2002 Request for Proposals

Light Helicopter Upgrade Program

19th Annual Student Design Competition

for

Undergraduate and Graduate Students

Sponsored by

and

Bell Helicopter TEXTRON
POST OFFICE BOX 482 * FORT WORTH TEXAS 76101
A SUBSIDIARY OF TEXTRON INC.

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1. Design Requirements and Objectives

There is as an abundant resource of aging light helicopters retired or will soon be retired that presents an opportunity for upgrade and re-manufacture for the purpose of increased performance, safety and reliability at a fraction of the cost of acquisition of a newly manufactured commercial helicopter. The wide-ranging multi-role missions remain a requirement, while increased speed, range and improved navigational aids are to be incorporated into the re-manufactured helicopter.

The aging 4-6 place turbine helicopters are typically capable of 110 - 130 kt, and the proposed advance is to be significant to justify the cost of acquisition. A specific helicopter model is to be selected for an upgrade program. Both commercial and military helicopters due for retirement or already retired are candidates for this commercial application. The model should be in service in sufficient quantity to support the proposed 450 aircraft minimum.

The aircraft must be designed in accordance with FAR parts 23 & 27 and other appropriate standards. The proposal may apply prior rules based on certification level of helicopter selected for upgrade. Substantiation and reasoning of prior rules application intent will be required. In order to meet stringent manufacturing cost restrictions, specific attention must be paid to minimizing the number of man-hours required to fabricate components and re-manufacture the helicopter. Manufacturing processes should be identified for each of the air vehicle subsystems. Features of the subsystems that reduce the aircraft's operational cost per flight hour should be identified.

1.1 Target Performance Goals

A. Speed – 140 kt cruise
B. Range – 400 nm absolute (dry tank)
C. Payload – An increase in current capability, plus increased seating capacity is a bonus

2. Participation

2.1 All graduate and undergraduate students may participate in this competition. Part time students may participate at the appropriate graduate or undergraduate level.

2.2 Schools are encouraged to form project teams, although individual entrants may participate. The highest education level on the team will determine the classification of the design team. There is no limit on the number of students on a team. Air vehicle designs must be the work of the students. Guidance may be provided by faculty advisors and should be acknowledged.

2.3 Air vehicle design projects used as part of organized curriculum requirements or class work are eligible and encouraged to enter this competition.

2.4 The AHS must be notified of the intent to submit a proposal in accordance with the schedule in section 4. Each individual or team may submit only one proposal, however, any number of proposals may be submitted from any school. If any student or team wishes to withdraw from the competition, they must notify the AHS National Headquarters immediately in writing.

3. Awards

Graduate Category:

- 1st place - $1000
- 2nd place - $500

Undergraduate Category:

- 1st place - $1000
- 2nd place - $500

In addition, the best new entrant (1st or 2nd year of participation) in each category will also be awarded $500.

Certificates will be presented to the winners and to their faculty advisors for display at the school. In the case of teams, each member will receive a certificate. The 1st place winner, or a representative if a team, in each category will be expected to present a technical summary of their design at the 2003 AHS Annual Forum. The 1st place winners will receive complimentary registration to the 2003 AHS Annual Forum and Bell Helicopter will provide $1000 to help defray the cost of attendance.

4. Evaluation Criteria

The proposal will be judged in 4 categories with the following weighting factors:

A. Technical Content (40 points)

- Design meets RFP requirements
- Assumptions are clearly stated and logical
- All major technical issues are considered
- Appropriate trade studies are performed to direct/support the design process
- Well balanced and appropriate substantiation of complete aircraft and subsystems with an emphasis on the systems to be upgraded
- Technical drawings are clear, descriptive, and represent a realistic design

B. Application & Feasibility (25 points)

- Proposal exhibits an understanding of the baseline helicopter to be upgraded
- Technology levels used are justified and substantiated
- Affordability considerations influenced the design process
- Reliability and maintainability features influenced the design process
- Manufacturing methods and materials are considered in the design process
- Performance enhancements meet the Design Requirements and Objectives
- Proposal demonstrates an appreciation for the operation of the aircraft in its current mission profiles as well as expanded applications

C. Originality (20 points)

- Aircraft concept is innovative and shows the use of imagination in treatment of problems
- Unique vehicle attributes and subsystem integration show innovative thinking
- Aesthetically pleasing lines and features

D. Organization & Presentation (15 points)

- Meets all format and content requirements
- Self-contained Executive Summary contains all pertinent information and a compelling case as to why the proposal should win.
- Introduction clearly describes the major features of the proposed helicopter upgrade
- Proposal is well organized so that all information is readily accessible and in a logical sequence
- Clear and uncluttered graphs and drawings

5. Schedule

Issue of RFP ....August 20, 2001
Request for information and clarification ....Up to April 16, 2002
Submit Letter of Intent to Propose (Outline of maximum 20 pages).......... April 16, 2002
Submit 6 copies of proposal (postmark date) ....July 2, 2002
Bell notifies AHS of winners..........August 9, 2002
AHS announces winners..........August 13, 2002
Presentation of winning papers at AHS Forum ....May 2003

All questions by teams put forward to the AHS before submittal of the Proposal Outline will be distributed with answers to all participating teams. Any Questions or Requests for Clarifications from the judges after review of a team's Proposal Outlines will not be provided to other teams.

6. Contacts

All correspondence will be mailed to the following address:

Kim Smith, Deputy Director
AHS
217 N. Washington St
Alexandria, VA, 22314

Telephone number: (703) 684-6777
Fax number: (703) 739-9279
Email: kim@vtol.org

7. Data Package

7.1 Powerplant

For such an airframe project, a parallel engine development would be undertaken. For a user-selected takeoff power P_{TO} between 200 and 1,000 kW, this engine would have the following characteristics:

SL ISA Uninstalled Takeoff power (kW) P_{TO} = given

SL ISA Maximum Continuous power (kW) P_{MC} = 0.8 P_{TO}

The above powers available vary at altitude in direct proportional to the density ratio (σ).

Specific Fuel Consumption @ P_{TO} (μg/J) $W_{FTO} = 300 \times P_{TO}^{-0.2}$

SFC @ any power P_X and altitude (μg/J) $W_{FX} = W_{FTO} \times (2\,(P_X/P_{TO})^2 - 4(P_X/P_{TO}) + 3) \times \sqrt{\sigma}$

Engine Mass (kg)	M_E	$= 20 + 0.12\,P_{TO}$
Engine Length (m)	L_E	$= 0.4 + 0.0006\,P_{TO}$
Engine Diameter (m)	D_E	$= 0.2 + 0.0005\,P_{TO}$
Output shaft speed (rpm)	N_E	= 21,000
Engine Cost (^{99})		$= 200 \times P_{TO}$

7.2 Weights

Pilot and passengers 80 kg each

Baggage allowance 22 kg/person (inc. pilot)

A fuel specific density of 0.81 (Jet-A) is to be used.

7.3 Cost

The following cost estimating relationships **may** be used to analyze design trades using existing technology levels. The cost components to be calculated are to include those systems being replaced by new components. The equations provide an average recurring cost to manufacture a specific quantity of a commercial aircraft to be certified in accordance with FAR Parts 23 & 27. To estimate the selling price of the aircraft, the total cost result should be increased by 50% to account for tooling amortization and profit. Cost of acquisition of the helicopter to be re-manufactured shall be included and averaged.

The equations are based on historical cost data and use weight (in kg), total production quantity, and production rate as primary cost drivers. Additional variables are used to adjust for differences in manufacturing complexities between various design parameters. These equations may be modified to account for the use of new or unusual manufacturing technology. Changes must be substantiated.

Estimates should be based on re-manufacturing 450 aircraft at a rate of 75 aircraft per year.

7.3.1 Global Variables

Prodq = Total production quantity

Prodr = Production rate per year

7.3.2 Rotor System Group

Average Main Rotor System Cost = 1,500 x $Weight^{.7}$ x Kyokmat x $Bldno^{.2}$ x Kbldmat x x $(Prodq \times Prodr)^{-.08}$

where: Weight = Predicted weight of the Rotor System

Kyokmat = Yoke material factor

Al = 1

Steel = 1.7

Titanium = 2.3

Composite = 2.8

Bldno = Number of main rotor blades (total for multiple rotors)

Kbldmat = Blade Material Factor

Metal = 1

Composite = 1.6

Average Tail Rotor Cost = 2,500 x $Weight^{.7}$ x Kyokmat x Kbldmat x $Bldno^{.9}$ x $(Prodq \times Prodr)^{-.08}$

Where: Weight = Weight of tailrotor

Kyokmat = Tail rotor yoke material factor

Aluminum = 1

Steel = 1.7

Titanium = 2.3

Composite = 2.8

Kbldmat = Tail rotor blade material factor

Metal = 1

Composite = 1.6

Bldno = number of tail rotor blades

7.3.3 Airframe Group

Average Airframe Structure Cost = 10,000 x $Weight^{.8}$ x Kmat x $(Prodq \times Prodr)^{-.13}$

Where: Weight = Weight of fuselage

Kmat = Fuselage material factor

Metal = 1

Composite (Assembly similar to metal) = 1.6

Composite (Large single-cure parts) = 1.1

7.3.4 Landing Gear Group

Average Landing Gear Cost = 5,000 x $Weight^{.5}$ x Klgtyp x $(Prodq \times Prodr)^{-.08}$

Where: Weight = Weight of landing gear

Klgtyp = Landing gear type

Skid gear = 1

Fixed wheel = 1.5

Retractable = 2.0

7.3.5 Powerplant Structure Group

Average Powerplant Structure Cost = 5,000 x $Weight^{.8}$ x $Noeng^{.1}$ x $(Prodq \times Prodr)^{-.12}$

Where: Weight = Weight of firewalls and panels

Noeng = Number of engines

7.3.6 Air Induction Group

Average Air Induct Cost = 5,000 x $Weight^{.8}$ x $Noeng^{.5}$ x $(Prodq \times Prodr)^{-.09}$

Where: Weight = Weight of inlets

Noeng = Number of engines

7.3.7 Propulsion Group

Average Engine Installation Cost = (2,000 x $Weight^{.7}$ x $Noeng^{.8}$x $(Prodq \times Prodr)^{-.06}$) + Engine Cost

Where: Weight = Weight of propulsion system

Noeng = Number of engines

Average Drive System Cost = 2,500 x $Weight^{.9}$ x $Noeng^{.4}$ x $(Prodq \times Prodr)^{-.07}$

Where: Weight = Weight of drive system

Noeng = Number of engines

7.3.8 Flight Controls Group

Average Flight Control System Cost = 300 x $Weight^{1.0}$ x $Bldno^{.5}$ x Kcontyp x $(Prodq \times Prodr)^{-.06}$

Where: Weight = Weight of flight control system

Bldno = Number of main rotor blades

Kcontyp = Flight control type factor

Mechanical = 1

Fly-by-wire = 1.5

7.3.9 Instrument Group

Average Instrument System Cost = 1,500 x $Weight^{1.0}$ x Ktype x $(Prodq \times Prodr)^{-.06}$

Where: Weight = Weight of instrument system

Ktype = Instrument type factor

Mechanical = 1

Electronic (EFIS, IIDS) = 4

7.3.10 Hydraulics Group

Average Hydraulic System Cost = 1,000 x $Weight^{1.0}$ x $(Prodq \times Prodr)^{-.07}$

Where: Weight = Weight of hydraulic system

7.3.11 Electrical Group

Average Electric System Cost =2,000 x $Weight^{.9}$ x $(Prodq \times Prodr)^{-.10}$

Where: Weight = Weight of electric system

7.3.12 Avionics Group

Average Avionics System Cost = 2,500 x $Weight^{1.0}$ x $(Prodq \times Prodr)^{-.08}$

Where: Weight = Weight of avionics system

7.3.13 Furnishings and Equipment Group

Average Furnishings System Cost = 500 x $Weight^{1.1}$ x $(Prodq \times Prodr)^{-.08}$

Where: Weight = Weight of furnishing and equipment (to include acoustical treatments)

7.3.14 Air Conditioning Group

Average Air Conditioning System Cost = 2,000 x $Weight^{.8}$ x Kecu x $(Prodq \times Prodr)^{-.06}$

Where: Weight = Weight of air conditioning system

Kecu = Environmental control unit factor

Without ECU = 1

With ECU = 1.9

7.3.15 Load and Handling Group

Average Load & Handling System Cost = 2,000 x $Weight^{.8}$ x $(Prodq \times Prodr)^{-.10}$

Where: Weight = Weight of load & handling system

7.3.16 Final Assembly

Average Final Assembly Cost = 30,000 x $Weight^{.4}$ x $Engno^{.9}$ x Kfusmat x $(Prodq \times Prodr)^{-.15}$

Where: Weight = Total empty weight of aircraft

Engno = Number of engines

Kfusmat = Fuselage material factor

Metal = 1

Composite = .9

7.3.17 System Components

The following information indicates the subsystem components that make up the system level components above. Note that attention is to be given primarily to the systems that are being upgraded.

- Main Rotor
  - Hub
  - Blades
  - Rotor Vibration Suppression
- Tail Rotor
  - Hub
  - Blades
- Body
  - Nose
  - Cockpit
  - Main Cabin
  - Crew Doors
  - Passenger/Cargo Doors
  - Baggage Compartment Door
  - Transparencies
  - Tailboom
  - Horizontal & Vertical Stabilizer
  - Pylon Vibration Suppression
- Landing Gear
  - Skid Gear
  - Main Wheel Gear
  - Aux Wheel Gear
  - Tail Bumper
- Powerplant Structure
  - Firewall
  - Cowl
  - Engine Mounts
  - Support Structure
- Air Induction
  - Air Inlet
  - Inlet Part Separator
- Propulsion

    - Engine
    - Engine Installation
    - Ejector
    - Tailpipe
    - Engine Controls
    - Engine. Start System
    - Propeller/Fan
    - Engine Cooling & Wash
    - Lubrication System
    - Fuel System
- Drive System
    - Main Transmission
    - Speed Reduction Gearbox
    - Freewheel Unit
    - Rotor Brake
    - Tailrotor 90 Deg Gearbox
    - Tailrotor Intermediate Gearbox
    - Engine. Input Shaft
    - Engine Nosebox/Bevel Gearbox
    - Combining Gearbox
    - Main Rotor Mast
    - Tailrotor Driveshaft
- Flight Controls
    - Cockpit Controls
    - Automatic Flight Control System
        - Automatic Flight Control System Equipment
        - Fly-By-Wire Wiring
    - Non-Rotating Controls
    - Rotating Controls
        - Main Rotor
        - Tail Rotor
    - Rudder Actuator & Controls
    - Elevator Controls
    - Main Rotor Hydraulic Actuators
- Instruments
- Hydraulics

- Electrical
  - Generator/Alternator
  - Battery
  - Transformer/Rectifier
  - Inverter
  - Distribution
- Avionics
  - Equipment
  - Installation
- Furnishings & Equipment
  - Crew Seats
  - Passenger Seats
  - Fire Extinguisher System
  - Soundproofing
  - Furnishings
- Air Conditioning
  - Bleed Air/Heat Defog
  - Environmental Control Unit
- Load & Handling
- Final Assembly

8. Proposal Data Package Requirements

Six copies of the proposal must be submitted to the AHS. Hardcopy or digital format readable using Microsoft Word 97, PC format is acceptable.

The proposal is not to exceed 100 typewritten 8½ x 11 or A4 pages, with a font of not less than 11 pt 1½ spaced, and will contain:

A. The following 7 items which are not numbered and not included in the page limit -
  - Cover page with the name of the school and the judging category
  - Page carrying the names and signatures of all members of the team
  - Table of Contents
  - List of Figures
  - List of Tables
  - List of Symbols and Abbreviations
  - Proposal Requirements Matrix

B. Executive Summary not to exceed 4 pages (including figures)

C. Table of Physical Data listing -
  - Major dimensions

- Gross weight, empty weight, and useful load
- Fuel capacity
- Engine TO (5 min) and MCP ratings
- Transmission ratings

D. MIL-STD-1374 Weight Statement

E. Recurring Cost Breakdown

F. Performance Charts -
   - HOGE altitude vs. gross weight
   - Payload vs. range
   - Altitude vs. maximum continuous speed

G. Drawings -
   - General Arrangement fold-out drawing on 1 or 2 sheets of 11x17 paper showing major dimensions and alternate modes (if applicable)
   - Inboard Profile fold-out drawing on 11x17 paper showing the size and location of major aircraft features and systems
   - Drive system schematic with gear ratios and shaft speeds

H. A description of the process by which the configuration was selected, a description of the technical approach and the design features of the air vehicle, and an explanation of the analyses supporting the design data. Special attention will be paid to the proposed manufacturing processes.

The proposal should convey an understanding of the RFP requirements as well as an understanding of the helicopter baseline configuration that the upgrade is to affect in terms of the significance of the various design features of the air vehicle, and the analysis used to select and design those features.