36th Annual Student Design Competition

2018-2019 Request for Proposal (RFP)
for an

Extreme Altitude Mountain Rescue Vehicle

Sponsored by

AIRBUS

FINAL 2.0 - 08/15/2018

Table of Contents

1.0 Basic Proposal Information

Airbus Helicopters **extends greetings and invites you to participate in the 36th Annual Student Design Competition (SDC) of *the Vertical Flight Society* (VFS),** previously known as the American Helicopter Society (AHS) International**.**

This Request for Proposal (RFP) is divided into two sections. Section 1 (this section) provides a general description of the competition and the process for entering. This section covers the rules (both general and proposal specific) and schedules what the sponsor requires of the participants. It also describes the awards and provides contact information. Section 2 describes the specific challenge by Airbus Helicopters and VFS.

1.1 Rules

1.1.1 Who May Participate

All undergraduate and graduate students from any school (university or college) may participate in this competition (with the exception of countries or persons prohibited by the United States government). A student may be full-time or part-time; their education level will be considered in the classification of their team (see 1.1.3).

1.1.2 Team Size and Number of Teams

We encourage the formation of project teams.

- **ALL teams, regardless of size, MUST name at least one (1) faculty advisor in order to compete**
- **the maximum number of students on a single-university team is ten (10)**
- **the minimum team size is one (1), an individual**
- **schools may form more than one team, and each team may submit a proposal, but each team is limited to a maximum of ten students**
- **a student may be a member of one team only**

We look favorably upon the development of collaborative, multi-university teams for the added experience gained in education and project management. ***The maximum number of students for a multi-university team is twelve (12), distributed in any manner over the multi-university team*.**

The members of a team must be named in the Letter of Intent. The Letter of Intent is drafted by the team captain and emailed to the Vertical Flight Society contact by the date specified in section 1.3. Information in the Letter of Intent must include:

- **name of the university or universities forming the team**
- **name of the team**

- **printed names of the members of the team from all the universities in the team**
- **e-mail addresses and education level (undergraduate or graduate) of each team member, including the team captain and faculty advisor(s)**
- **affiliation of each student in the case of a multi-university team**
- **printed names and affiliations of the team captain and faculty advisor(s)**

1.1.3 Categories and Classifications

The competition has three categories, in additional to an optional bonus task, that are eligible for prizes. They are:

- Undergraduate Student Category (1st, 2nd, 3rd)

- Graduate Student Category (1st, 2nd, 3rd)
  NOTE: The classification of the team is determined by the highest educational level currently pursued by any member of the team.

- New Entrant Category: A new entrant is defined as any school (undergraduate or graduate) that has not participated in the last three competitions.

- Bonus Weight Optimization (*Optional)*: A bonus award will be provided to one undergraduate and one graduate team that successfully meets the evaluation criteria stated in the optional Bonus Task Section 2.2.3 in addition to all other submission requirements.

1.1.4 Language of Proposal

Regardless of the nationality of the teams, all submittals and communications to and from the Vertical Flight Society will be in English.

1.1.5 Units Used in Proposal

All teams must submit using both English and SI units. The primary units are to be SI units, followed by the secondary units in parentheses. The use of units shall be consistent throughout the proposal. All engineering units should be expressed in the units of Newtons (force), kilograms (mass), seconds, minutes or hours as appropriate (time), meters (length), and kilometers per hour (velocity).

1.1.6 Proposal Format, Length and Medium

Two separate files (three if the team is participating in the optional Weight Optimization bonus task) comprise the Final Submittal; each file must be provided for a submission to be considered complete. The judges shall apply a penalty if a file is missing.

The two mandatory files are the Executive Summary and the Final Proposal. Each is described herein.

The first file is called the Final Proposal. It is the complete, self-contained proposal of the team. It shall be submitted in PDF format readable with Adobe Acrobat. Exceptions will be considered with advance request.

Undergraduate category Final Proposals shall be no more than 50 pages and graduate category Final Proposals shall be no more than 100 pages. All pages are to be numbered except the cover. This page count includes all figures, diagrams, drawings, photographs and appendices. In short, anything that can be read or viewed is considered a page and subject to the page count, with the following exceptions: the cover page, acknowledgement page, signature page, posting permission page (see section 1.1.9), table of contents, list of figures, list of tables, nomenclature, reference pages and the Executive Summary are excluded from the page count for the Final Proposal. See section 1.1.7 for specific information about the signature page.

Pages measure 8 ½ x 11 inches. Undergraduate submissions may have four (4) larger fold-out pages with a maximum size of 11 x 17 inches, and graduate submissions may have eight (8) larger fold-out pages with a maximum size of 11 x 17 inches. If a submission exceeds the page limit for its category, the judges will apply a penalty equal to ¼ point per page over the limit.

All proposals and summaries shall use a font size of at least 10 point and spacing that is legible and enhances document presentation.

The second file is a PDF file called the Executive Summary. This is a self-contained "executive" briefing of the proposal. Both undergraduate and graduate category Executive Summaries are limited to twenty (20) pages measuring 8 ½ x 11 inches, with no more than four (4) larger fold-out pages of a maximum size of 11 x 17 inches. The Executive Summary can take the form of a viewgraph-style presentation, but it must be a PDF file readable with Adobe Acrobat. No additional new technical content may be introduced in the Executive Summary. The judges shall apply the same page count penalty to the Executive Summary score as with the Final Proposal. The Executive Summary is not scored separately but contributes up to 10% of the total score of the complete submission.

The third file (optional) is a PDF file describing the Bonus Weight Optimization Task (if submitted) conducted in accordance with the requirements defined in 2.2.3.

All submissions shall be made via e-mail to the VFS contact OR by upload to VFS – team captains will be notified how and where to upload their final submissions.

1.1.7 Signature Page

All submittals must include a signature page as the second page, following immediately after the cover page. The signature page must include:

- **printed name, e-mail addresses and education level (undergraduate or graduate)**
- **signature of each student that participated**
- **in the case of a multi-university team, the page must also indicate the affiliation of each student**

The submittals must be wholly the effort of the students, but faculty advisors may provide guidance. The signature page must also include the printed names, e-mail addresses and signatures of the faculty advisors.

Design projects for which a student receives academic credit must be identified by course name(s) and number(s) on the signature page.

1.1.8 Withdrawal

If a student withdraws from a team, or if a team withdraws their project, including the Bonus Task, from the competition, the team captain must notify the VFS Student Design Competition point of contact in writing immediately via email.

1.1.9 Permission/Proposal Posting

VFS will post at least the Executive Summaries of each of the winning entries in the undergraduate and graduate categories on their web site. *Therefore written permission MUST appear on a separate page immediately following the signature page*. This permission page will not count against the page count.

1.2 Awards

Airbus Helicopters is very pleased to sponsor the 36th Annual Vertical Flight Society Student Design Competition this year. Airbus will provide the funds for the awards and travel stipends, as described below (all amounts in US Dollars). Submittals are judged in three (3) categories, with an additional optional bonus task.

Undergraduate category:

- 1st place - $2,000
- 2nd place - $1,200
- 3rd place - $750

Graduate category:

- 1st place - $2,500
- 2nd place - $1,800
- 3rd place - $1,000

Best New Entrant (as defined in section 1.1.3):

- Undergraduate - $500
- Graduate - $750

Optional Weight Optimization Bonus Task sponsored and funded by **Altair** (as defined in section 2.2.3):

- $1,000 – awarded to one *undergraduate* team completing the bonus task, judged independent from the design portion
- $1,000 – awarded to one *graduate* team completing the bonus task, judged independent from the design portion

Certificates of achievement will be presented to each member of the winning team and to their faculty advisors for display at their school. A team representative for the first place graduate and undergraduate winners is expected to present a technical summary of their design at the Vertical Flight Society's 76th Annual Forum, May 19-21, 2020 in Montreal, Canada, during an Aircraft Design Technical Session. The individual(s) presenting the winning design will receive complimentary registration and will be provided a $1,000 stipend to help defray the cost of attendance.

The Vertical Flight Society and the Student Design Competition Committee reserves the right to decline to make all of the awards in the above categories if there are not a sufficient number of submissions that meet the expectations of the judges. Proposals that do not, in the assessment of the judges, demonstrate an adequate understanding of the problem may be deemed ineligible for an award. In addition, any proposal that includes plagiarism or that copies substantial portions of prior proposals or publications will be disqualified.

1.3 Schedule

Schedule milestones and deadline dates for submission are as follows:

Milestone	**Date**
VFS Issues a Request For Proposal	**August 15, 2018**
Submit Letter of Intent to Participate, including intent to participate in the Weight Optimization Bonus Task (Optional)	**No Later Than (NLT) February 4, 2019**
Submit Requests for Information/Clarification, including Altair Bonus Task questions	**Continuously, but NLT February 28, 2019**
VFS Issues Responses to Questions	**NLT March 29, 2019**
Teams submit Final Submittal (Final Proposal and Executive Summary)	**NLT May 31, 2019**
SDC Committee completes proposal evaluations	**August 1, 2019**
VFS announces winners	**August 15, 2019**
Winning team presents at VFS Annual Forum	**May 19-21, 2020**

To reiterate:

- Letter of Intent must be received by the Vertical Flight Society no later than **February 4, 2019**, **and must include your team's intent to participate in the Weight Optimization optional bonus task or not**. The signature page must include all of the information requested in section 1.1.7.

- All questions and requests for information/clarification from teams must be submitted to VFS by **February 28, 2019 and can include questions on the Weight Optimization bonus task.**

- VFS will distribute ALL of the questions and answers **collectively to ALL entrant team captains by March 29, 2019.**

- **Final proposals must be submitted by May 31, 2019**. Team captains will be advised by VFS where and how to submit their final proposals.

1.4 Contacts

All correspondence with VFS must be directed to:

Julie M. Gibbs, Technical Programs Director
The Vertical Flight Society
2701 Prosperity Ave., Ste. 210
Fairfax, VA 22031 USA
Phone: +1-703-684-6777 x 103
E-mail: jmgibbs@vtol.org

1.5 Evaluation Criteria

The proposals will be judged on four (4) primary categories with the weighting factors specified below.

A. Technical Content (40 points)

The Technical Content of the proposal requires that …

- The design meets the RFP technical requirements
- The assumptions are clearly stated and logical
- A thorough understanding of tools is evident
- 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 is present
- Technical drawings are clear, descriptive, and accurately represent a realistic design

B. Application & Feasibility (25 points)

The proposals will be judged on how well current and anticipated technologies are applied to the problem, and on the feasibility of the solution. The proposals must …

- Justify and substantiate the technology levels that are used or anticipated
- Direct appropriate emphasis and discussion to critical technological issues
- Discuss how affordability considerations influenced the design process
- Discuss how reliability and maintainability features influenced the design process
- Discuss how manufacturing methods and materials were considered in the design process
- Show an appreciation for the operation of the aircraft

C. Originality (20 points)

The originality of the proposal shall be judged on …

- How innovative is the solution
- How much does the solution demonstrate originality and show imagination
- Vehicle/system aesthetics

D. Organization & Presentation (15 points)

The organization and presentation of the proposal requires …

- A self-contained Executive Summary that contains all pertinent information and a compelling case as to why the proposal should win. It must be a separate file.
- An introduction that clearly describes the major features of the proposed system
- A well-organized proposal with all information presented in a readily accessible and logical sequence
- Clear and uncluttered graphs, tables, drawings and other visual elements
- Complete citations of the state-of-the-art technologies relevant to the work
- Professional quality and presentation
- The proposal meets all format and content requirements
- The RFP describes the proposal requirements (section 1.6) and design objectives (section 2)

1.6 Proposal Requirements

The Final Submittal needs to communicate a description of the design concepts and the associated performance criteria (or metrics) to substantiate the assumptions and data used and the resulting predicted performance, weight, and cost. Use the following as guidance while developing a response to this Request for Proposal (RFP):

A. Demonstrate a thorough understanding of the RFP requirements.

B. Describe how the proposed technical approach complies with the requirements specified in the RFP. Technical justification for the selection of materials and technologies is expected. Clarity and completeness of the technical approach will be a primary factor in evaluation of the proposals.

C. Identify and discuss critical technical problem areas in detail. Present descriptions, method of attack, system analysis, sketches, drawings and discussions of new approaches in sufficient detail in order to assist in the engineering evaluation of the submitted proposal. Identify and justify all exceptions to RFP technical requirements. Design decisions are important, but so is the process and substantiation.

D. Describe the results of trade-off studies performed to arrive at the final design. Include a description of each trade and a thorough list of assumptions. Provide a brief description of the tools and methods used to develop the design.

Section 1.1.6, titled “Proposal Format, Length and Medium” describes the data package that a team must provide in the Final Submittal. Specifically, the Final Submittal must contain the primary two files submitted via email and/or via the VFS SDC web page (instructions/passwords to be provided to Team Captains).

1. The first file is the ***Final Proposal***, which is the full length, complete and self-contained proposed solution to the RFP. By self-contained, we mean that the proposal does not refer to and does not require files other than itself.
2. The second file is an ***Executive Summary***, which presents a compelling story why the VFS evaluators should select your design concept. The Executive Summary should highlight critical requirements and the trade studies you conducted, and summarize the rotorcraft concept design and capabilities.
3. The third file (optional) is the ***Bonus Weight Optimization Task*** (if submitted) conducted in accordance with the requirements defined in 2.2.3.

2 System Objectives

2.1 Operating Concept

On May 14, 2005, the Airbus H125 (then called the AS350 B3) piloted by Didier Delsalle, was recorded as completing the highest helicopter landing and takeoff at 8,848 meters (29,029 feet) on Mount Everest – the highest point on earth – an unbeatable title it still holds alone today.

However, evacuating people during helicopter rescue missions in such extreme altitudes is not possible today and remains an immense challenge, for the rotorcraft as well as for the crew, even in lower altitudes. Freezing temperatures, thin air and hostile weather conditions with oftentimes degraded visual environment all contribute to making rescue work in high-altitude environments particularly dangerous.

As the environment changes very rapidly, getting relevant information for mission preparation and possible mission adjustments can be of similar importance as rotorcraft performance.

Today serial helicopters, based on multi-purpose design trade-offs, with known good high-altitude performance are somewhat adapted to allow high altitude mountain rescue operations in extreme conditions. However no rotorcraft model is available today that has been specifically designed for this specific task.

The goal of this year's VFS Student Design Competition is to answer the question:
What would a rotorcraft look like when specifically designed to perform emergency medical services up to the highest peaks of the planet? What technologies could enable such a vehicle? Could it be used for other purposes as well?

2.2 Specific Objectives

The goal of this year's competition is to develop a conceptual design for a rotorcraft capable of performing rescue missions up to the highest altitudes in the world.

2.2.1 Task 1: Vehicle Conceptual Design (ALL Participants)

Teams taking part in this competition must choose a rotorcraft configuration (classical single-main rotor helicopter, tandem, side-by-side, compound aircraft, etc.) and the engine technology best suited to perform the high-altitude rescue mission stated below.

The design task includes:

- Trade studies for competing overall architectures / vehicle configurations
- Rotating system optimization studies
- Engine optimization studies based on existing engine technologies

- Performance analysis for the relevant atmospheric conditions for the specific mission
- Weight breakdown (according to Military Standard MIL-STD-1374, SAWE RP-A7 or RP-8 or similar format)
- Center of Gravity analysis throughout the mission
- Transmission architecture
- Technological studies for the key components
- Cost considerations

Teams should pay particular attention to designing a compact airframe/rotor configuration that meets the mission requirements. Important design aspects include simplicity of design, a low maximum gross weight (MGW), low installed power, and low MGW Payload ratio.

Mission Description:

The rotorcraft shall be able to accomplish a mountain rescue mission starting from a larger international airport, with possible refuel stopover at a smaller airport close to the mountain peak, in less than 3 hours, including 30 minutes hovering at the peak during the search and rescue.

Leg 1: Transfer flight from international airport to smaller airport for refuelling

- Atmosphere: ISA + 20
- Payload: 3 crew + 150 kg EMS equipment (405 kg)
- Take off from 1,402 m (4,600 ft), duration 2 min, hover
- Climb to 3,780 m (12,400 ft) and level cruise for a distance of 135 km (73 nautical miles)
- Landing @ 3,780 m (12,400 ft), duration 2 min, hover, fuel margin 10%
- Refuelling 20 min

Leg 2: Take off from smaller airport, rescue mission and return to smaller airport

- Take off from 3,780 m (12,400 ft), duration 2 min, hover
- Climb to 8,870 m (29,100 ft) and level cruise for a distance of 28 km (15 nautical miles)
- Hover out of ground effect @ 8,870 m (29,100 ft) for 30 min
- Payload increase: 3 Crew + 2 PAX + 150 kg EMS equipment (575 kg)
- Descent to 3,780 m (12,400 ft) and level cruise 28 km (15 nautical miles)
- Landing @ 3,780 m (12,400 ft), duration 2 min, hover, fuel margin 10%

Leg 3: Refuelling and return with PAX to larger airport

- Refuelling 20 min
- Take off from 3,780 m (12,400 ft), duration 2 min, hover
- Descent to 1,402 m (4,600 ft) and level cruise 135 km (73 nautical miles)
- Landing @ 1,402 m (4,600 ft), duration 2 min, hover, fuel margin 10%

Specific Requirements

- The rotorcraft must include an internal or external hoist system rated for a 300 kg load.
- The aircraft must be well-controllable in any foreseeable flight condition.
- Due to strong winds, the control system (particularly the anti-torque system) must be capable of maintaining heading in hover with wind from any azimuth up to 74 km/h (40 kts) at 8870 m (29,100 ft).
- The rotorcraft must be configured with an avionics suit that meets minimum FAA requirements for single pilot day/night IFR operations and all navigation/communication means deemed relevant to safely perform the mission. Appropriate weight allocation should be made for all components.
- In order to perform the mission in the given time, a cruise speed above 259 km/h (140 kts) for the transfer flight (Leg 1) should be considered.

Powerplant

Since the available propulsion power is a crucial factor and to allow even judging of proposals it is required that the teams submit designs based on existing engine technology for all performance estimates.

If the actual performance datasets of the chosen engine are not available to the team, the engine performance model used to describe the engine shall be included in the report.

Specific measures may be required to allow existing thermal engines to provide sufficient power in the high altitude environmental conditions. Any such measure has to be thoroughly described and assumptions on related performance improvements need to be well substantiated.

Considering hybrid systems and alternative propulsion concepts in a design trade-off is welcome. However, any assumption has to be based on state-of-the art technologies referring to publicly available material.

If the proposed technologies are under development, an explanation for how these technologies could be matured to a suitable level for the proposed vehicle must be included.

2.2.2 Task 2: Detailed Design (Graduate Teams ONLY)

For the graduate category, a deeper technological investigation of key elements of the aircraft is required. This will entail an assessment of structural stress level and static and/or fatigue substantiation of the critical elements. The objective is to demonstrate, on a few selected cases, that the students master substantiation tasks, including FAR requirements.

The stress assessment shall characterize the structural and aerodynamic loads acting on the rotors and on major airframe components (frame, tail boom, stabilizer…).

Some elements of further detailed analysis should be conducted to demonstrate the capability of advanced system analysis. Students can choose their preferred field of expertise, for example:

- Identify aeroelastic stability boundaries and show that they fall outside of the aircraft's operating envelope.
- Handling qualities assessment covering equilibrium, static and dynamic stability.
- Elaborate upon concepts to improve flight under degraded visual conditions and/or in known icing conditions. Both are not hard requirements but could considerably enhance the mission capability of the rotorcraft.

2.2.3 Bonus Task Sponsored by Altair Engineering, Inc. - Weight Optimization (Optional)

Altair Engineering, Inc. will provide two prizes for the Most Innovative Approach to Weight Optimization: one prize each of $1,000 for the undergraduate and graduate teams. Altair will form a judging committee consisting of experts from Altair, the vertical flight industry and academic institutions.

Teams are free to select one or more component/subsystem/system for weight optimization.

Entries will be judged using the following criteria:

- **Problem Formulation**: Good optimization problem formulation is key to its success. An optimization problem is essentially an approximate mathematical representation of a real-life physical problem. Participants should demonstrate understanding of the underlying approximations they make while formulating the optimization problem.
- **Design Engineering:** Results obtained from optimization are just one input to the engineering decision making. One receives the best results when optimization is used to gain additional insight into the design problem, and not as a black box. Optimization results should be used in conjunction with other engineering considerations to drive the design. Participants should demonstrate design engineering expertise in conjunction with optimization.
- **Application of Multiphysics Simulation:** Design of a real-life product may involve multiple disciplines of physics such as mechanical/structural, fluid dynamics, heat transfer, electro-magnetics, impact, etc. Participants should address as many disciplines of physics as feasible in the project. This can be done either by including those in the Optimization Formulation, or in the Design Engineering decision-making phase.
- **Weight and Balance**: Weight optimization of a part of the aircraft may impact its overall weight and balance, which in turn may impact its performance. Participants should track weight and balance of the aircraft during the optimization process, evaluate its impact

on performance, and make the necessary engineering decisions to ensure aircraft performance.

- **Impact on Aircraft Performance:** The goal of weight optimization is to improve aircraft performance. Participants should provide quantification of actual or estimated improvement in aircraft performance attributed to optimization.

Participants submitting the bonus task must use Altair products (see below) as much as possible. However, they are free to use any other software product if the capability offered by that product is not offered by any Altair product.

Once the winning graduate and undergraduate teams for this Bonus Task have been announced – and prior to teams receiving the prize money – each team will be required to:

- **Provide Altair with a 3D CAD model of the optimized parts that can be 3D printed.**
- **Present their findings at an Altair sponsored webinar.**
- **Altair will contact the winning team captain(s) and faculty advisor(s) directly about providing the CAD files and setting up the webinar.**

Altair will also provide the following assistance to all the participants:

- Sufficient number of no-cost licenses of Altair software to teams that intend to participate in the bonus task
- Participants may receive free training at any Altair location or online on any product of their choice, given availability of space
- Altair will provide technical application engineering support to each team using local technical teams as much as possible

Note: Altair will be free to use materials submitted by participants for Altair's training tutorials as well as marketing purposes.

3. Glossary

- 3D three dimensional
- AHS American Helicopter Society International
- CAD computer aided design
- EMS emergency medical service
- FAA US Federal Aviation Administration
- FAR US federal aviation regulations
- IFR instrument flight rules
- ISA International Standard Atmosphere
- MGW maximum gross weight
- NLT no later than
- PAX passengers
- PDF portable document format
- RFP request for proposals
- SAWE Society of Allied Weight Engineers
- SDC Student Design Competition
- USA United States of America
- VFS Vertical Flight Society