UCAV-N RFP, version of Sept. 13, 2002

We will design a UCAV-N for the Navy, but one that can use a much smaller deck than the current UCAV-N concepts, which are apparently assuming that they will be using current carriers. Since the current carriers are both very expensive and huge targets, the ship folks have in mind ships of 500-ft length, and actually they’d like even less.

The UCAV-N RFP prepared for us from the Navy is included with this RFP/Hwk. It also has attachments describing the JDAM and HARM. A second attachment describes the sensor suite (It is password protected, so it can’t be bundled with the rest of this document)

The goal this semester will be to define the concept, size it, and determine the sensitivity of the concept capability to the required ship size. Would we have to give up some capability to use a smaller deck? If so, how much? We will use this sensitivity information to work with the Ocean Design Team and pick the “best” ship/airplane system.

Individual Homework:

0. Describe the current UCAV-N design activity. How does it compare with the RFP we were given? Is anybody else doing anything that satisfies our RFP?
1. Compare the current carrier decks to a 500-ft deck carrier. What do the Russians, English and French use? What are the issues associated with a shorter deck? How does the ski-jump concept fit into this problem?
2. List ways to launch and recover UCAV-Ns on short decks.
3. List key aero considerations to be used in developing a configuration concept.
4. Suggest 3 possible concepts (good sketches), and explain the connection between the concepts and the requirements. How are you going to control the plane? This requires some comments on the S&C aspects of the concepts.
5. Use the sizing methods discussed in class to estimate the weight, wing area and thrust required by the concepts. Look at airplane sizes and concepts for various deck sizes and capabilities.
6. Pick your favorite concept and size and make a good 3 view drawing of the concept.

Dues dates: Parts 0-3 due Sept. 20, 5pm, parts 4-5 due Sept 27, part 6 due Oct. 4
4 September 2002

Naval Unmanned Combat Air Vehicle (UCAV-N)

Note: This document is an adaptation of the “AIAA Ultra Heavy-Lift Aircraft (UHLA) RPF” and its sole purpose is to support the Virginia Tech Department of Aerospace and Ocean Engineering 2002-2003 Aircraft Design Course activities. Information contained in this document does not reflect official U.S. Navy requirements.

1. Background

The successful use of unmanned air vehicles (UAVs) in recent conflicts has demonstrated the military utility of such an aircraft. The majority of the use of these vehicles has been in battlefield surveillance. In addition, limited operations have demonstrated that these vehicles can also be "weaponized" to provide the war-fighter an offensive capability. Both the US Air Force and the US Navy are pursuing the research, development, and potential acquisition of more capable UAVs dubbed “Unmanned Combat Air Vehicles” (UCAVs).

It is hoped that the UCAVs will provide the Air Force and Navy with a revolutionary new tactical air warfare capability. The capability is characterized by a weapon system that can be employed with the daring of a kamikaze but without the attendant ceremony, sorrow, and loss of a very talented citizen and his/her aircraft. The absence of a requirement for human accommodations increases the designer's flexibility in configuration arrangement and the attendant decrease in internal volume and systems requirements allows for a design that is much less expensive to build and operate than a manned aircraft.

The Air Force is pursuing a UCAV designed for suppression of enemy air defenses (SEAD) and deep strike. The Navy is interested in these missions but has a primary requirement for battlefield surveillance. Inclusion of surveillance in the Navy mission set reflects the need for shipboard aircraft to be multi-mission capable and the need for the Battle Group Commander to maintain an operational picture around the clock.

There are several key system attributes that an UCAV-N system will have to address:

- A Mission Control System (MCS) that employs mission controllers who can control the aircraft from their location on aircraft carriers. Using intelligent decision aids, a single controller will need to monitor and control several aircraft simultaneously.
- An air vehicle, MCS, and information network that allow for robust and secure command, control and communications peculiar to the maritime environment, including line-of-sight, non-line-of-sight, and over-the-horizon communications.
- An intelligent air vehicle that can execute pre-planned missions as well as being able to adapt to the ever-changing battlefield through the use of onboard intelligence and/or MCS controller inputs. On board intelligence may also be of value in allowing mixed manned and unmanned operations.
- An air vehicle that is an affordable system to procure and operate. Supportability will be an integral part of the design, providing for minimal maintenance requirements and a very high sortie rate.
- An air vehicle that will support carrier-based operations and take into consideration aircraft carrier launch and recovery, deck handling and storage, maintenance and training, and interoperability with other Naval aviation systems. Land based operations are also envisioned.
2. Aircraft General Requirements

2.1 General - Design an UCAV-N air vehicle, including an engine data package.

2.2 Configuration - The UCAV-N aircraft configuration is to be a fixed wing, carrier-based aircraft. Configuration is to be highly survivable with an emphasis on reduction of aircraft signatures. Particular emphasis is to be made to reduce detection of the aircraft in the forward and rear sectors to enhance aircraft survivability during target ingress and egress.

2.3 Mission Payloads - The aircraft must exhibit the ability to internally carry and deliver the weapon payloads listed below. Weapon payloads are specific to the indicated mission. It is not necessary for the aircraft to carry the payloads for the SEAD and Deep Strike missions simultaneously.

2.3.1 Deep Strike - two (2) Joint Direct Attack Munitions (JDAM), GBU-31 (v)3B (see Attachment 1)

2.3.2 SEAD - two (2) AGM-88, High-Speed Anti-Radiation Missiles (HARM) (see Attachment 2 with reduced physical dimensions)

2.4 Mission Avionics - The UCAV-N must be capable of performing battlefield surveillance. The sensor system to be incorporated as part of the aircraft design is the Global Hawk Integrated Sensor Suite (see Attachment 3). This sensor system is to be part of the fixed aircraft equipment. Considerations are to be made for the location of this system to facilitate the maintenance and support of the required electronic components.

2.5 Propulsion - The UCAV-N must be powered by air-breathing power plant(s) currently in service or anticipated to enter service within the next 10 years. The power plant(s) may be of U.S. domestic or foreign/international origin. Aircraft self start capability is required. The propulsion installation should be consistent with the survivability approach.

3. Performance and Design Requirements

3.1 Performance - The UCAV-N must exhibit an un-refueled 10-hour surveillance mission time using internal fuel only, at cruise airspeeds Mach 0.7 or greater, at configuration specific optimized flight altitudes. The UCAV-N must also exhibit an un-refueled strike and SEAD mission radius of 500nm at 40,000+ ft with a mid-mission combat fuel allowance of 3 minutes of maximum thrust at Mach 0.7, 40000 ft. Initial rate of climb for all mission configurations should be no less than 8,400 ft/min. Maximum speed at sea level should be no less than Mach 0.85.

3.2 Operations - The UCAV-N design and performance must support land and carrier-based operations and take into consideration aircraft carrier launch and recovery, deck handling and storage. Carrier driven geometric constraints on the air vehicle must also be addressed. Take-off and landing performance must be compatible with the NATO standard 8000 ft runway.

3.3 Structure – The UCAV-N design limit load factors are +4.0 and -1.5 vertical gs with 100% internal fuel and 100% payload. Construction materials should be compatible with outside storage in a salt spray environment. The structure should be designed to withstand a maximum dynamic pressure of at least 1,200 psi (M=0.9+ at Sea Level). A safety factor of 1.5 must be used in analysis of ultimate design loads.

3.4 Electric, Hydraulic, and Fuel Systems - The UCAV-N must employ a current state of the art electrical power and hydraulic systems suitable for naval tactical aircraft. Alternatively, an ‘all electric’ design, eliminating the need for traditional
hydraulic/electric systems, may be employed. Subsystem design shall be compatible with available deck edge power for on-board maintenance and systems checkout; on-aircraft power generation may be substituted. UCAV-N fuel (JP-5) tankage may be integral or self-sealing. The aircraft must facilitate carrier deck refueling from a single pressure point refueling/defueling receptacle with gravity refueling as secondary backup. Provisions for external fuel carriage are not required.

3.5 Avionics - The UCAV-N must employ Commercial Off-The-Shelf (COTS) avionics. The avionics must support autonomous air vehicle operations yet also allow mission control operators the ability to redirect the air vehicle when the need arises. Avionics must support robust and secure command, control and communications peculiar to the maritime environment, including line-of-sight, non-line-of-sight, and over-the-horizon communications.

3.6 Stability and Control - Static and dynamic stability and handling characteristics must meet MIL-F-8785B requirements. The aircraft may exhibit positive static and dynamic stability, although unstable configurations reliant upon stability augmentation due to static instability along the longitudinal axis are acceptable. A margin of safety to accommodate a 15% uncertainty in aerodynamic forces and moments must be demonstrated at the edge of the alpha/beta envelope. The flight control system will be of sufficient reliability and redundancy to minimize the PLOC while maintaining reasonable cost.

4. Measures of Merit

Submissions under this RFP will be evaluated based upon adequacy of the design in meeting said design and performance criteria, overall design feasibility, and feasibility and historical trend support of design and system costs analyses. Specific Measures of Merit that must be reported include:

4.1 General Arrangement and Design Drawings including detailed three-view, 3-D perspective and internal arrangement. A material selection drawing must also be provided, as well as a power plant data sheet.

4.2 Aircraft Geometry and Systems Integration data including spot factor, wing and control surface area, fuselage size and volume, frontal area, wetted area, power-plant and air intake/diffuser, landing gear, weapon bays, sensors and avionics locations, etc.

4.3 Weight Summary including a complete weight statement indicating GTOW, We, Wf, W/S, T/W, etc and corresponding CG envelope.

4.4 Aerodynamic substantiation data including lift, drag, and moments.

4.5 Aircraft performance data at GTOW including mission definitions, 1-g level flight envelope, V-n diagram, maximum thrust maneuvering performance and rate-of-climb diagrams at sea level and 15,000 ft, maximum range, endurance, wing loading and power loading/thrust-to-weight ratio diagrams, etc. All calculations and performance estimates are to be made at sea level with Standard Day conditions unless otherwise noted.

4.6 Flyaway and total life cycle costs with cost trade studies for aircraft buys of 150, 300, and 500.
Attachment 1 – JDAM USAF Fact Sheet
Attachment 2 – HARM USAF Fact Sheet
Attachment 3 – ISS Raytheon Fact Sheet
Mission
The Joint Direct Attack Munition (JDAM) is a guidance tail kit that converts existing unguided free-fall bombs into accurate, adverse weather “smart” munitions. With the addition of a new tail section that contains an inertial navigational system and a global positioning system guidance control unit, JDAM improves the accuracy of unguided, general purpose bombs in any weather condition. JDAM is a joint U. S. Air Force and Department of Navy program.

Features
JDAM is a guided air-to-surface weapon that uses either the 2,000-pound BLU-109/MK 84 or the 1,000-pound BLU-110/MK 83 warheads as the payload. JDAM enables employment of accurate air-to-surface weapons against high priority fixed and relocatable targets from fighter and bomber aircraft. Guidance is facilitated through a tail control system and a GPS-aided INS. The navigation system is initialized by transfer alignment from the aircraft that provides position and velocity vectors from the aircraft systems. Once released from the aircraft, the JDAM autonomously navigates to the designated target coordinates. Target coordinates can be loaded into the aircraft before takeoff, manually altered by the aircrew before weapon release, and automatically entered through target designation with onboard aircraft sensors. In its most accurate mode, the JDAM system will provide a weapon circular error probable of 13 meters or less during free flight when GPS data is available. If GPS data is denied, the JDAM will achieve a 30-meter CEP or less for free flight times up to 100 seconds with a GPS quality handoff from the aircraft.

JDAM can be launched from very low to very high altitudes in a dive, toss and loft or in straight and level flight with an on-axis or off-axis delivery. JDAM enables multiple weapons to be directed against single or multiple targets on a single pass.

JDAM is currently compatible with B-1B, B-2A, B-52H, F-16C/D and F/A-18C/D aircraft. Follow-on integration efforts are currently underway or planned to evaluate compatibility with the A-10 F-15E, F-22, F-117, AV-8B, F-14A/B/D, F/A-18E/F, S-3, and the Joint Strike Fighter.

Background
Desert Storm highlighted a shortfall in air-to-surface weapon capability. Adverse weather conditions limited employment of precision guided munitions. Unguided weapon accuracy was also degraded when delivered from medium and high altitudes. Research and development of an ‘adverse weather precision
“guided munition” began in 1992. The first JDAMs were delivered in 1997 with operational testing conducted in 1998 and 1999. More than 450 JDAMs were dropped during testing, recording an unprecedented 95 percent system reliability while achieving a 9.6-meter accuracy rate. JDAM performance has been demonstrated in operationally representative tests including drops through clouds, rain and snow. These tests included a B-2 releasing 16 JDAMs on a single pass against multiple targets in two separate target areas.

JDAM and the B-2 made their combat debuts during Operation Allied Force. The B-2s, flying 30-hour, nonstop, roundtrip flights from Whiteman Air Force Base, Mo., delivered more than 600 JDAMs during Allied Force. This combination of stealth and accuracy has revolutionized air warfare. Growth of the JDAM family of weapons expanded to the MK-82 500-pound version, which began development in late 1999. Also, the Navy is currently studying the effects of adding enhancements such as improved GPS accuracy, a precision seeker for terminal guidance and additional warheads.

**General Characteristics**

**Primary Function:** Guided air-to-surface weapon  
**Contractor:** Boeing Corp.  
**Length:** (JDAM and warhead) GBU-31 (v) 1/B: 152.7 inches (387.9 centimeters); GBU-31 (v) 3/B: 148.6 inches (377.4 centimeters); GBU-32 (v) 1/B: 119.5 inches (303.5 centimeters)  
**Launch Weight:** (JDAM and warhead) GBU-31 (v) 1/B: 2,036 pounds (925.4 kilograms); GBU-31 (v) 3/B: 2,115 pounds (961.4 kilograms); GBU-32 (v) 1/B: 1,013 pounds (460.5 kilograms)  
**Wingspan:** GBU-31: 25 inches (63.5 centimeters); GBU-32: 19.6 ins. (49.8 centimeters)  
**Range:** Up to 15 miles  
**Ceiling:** 45,000-plus feet (13,677 meters)  
**Guidance System:** GPS/INS  
**Unit cost:** Approximately $21,000 per tailkit (FY 01 dollars)  
**Date Deployed:** 1999  
**Inventory:** The tailkit is in full-rate production. Projected inventory is 87,496 total, 62,000 for the Air Force and 25,496 for the Navy  
**Point of Contact**  
Air Combat Command, Public Affairs Office; 115 Thompson St., Suite 211; Langley AFB, VA 23665-1987; DSN 574-5007 or (757) 764-5007.  
May 2001
AGM-88 HARM

Mission
The AGM-88 HARM (high-speed antiradiation missile) is an air-to-surface tactical missile designed to seek and destroy enemy radar-equipped air defense systems.

Features
The AGM-88 can detect, attack and destroy a target with minimum aircrew input. The proportional guidance system that homes in on enemy radar emissions has a fixed antenna and seeker head in the missile nose. A smokeless, solid-propellant, dual-thrust rocket motor propels the missile. The F-16C has the capability to employ the AGM-88, and is the only aircraft in the current inventory to use the AGM-88.

Background
The Defense Systems Acquisition Review Council approved the AGM-88 missile for full production in March 1983. The Air Force equipped the F-4G Wild Weasel with the AGM-88 to increase the F-4G's lethality in electronic combat. The missile worked with the APR-47 radar attack and warning system on the aircraft. The missile is operationally deployed throughout the Air Force and in full production as a joint U.S. Air Force-U.S. Navy project.

General Characteristics

Primary Function: Air-to-surface anti-radiation missile
Contractor: Texas Instruments
Power Plant: Thiokol dual-thrust rocket motor
Thrust: Dual thrust
Length: 13 feet, 8 inches (4.14 meters)
Diameter: 10 inches (25.40 centimeters)
Wingspan: 3 feet, 8 inches (101.60 centimeters)

Note: use the following dimensions for VA TECH design project
Length: 12 feet (3.6 meters)
Diameter: 7 inches (17.78 centimeters)
Wingspan: 21 inches (53.3 centimeters)

Launch Weight: 800 pounds (360 kilograms)
Range: 30 plus miles (48 plus kilometers)
Speed: Supersonic
Aircraft: Used aboard the F-16C
Guidance System: Proportional
Warheads: High explosive
Unit Cost: $200,000
Date Deployed: 1984
Point of Contact