2008 – 2009 AIAA Foundation Graduate Team Aircraft Design Competition

I. RULES

1. All undergraduate AIAA branch or at-large Student Members are eligible and encouraged to participate.

2. An electronic copy of the report in MS Word or Adobe PDF format must be submitted on a CD or DVD to AIAA Student Programs. Total size of the file(s) cannot exceed 60 MB. **A "Signature" page must be included in the report and indicate all participants, including faculty and project advisors, along with their AIAA member numbers**. Designs that are submitted must be the work of the students, but guidance may come from the Faculty/Project Advisor and should be accurately acknowledged.

3. *Design projects that are used as part of an organized classroom requirement are eligible and encouraged for competition.*

4. The prizes shall be: First place-$2,500; Second place-$1,500; Third place-$1,000 (US dollars). Certificates will be presented to the winning design teams for display at their university and a certificate will also be presented to each team member and the faculty/project advisor. One representative from the first place design team may be expected to present a summary design paper at an AIAA Conference in 2009. Reasonable airfare and lodging will be defrayed by the AIAA for the team representative

5. More than one design may be submitted from students at any one school. Projects should be *no more than 100 (total) double-spaced typewritten pages and typeset should be no smaller than 10pt Times* (including graphs, drawings, photographs, and appendix) on 8.5" x 11.0" paper. Up to five of the 100 pages may be foldouts (11" x 17" max).

6. If a design group withdraws their project from the competition, the team chairman must notify AIAA Headquarters immediately!

7. Team competitions will be groups of not more than ten AIAA branch or at-large Student Members per entry. Individual competitions will consist of only 1 AIAA branch or at-large Student Member per entry.

II. COPYRIGHT

All submissions to the competition shall be the original work of the team members.

Any submission that does not contain a copyright notice shall become the property of AIAA. A team desiring to maintain copyright ownership may so indicate on the signature page but nevertheless, by submitting a proposal, grants an irrevocable license to AIAA to copy, display, publish, and distribute the work and to use it for all of AIAA's current and future print and electronic uses (e.g. "Copyright © 20__ by _____. Published by the American Institute of

Aeronautics and Astronautics, Inc., with permission.).

Any submission purporting to limit or deny AIAA licensure (or copyright) will not be eligible for prizes.

II. SCHEDULE AND ACTIVITY SEQUENCES

Significant activities, dates, and addresses for submission of proposal and related materials are as follows:

A. Letter of Intent – 13 Mar 2009
B. Receipt of Proposal – 12 June 2009
C. Announcement of Winners – Aug 2009

Groups intending to submit a proposal must submit a one page Letter of Intent along with the signed attached Intent Form (Item A) on or before the date specified above, at the following address:

AIAA Student Programs
1801 Alexander Bell Drive
Suite 500
Reston, VA 20191-4344

The CD containing the finished proposal must be received at the same address on or before the date specified above for the Receipt of Proposal (Item B).

III. Proposal Requirements

The technical proposal is the most important factor in the award of a contract. It should be specific and complete. While it is realized that all of the technical factors cannot be included in advance, the following should be included and keyed accordingly:

1. Demonstrate a thorough understanding of the Request for Proposal (RFP) requirements.

2. Describe the proposed technical approaches to comply with each of the requirements specified in the RFP, including phasing of tasks. Legibility, clarity, and completeness of the technical approach are primary factors in evaluation of the proposals.

3. Particular emphasis should be directed at identification of critical, technical problem areas. Descriptions, sketches, drawings, systems analysis, method of attack, and discussions of new techniques should be presented in sufficient detail to permit engineering evaluation of the proposal. Exceptions to proposed technical requirements should be identified and explained.

4. Include tradeoff studies performed to arrive at the final design.

5. Provide a description of automated design tools used to develop the design.

IV. Basis For Judging

1. Technical Content (35 points)
This concerns the correctness of theory, validity of reasoning used, apparent understanding and grasp of the subject, etc. Are all major factors considered and a reasonably accurate evaluation of these factors presented?

2. Organization and Presentation (20 points)

The description of the design as an instrument of communication is a strong factor on judging. Organization of written design, clarity, and inclusion of pertinent information are major factors.

3. Originality (20 points)
The design proposal should avoid standard textbook information, and should show the independence of thinking or a fresh approach to the project. Does the method and treatment of the problem show imagination? Does the method show an adaptation or creation of automated design tools.

4. Practical Application and Feasibility (25 points)
The proposal should present conclusions or recommendations that are feasible and practical, and not merely lead the evaluators into further difficult or insolvable problems.

Background

The United States Coast Guard plays a unique role among the U.S. services by assuming roles that span across the humanitarian, military, and civilian law enforcement realms. This plurality is ever more evident with the expansion of homeland security responsibilities and is captured in the Coast Guard's five core missions: Maritime Safety, Maritime Security, Maritime Mobility, National Defense, and Protection of Natural Resources.

The USCG counts with a multi-platform fleet to perform a wide variety of operations defined within this core mission set. This fleet includes small boats, cutters, rotorcraft, and fixed-wing aircraft. Current fixed-wing assets include the HC-130H "Hercules" and the HU-25 "Guardian" Falcon Jet, which operate from a limited number of Coast Guard Air Stations (CGAS) and serve as long-range and medium-range surveillance aircraft respectively. These aircraft are used in a variety of operations such as Search And Rescue (SAR), Drug Interdiction, Alien Migrant Interdiction, and transport of equipment and personnel.

The expansion of homeland security responsibilities across the various U.S. services, along with the aging service life of some USCG assets, has been partially responsible for the re-evaluation of coast guard capabilities, the assessment of its existing fleet, and the subsequent plan to acquire new assets accordingly. It is recognized that the evolution of the USCG fleet will follow the general trend observed in the armed forces: new platforms will be more flexible, providing a wider range of capabilities in a single platform that were previously offered by multiple ones.

For instance the USCG recently initiated the acquisition of 36 HC-144A "Ocean Sentry" units as the new medium range surveillance aircraft, focusing on its reconfigurability, range and size to fulfill an ever wider variety of missions. Likewise it plans to acquire 22 HC-130J units to expand long-range surveillance capabilities.

Opportunity Description

Projections of this fleet evolution trend suggest that next-generation platforms will further expand operational flexibility and capability ranges. These assets will be able to complete a wider range of missions, some of which may become more demanding on an individual basis. It is expected that homeland security and interdiction-type operations will grow in number and complexity, while other surveillance operations such as SAR, international ice patrol, marine environmental protection, and resource transport will experience only moderate change.

A USCG Next-Generation Interdictor (NGI) concept has been identified to meet these needs. This aircraft will serve as a replacement for current and upcoming medium-range surveillance platforms, and will represent an extension in platform capability by meeting important long range surveillance requirements as well as some of the slow-flight SAR and interdiction tactical maneuverability. Additionally its design will include maintainability and part-life considerations necessary for platforms continually operating in close proximity to the sea, as well ease of reconfiguration across a range of equipage variants.

Design Requirements

General Considerations

The NGI concept has been conceived as a fixed-wing, manned aircraft with an IOC date of 2030. The crew will consist of two, plus additional equipment operators as defined in specific design missions. The aircraft must accommodate all crewmembers ranging from the 5 percentile female to the 95th percentile male. The aircraft must also be compliant with appropriate Federal Aviation Regulations and Military Specifications.

Maintainability

The NGI is expected to operate from CGAS in close proximity to the coast, and will be required to perform extensive low-altitude patrol missions over maritime waters. It will also perform ice patrol missions and must be able to operate from austere bases with unpaved fields. Thus, maintainability and reliability are of critical importance in the design of the vehicle. Issues such as material selection and access panel location, among others, must address this design requirement accordingly.

Reconfigurability and Mission Flexibility

Coast Guard operators must be able to service the NGI and fully reconfigure it for different types of missions in a short turn-around time. The NGI will make use of a modular internal reconfiguration system based on palletized units. These units will be easily loaded and connected to provide the necessary accommodations and equipment for different missions. Thus it is expected that a variety of sensors will be permanently installed and adequately located on the exterior of the aircraft, whereas operator stations and equipment in the interior of the aircraft will be palletized, easily installed and removed, and interchangeable. Four main configurations have been identified for the NGI, though its design must accommodate new internal configurations to be determined in the future.

1. Full surveillance equipage: equipment / stations for a crew of 4 - 9,000 lbs
2. SAR: equipment / stations for a crew of 2 - 6,000 lbs (treat as partial version of full equipage suite);

rescue equipment pallet – 4,000 lbs (treat as bulk cargo with no power requirements)
3. Medical evacuation: must accommodate 24 patients in stretchers and 4 medics.
4. Multi-person transport: must accommodate 56 passengers

(NOTE: equipment weights are based on available equipment estimates, and do NOT include weight of operating crew. Weight estimates for stretchers, seats and other necessary structures to be determined by design proponents.)

No formal list of required external sensors is currently available. However the NGI assumes superior sensing and surveillance capabilities at the IOC date, as extrapolated from the current systems reference. Appendix A presents a list of currently available sensor equipment. Similarly, no specific design for the surveillance equipment crew stations is currently available. Design proposals must assume surveillance station units commensurate with geometry and layout of existing comparable equipment. Examples existing units are also shown in Appendix A.

Power Plant and Equipment Power Requirements

The NGI concept does not specify a power plant type, quantity, or any other relevant characteristic. However, the design and power plant selection of the NGI must adequately account for the anticipated power requirements of aircraft systems as well as those of the surveillance and detection equipment, even when these last are only installed and used in some missions. A platform architecture that meets this need in a flexible, adaptive fashion, building upon power-optimized and more-electric design trends, is highly desirable

Additionally cost considerations establish a preference for use of existing models or those expected to be available by the IOC date as part of the anticipated industry development. Proposals with all-new or derivative models are allowed, but must sufficiently document all cost implications and tradeoffs performed justifying this choice.

Infrastructure Compatibility

The NGI must make as much use as possible of existing and anticipated USCG infrastructure. This refers to use of runways, maintenance equipment, hangars, fueling and servicing equipment, loading equipment, etc.

Costs

The NGI program assumes a production schedule of 15 years and 200 units. The unit cost of the NGI is an important criterion for design selection, and should be reduced as much as possible without compromising key performance attributes. Additionally a maximum average unit cost of $75 million, FY2030$, is set. This value includes the palletized internal accommodations for operator stations and equipment used in the surveillance mission.

Takeoff and Landing Performance Requirements

The NGI must be able to operate from ALL existing Coast Guard Air Stations equipped for HC-130J and HC-144A deployment. Takeoff and landing distance requirements are set at 65% of runway length for each Air Station.

Although the NGI will be operating from paved runways on a regular basis it should allow for the safe take of and landing on austere locations where field conditions are deficient or where pavement is unavailable (e.g. grass and dirt strips).

Weight Restrictions

The NGI does not have an explicit maximum take off weight restriction. However, relevant weight, payload loading and landing gear configuration considerations must be accounted for in the design of the NGI to enable operations from the prescribed Air Stations and fields.

Missions

The NGI must be able to successfully complete all of the missions presented in this section. Missions should not assume air refueling. Mission segments or requirements whose limit/threshold values are not specified will be used as criteria for comparison and evaluation among proposed designs.

Surveillance / Interdiction

Crew: 2 pilots, 4 equipment operators
Payload: Palletized surveillance and detection equipment / operator stations – 9,000 lbs

Takeoff
Climb to cruise: 1,700 ft/min minimum average climb rate
Cruise at optimum altitude and optimum cruise speed no lower than 230 kts., for 1,000 nmi.
Loiter at optimum altitude, and speed, for 6 hours
Descend to 5,000 ft
Perform a 360 degree sustained level turn at a speed no greater than 170 kts for minimum turning radius
Cruise for 400 nmi at 170 kts
Climb to optimum cruise altitude, minimum average climb rate 1,700 ft/min
Cruise at optimum altitude and optimum cruise speed no lower than 230 kts, for 1,000 nmi
Descend and land
Allow for 30 minutes reserve at 7,000 ft and optimum speed.

SAR / Low-Altitude Patrol

Crew: 2 pilots, 2 equipment operators, 2 observers / rescue staff
Payload: Palletized surveillance and detection equipment / operator stations (partial) – 6,000 lbs; Rescue equipment – 4,000 lbs

Takeoff
Climb to cruise: 1,700 ft/min minimum average climb rate
Cruise at optimum altitude and optimum cruise speed no lower than 230 kts. for 800 nmi
Descend to 2,000 ft
Perform a 360 degree sustained level turn at a speed no greater than 150 kts for minimum turning radius
Cruise at patrol speed, no greater than 155 kts, for maximum allowable distance
Climb to optimum cruise altitude, minimum average climb rate 1,700 ft/min
Cruise at optimum altitude and optimum cruise speed no lower than 230 kts, for 800 nmi
Descend and land
Allow for 30 minutes reserve at 7,000 ft and optimum speed.

Cargo Mission

Crew: 2 pilots
Payload: 23,000 lbs

Takeoff
Climb to cruise: 1,200 ft/min minimum average climb rate
Cruise at optimum altitude and optimum cruise speed no lower than 230 kts. for maximum allowable range.
Descend and land
Allow for 30 minutes reserve at 7,000 ft and optimum speed.

NOTES:
Assume that cargo is palletized, and is loaded/unloaded using palletized system on the NGI. No internal units or accommodations required for cargo mission.

Human Transport – Med-Evac & Multi-Person

Crew: 2 pilots
Payload: To be calculated by proponents

Takeoff
Climb to cruise: 1,700 ft/min minimum average climb rate
Cruise at optimum altitude and optimum cruise speed no lower than 230 kts. for maximum allowable range.
Descend and land
Allow for 30 minutes reserve at 7,000 ft and optimum speed.

NOTES:
This mission uses the medical evacuation configuration, or the multi-person transport configuration, as identified in the section for "Reconfigurability and Mission Flexibility". Proponents must estimate and support the total payload for these two configurations.

Data Requirements

The technical proposal must clearly and concisely present the design of the NGI, covering all relevant aspects, features and disciplines of the finalized system and explaining with adequate detail the methodologies, studies and tradeoffs performed. A full description of the aircraft's performance capabilities and operational limits is expected. These include, as a minimum:

1. Aircraft weight statement
2. Aircraft center-of-gravity envelope
3. Complete geometric description, including clearances, control surfaces, fuselage size and volume, landing gear, etc.
4. Materials selection for main structural groups and general structural design
5. Aircraft drag polars for cruise, takeoff, and landing configurations, and description of high-lift devices
6. Powerplant description and relevant performance maps/trends (e.g. thrust, TSFC vs. alt, V)
7. Summary of stability and control analyses
8. Summary of cost estimate analysis, production schedule, main cost groups and drivers, etc.
9. Complete description of mission performance for each of the four missions, including non-specified elements (optimum cruise altitude and speed, minimum turning radius, maximum allowable distance in patrol configuration, maximum range, etc)
10. Flight envelope (altitude vs. speed) and a V-n diagram
11. Takeoff and landing performance

12. Compliance with relevant regulations

Proponents must substantiate and document all major design choices and performance trades indicating how said choices address one or more of the design requirements contained herein. This includes, but is not limited to, trades and sensitivities for powerplant selection among several types, determination of best altitude and speed profile for cruise and loiter, weight and cost minimization, etc. Major design drivers and tradeoffs should be clearly identified.

Likewise the proposal must adequately document all assumptions and substantiate any necessary estimates such as operator station power requirements or weight estimates for palletized equipment for each configuration. Assumption traceability is particularly critical with respect to future equipment, anticipated trends, and technology availability, maturity, uncertainty, and capabilities afforded.

Finally, the proposal must include 3-views and 3-D model imagery depicting the following:

- General configuration of the aircraft, placement of external sensors and equipment, and internal layout of primary and secondary structures, as well as subsystems
- Main access panels and performance of notional maintenance and subsystem replacement/servicing procedures by ground personnel
- Internal layout of main compartment and pallet system, internal layout of the aircraft for the four prescribed configurations, and notional loading-unloading procedure of palletized surveillance operator station modules (configuration 1) by ground crew

Appendix A

<u>Sensor Equipment:</u>

- Forward looking infrared/electro-optical sensors
- High-resolution, long altitude video capture
- Direction finding equipment
- Automatic Identification System (AIS)
- Satellite and emergency response radios
- C4ISR equipment
- Mission data recording
- First-responder/law enforcement and marine communications suite
- Enhanced secure data encryption capabilities

Sources: [1], [2]

Workstation aboard an HC-130J. Source: [1]

A Mission System Pallet aboard the HC-144A. Source: [1]

[1] King S, Mellott E. Coast Guard HC-144A and HC-130J Projects Spotlight Aircrew Training Efficiency. Delivering the Goods: News from U.S. Coast Guard Acquisition Vol: 6, April/may 2008, page 3

Available at: http://www.uscg.mil/acquisition/newsroom/pdf/cg9newsletterapr_may08.pdf

[2] Medium Range Surveillance Aircraft, United States Coast Guard, URL: http://www.uscg.mil/acquisition/mrs/features.asp, Accessed: 5/15/2008

Intent Form

2008/2009
AIAA Foundation
Graduate Team Aircraft Design Competition
Request for Proposal:
A USCG Next-Generation Interdictor (NGI)

Title of Design Proposal: ____

Name of School: ____

Designer's Name	**AIAA Member #**	**Graduation Date**	**Degree**
____________________ Team Leader	____________	____________	__________________
________________________ Team Leader E-mail			
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In order to be eligible for the 2008/2009 AIAA Foundation Graduate Team Aircraft Design Competition, you must complete this form and return it to AIAA Student Programs ***before 13 March 2009***, at AIAA Headquarters, along with a one-page "Letter of Intent" as noted in Section III, "Schedule and Activity Sequences." For any nonmember listed above, a student member application and member dues payment should also be included with this form.

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Signature of Faculty Advisor | Signature of Project Advisor | Date

____

Faculty Advisor – Printed | Project Advisor – Printed | Date