the-art). The missiles were not fired, but carried home for these performance calculations.

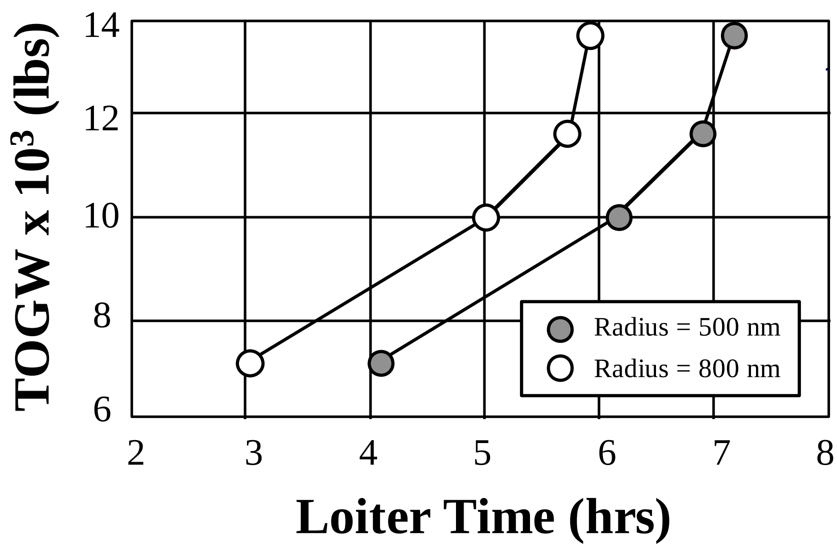

Figure 8-3. *Loiter versus Weight Trades*

The loiter time variation for the selected vehicle with radius is shown in Figure 8-4.

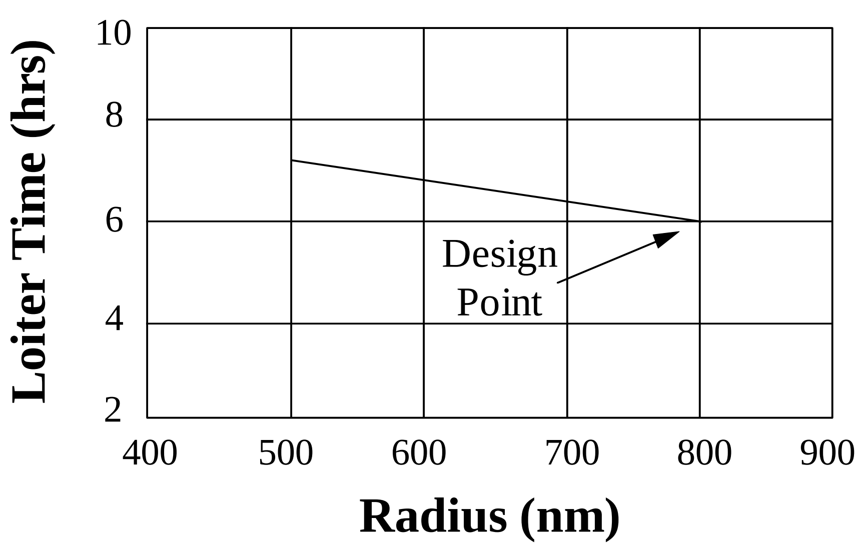

Figure 8-4. *Loiter versus Radius Trades*

The selected design has the characteristics shown in Table 8-1.

Table 8-1. *SEAD Aircraft Characteristics*

Characteristics	
Wing area	153.4 sq ft
Span	22 ft
Length	13.95 ft
Aspect Ratio	3.155
Engine	
Static thrust	3,700 lb (fixed geometry)
Diameter	19 in.
Weights	
Structure	4,500 lb
Engine	675 lb
Landing gear and subsystems	610 lb
Mission systems	400 lb
Fuel	6,515 lb
Weapons	800 lb (8 internal @ 100 lb ea.; no external)
Total TOGW	13,500 lb
Signature	Low-observable treatment for low- and high-frequency RF Tailored IR signature control
Storage	20 years
Deployment	C-5 or C-17

Mission System. The SEAD UAV requires minimal mission systems because it receives primary targeting information from offboard precision emitter location sensors. The functions that the onboard avionics must provide, in addition to basic vehicle operation and the command data link, are:

- Precise platform navigation via GPS-aided inertial navigation system (INS).
- Data link with TADIL-J class capacity and LPI/AJ features; transmissions in threat areas will be power managed and highly compressed to limit emissions.
- ESM functions, including emitter detection in the 2-18 Ghz region and coarse (3°- 5°) angle-of-arrival determination for threat warning and confirmation of attack data.
- Infrared and RF countermeasures (IRCM/RFCM) for survivability in close-in threat exposures; these may include flares and chaff, active IRCM, and towed decoys as determined by survivability analyses.

- Weapon interface, including utilities and guidance data download; the prelaunch weapon load will include GPS initialization, accurate INS transfer alignment, and target GPS (WGS-84) coordinates.

The option is reserved to add an imaging sensor as part of the SEAD UAV payload to allow both target confirmation and aimpoint adjustment, e.g., to strike an electronics van physically separated from the antenna that the emitter location system has targeted. The possibilities include a low-power synthetic aperture radar (SAR) and an imaging infrared seeker such as a forward-looking infrared (FLIR). It would be very important to exploit the limited performance required of such a sensor to hold down both cost and RCS contribution. More detailed operational effectiveness and survivability analysis is needed to validate the requirement for this sensor and to refine its characteristics.

Weapons. The study group established a weapon payload capacity of 800 lb, intended to be eight weapons, each weighing 100 lb. In particular, the kinetic energy penetrator was selected for the SEAD role. The kinetic energy penetrator itself has been the subject of considerable technical investigation. Existing designs developed by various contractors could be adapted to this application. The 3.5 in. diameter was selected because most of the boosted kinetic energy penetrator work conducted circa 1985 to 1992 was at this measurement and it is a proven design. This design has folding fins in the backend to provide mid-course corrections. The missile incorporates a GPS/DGPS receiver as well as an INS (to ensure target kill even if GPS is jammed). The study group proposed to adapt this design directly to the SEAD UAV system.

The kinetic energy penetrator would be capable of delivering several different warheads, including:

- High Explosive - the warhead would use a CL-20 containing high explosive capable of generating up to 450 kbar of detonation pressure to destroy the target.

- Flechette - high lethality could be achieved with 500-600 grain flechettes.

- Incendiary - the warhead would employ an incendiary explosive to generate extremely high temperature (3,700°C) persistent, high-volume reactive fireballs.

- Directed Energy - The concept would employ an explosively driven, HPM directed energy warhead capable of delivering high levels of microwave energy to destroy electronics, digital equipment, communications equipment, and other target elements susceptible to electronic upset or damage.

Human Systems. While automatic systems will play a role in navigation and other functions, the human will have the ability to override and directly control most functions, due to the fact that the UAV will be flying in combat and subject to battle damage. Control lags must be accounted for in relayed communications links. The operator(s) will have full access to onboard and other sensors providing a real-time-information-to-the-cockpit (RTIC) capability in the MCE. Wide angle, high-resolution cockpit views will be available on large screen color displays, providing integrated information from various EO/IR and radar sensors displayed in readily assimilated "intuitive" formats. Use of synthetic speech for warnings and voice recognition for selected control functions will be facilitated by the relatively controlled environment of the ground-based MCE.

Automated combat operation is preferred, with full fighter-type controls incorporating hands-on-throttle-and-stick (HOTAS) features provided for mission intervention. The MCE crew will include trained fighter pilots as vehicle operators. Mission rehearsal capabilities will be provided within the MCE to facilitate training and improve mission performance in the event of retasking. Rehearsal will be possible during the navigation legs. Crew station layout will be designed to facilitate the rapid decision making and response required but will be simplified by the reduction in constraints normally imposed by the need to satisfy fighter dynamics and size. The MCE will be palletized for rapid relocation.

8.4 SEAD UAV Point Design Summary

The design based on the SEAD mission benefits greatly from the flexibility and small size of the payload missile. The small size permits a reasonable design which can carry eight missiles. Initially, these missiles would have combined effects bomblets, flechette, incendiary, or high explosive warheads. The use of offboard sensors and targeting helps keep both the UAV and missiles small. Thus, target kill can be achieved by employing GPS-updated inertial guidance after target radar radiation is eliminated.

In the far-term, it may be possible to develop recce-strike versions with a HPM generator on the vehicle. The weapons bays could be used for electronic gear and antennas. The vehicle could loiter, detect emitters, attack the emitter with HPMs, monitor to see if the attacks were successful, and, if not, reattack the emitter.

The point design was prepared to give a first-order sizing of a combat UAV. It shows that a relatively compact aircraft capable of multiple SEAD kills is possible. Fundamentally, the combination of stealth and unmanned operation allows an impunity that makes smaller weapons effective, thereby providing multiple kill capability. It is important that integration and modularity be key considerations in the design of such a vehicle, not only for the success of the concept but also for the flexibility to accomodate multiple payloads and missions. The SEAD UAV might be built for $5M-$10M. Along with double the number of kills per mission likely and long-term storage utilized to reduce operational and support costs, substantial life-cycle cost savings are possible.

The Air Force can use this first-order calculation as a point of departure for a detailed design of a SEAD UAV. The greatest threat to a successful program based on this point design is requirements growth: adding missions that increase size, weight, cost, etc. Hence, close control of such a program is essential.