



37th Annual Student Design Competition

2019-2020 Request for Proposal (RFP)

**Leonardo's Aerial Screw:
500 Years Later**

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1.0 Basic Proposal Information

Leonardo Helicopters extends greetings and invites you to participate in the 37th Annual Student Design Competition (SDC) of the *Vertical Flight Society (VFS)*, previously known as AHS International.

This Request for Proposal (RFP) is divided into two sections. Section 1 (this section) provides:

- General description of the competition
- Process for entering
- Rules (both general and proposal specific)
- Schedules
- Award description
- Contact information

Section 2 describes the specific challenge by **Leonardo Helicopters** and VFS.

1.1 Rules

1.1.1 Who May Participate

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

The formation of project teams is encouraged and must follow these rules:

- **ALL teams, regardless of size, MUST name at least one (1) faculty advisor in order to compete (the same faculty advisor is allowed for different teams)**
- **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 LOI 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**
- **Email 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 that are eligible for prizes, as well as a bonus category if applicable, which 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 Task (*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 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 VFS 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, N (force)
- Kilograms, kg (mass)
- Seconds, minutes or hours as appropriate (time)
- Meters, m (length)
- Kilometers per hour, km/h (velocity)

1.1.6 Proposal Format, Length and Medium

Three separate files — four if the team is participating in the optional **Flight Simulation Model** bonus task — comprise the Final Submittal and must be present for a submission to be considered complete. The judges shall apply a penalty if any file is missing. All files must be submitted in PDF readable with Adobe Acrobat (exceptions will be considered but only with advance request).

The three mandatory files are the Executive Summary, the Final Proposal and Poster. They are described herein.

The first file is called the Final Proposal. It is the complete, self-contained proposal of the team and must follow these guidelines:

- Undergraduate category Final Proposals shall be no more than 50-pages
- Graduate category Final Proposals shall be no more than 100-pages
- All pages are to be numbered
- Page count includes all figures, diagrams, drawings, photographs and appendices
- Pages should measure 8 ½ x 11 inches
- Use of font size of at least 10-points and spacing that is legible
- 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.

In short, anything that can be read or viewed is considered a page and subject to the page count, with the following exceptions:

- Cover page
- Acknowledgement page
- Signature page (see Section 1.1.7)
- Posting permission page (see section 1.1.10)
- Table of contents
- List of figures
- List of tables
- Nomenclature
- Reference pages
- Executive Summary

The second file is called the Executive Summary. This is a self-contained “executive” briefing of the proposal and must follow these guidelines:

- Limited to twenty (20) pages for both undergraduate and graduate category and can take the form of a viewgraph-style presentation
- No additional technical content should be introduced in the Executive Summary
- All pages are to be numbered
- Pages should measure 8 ½ x 11 inches

- Use of font size of at least 10-points and spacing that is legible
- If a submission exceeds the page limit, judges will apply the same page count penalty to the Executive Summary score as 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 is called the Poster. It is a poster of the project (A2 format, digital edition) with brief descriptions of the project and the team, a 3-view and a 3D rendering of the aircraft with team-selected significant details. The best posters will be exhibited at Leonardo Helicopters headquarters.

The fourth file, if participating in the bonus task, is called the Flight Model Simulation Summary. It is related to the Flight Model Simulation task (Optional) if performed and it is a proper presentation of the simulation work done and must follow these guidelines:

- Limited to twenty (20) pages for both undergraduate and graduate category and can take the form of a viewgraph-style presentation
- All pages are to be numbered
- Pages should measure 8 ½ x 11 inches
- Use of font size of at least 10-points and spacing that is legible

Alongside the Flight Model Simulation Summary, the Flight Lab model must be also be provided.

All submissions shall be made via email to the VFS contact or by upload to VFS; team captains will be instructed on how to submit their proposals.

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:

- Student name
- Email address
- Education level (undergraduate or graduate)
- Signature of each student
- 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, email 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 from the competition, that team must notify the VFS POC in writing immediately.

1.1.9 **Award Disbursement/Disqualification**

The Vertical Flight Society and the Student Design Competition Committee reserves the right to decline to make all of the awards under the award 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.

1.1.10 **Permission/Proposal Posting**

VFS will post the winning entries in the undergraduate and graduate categories on its website. By entering the competition, teams give VFS permission to post their entry online if selected as a winner. *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**

Leonardo Helicopters is very pleased to sponsor the VFS Student Design Competition this year and 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.

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 Bonus Task (\$2,000)

- \$1,000 (awarded to one *undergraduate* team completing the **Advanced Rotorcraft Technology (ART) Flight Model Simulation** task, judged independent from the design portion)
- \$1,000 (awarded to one *graduate* team completing the **ART Flight Model Simulation** 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.

- Student representatives from the first place graduate (up to two students) and undergraduate (up to two students) teams are expected to present a technical summary of their design at the Vertical Flight Society's 77th Annual Forum, May 11-13, 2021 in West Palm Beach, Florida, during an Aircraft Design Technical Session.
- The students(s) presenting the winning design teams will receive complimentary registration to the Forum.
- In addition, the first place graduate and undergraduate team's universities will each be provided a \$1,000 stipend to help defray the cost of the team's attendance. The \$1,000 travel stipend amount will be included in the first place award disbursement to the university.

1.3 Schedule

Schedule milestones and deadline dates for submission are as follows:

Milestone	Date
VFS Issues a Request For Proposal	Early September
Submit Letter of Intent to Participate	No Later Than (NLT) February 3, 2020
Submit Requests for Information/Clarification	Continuously, but NLT February 28, 2020.
VFS Issues Responses to Questions	NLT March 28, 2020
Teams submit Final Submittal (Final Proposal and Executive Summary)	NLT May 31, 2020
SDC Committee and sponsor notifies VFS of results	Early August 2020
VFS announces winners	Mid to Late August 2020
Winning teams present at VFS Forum 77	May 11-13, 2021

To reiterate:

- Letter of Intent must be received by VFS no later than **February 3, 2020**. 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, 2020**.
- VFS will distribute ALL of the questions and answers **collectively to ALL entrant team captains by March 27, 2019**.
- **Final proposals must be submitted by May 31, 2020.**

1.4 Contacts

All correspondence should be directed to:

Julie M Gibbs, Technical Programs Director
The Vertical Flight Society (VFS)
2700 Prosperity Ave., Suite 275
Fairfax, Virginia 22031 USA
Phone: +1-703-684-6777 x 103
Email: jmgibbs@vtol.org

1.5 Evaluation Criteria

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

A. Technical Content (40 points)

The Technical Content of the proposal requires that:

- Design meets the RFP technical requirements
- 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 the solution is
- 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 (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 all previous relevant work (the “state of the art”)
- 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 required three files submitted via email or upload.

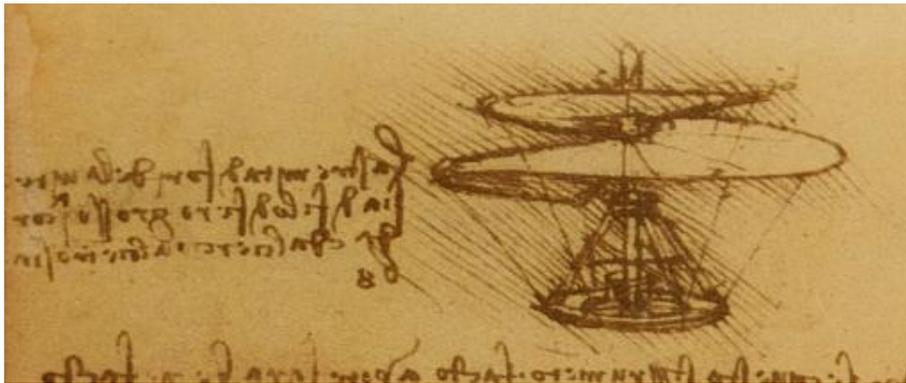
1. The first file is the **Final Proposal**, which is the full length, complete and self-contained proposed solution to the RFP. By self-contained, we mean that the proposal does not refer to and does not require files other than itself.
2. The second file is an **Executive Summary**, which presents 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 is the **Poster**, which presents a description of the project and the team, a 3-view and a 3D rendering, as well as selected significant details.
4. The fourth file (optional) is the **Bonus Task** (if submitted) conducted in accordance with the requirements defined in 2.2.3.

2.0 System Objectives

2.1 Operating Concept

2019 marks the 500th anniversary of the death of Leonardo Da Vinci, the famous Renaissance inventor who conceived many outstanding and innovating ideas far ahead of his time. Among them was the sketch of the Aerial Screw, recognized by VFS and others as the first human-carrying vertical take-off and landing (VTOL) machine ever designed — in this case, some 400 years before a helicopter carried a person aloft (see the links at vtol.org/heritage).

The famous drawing of the Aerial Screw, together with a few lines of text describing the working principle, clearly envisioned the first technical concept for a VTOL vehicle and is considered the first heavier-than-air VTOL aircraft design in history.



Although this concept, for a number of reasons, is clearly far from being a practical solution of an actual VTOL capable machine, Leonardo Helicopters wishes to highlight that little attention has been posed from a technical standpoint to the idea of the Italian inventor. ***The actual pros and cons of the Aerial Screw are often quoted but have not been analyzed extensively, nor has a possible working application been studied, leaving a gap in the technical understanding of the significance of the invention.***

The 37th Annual Student Design Competition will have an historical mark, proposing a critical review of the Leonardo Aerial Screw idea to understand how the concept can be considered the foundation of vertical flight.

The goal of this year's VFS Student Design Competition is to design a VTOL vehicle based on Leonardo's Aerial Screw concept, studying and demonstrating the consistency of its physics and potential feasibility.

2.2 Specific Objectives

The competitors shall design a vehicle relying for lift and thrust from **one or more** "Aerial Screws," i.e. single-blade rotor with solidity equal or greater than one with a continuous surface, making use of any possible airborne powerplant/energy storage (buoyancy can be considered), capable of:

- Carrying 1 pilot or a passenger of a total of at least 60 kg (basically minimum human load of 60 kg)
- Take-off vertically, holding the position for at least 5 seconds (within 10 m radius from take-off spot, no wind)
- Flying for at least one minute, covering at least 20 m of distance at an altitude above the ground of at least 1 meter, untethered.
- Land vertically, after holding the position for 5 seconds (within 10 m radius from landing spot, no wind)

2.2.1 Task 1: Vehicle Conceptual Design (ALL Participants)

The teams shall select a configuration based on the Aerial Screw as described above and provide:

- A concept definition and description, including significant configuration trade off analysis
- Preliminary study of all required systems including aerodynamics, structures, power-plant, rotor, controls, etc., based on documented existing proven technologies and/or existing equipment
- Preliminary capability and performance definition
- Validation of the design and/or the aircraft elements, especially as far as the Aerial Screw lifting device(s), by analysis, simulation or scaled models
- A poster of the project (A2 format, digital edition) with brief description of the project and the team, a 3-view and a 3D rendering as well as selected significant details; the best physical posters will be exhibited at the Leonardo Helicopters headquarters

The Conceptual design will be evaluated by means of the following metric:

- Demonstration of the compliance to the above minimum requirements
- Distance exceeding the above requirements
- Aesthetics and similarity to the drawings of Leonardo Da Vinci

2.2.2 Task 2: Detailed Design (Graduate Teams ONLY)

For the graduate category, a deeper technological investigation of key elements of the Aerial-Screw concept 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 developed conceptual design could actually be tested on a real demonstrator aircraft.

Areas to be assessed include the following:

- Assessment of weights and applicable rotor and airframe loads
- Assessment of structural integrity
- Assessment of reasonable manoeuvrability and workload
- Control system concept and control laws definition (in case of stability and control assistance or automation is considered)
- Assessment of crew accommodation/accessibility suitable for demonstrator-level operation
- Assessment of demonstrator-level manufacturability

The levels of details of any of the above is left to the team discretion and will be evaluated accordingly. Also, a preliminary assessment of any of the above is considered sufficient.

The detailed design work will be evaluated with the similar metric used for the Conceptual Design.

2.2.3 Optional Bonus Task: Flight Simulation Model sponsored by Advanced Rotorcraft Technology, Inc. (ART)

ART will form a judging committee consisting of experts from ART and VFS (and other vertical flight industry and academic institutions at their discretion) and **will provide two prizes for the best FlightLab flight simulation of the concept: one prize each of \$1,000 for the undergraduate and graduate teams.**

Entries will be judged using the following criteria:

- **Data:** completeness and detail level of the proposed model
- **Modeling:** adequacy of the approach and correctness of the model
- **Analysis:** effectiveness of the analyses used in the design activities and decisions
- **Pilot-in-the loop:** model capability to run in real time with human input
- **Communication:** description and discussion of assumptions, approach, techniques, results in a formal report as well as in a presentation.

ART will provide specific details for obtaining the necessary software licenses to teams AFTER receipt of the Letter of Intent to Participate and ONLY if a team has indicated their plan to participate in the bonus task.

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Training (electronic tutorials or similar) is also provided in an equal way to all participating teams; in order to foster a fair competition, no direct help or support can be provided to teams.

Note: By providing a submission for the optional task, you are providing permission for ART to be free to use materials submitted for training tutorials and marketing purposes.

3.0 Glossary

- 3D three dimensional
- AHS American Helicopter Society
- ART Advanced Rotorcraft Technology, Inc.
- LOI letter of intent
- NLT no later than
- PDF Portable Document Format
- POC point of contact
- RFP request for proposals
- SI International System of Units (Système international [d'unités])
- SDC Student Design Competition
- USA United States of America
- VFS Vertical Flight Society
- VTOL vertical take-off and landing

REMINDERS

The Vertical Flight Society, Leonardo Helicopters and Advanced Rotorcraft Technology wish you success in your endeavors to meet the challenges of this RFP. Please remember the following important deadline dates:

- Letter of Intent no later than **February 3, 2020**.
- Request for Information no later than **February 28, 2020**
- Final Proposal Submission **May 31, 2020**.

No extensions will be given — please plan ahead. All information on the competition is available at www.vtol.org/sdc.

Good luck!

