Vertical Flight Society

38th Annual Student Design Competition

2020-2021 Request for Proposal (RFP)

2025 Unmanned Vertical Lift for Medical Equipment Distribution

Sponsored by

BOEING

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1.0 Basic Proposal Information

The Boeing Company extends greetings and invites you to participate in the Vertical Flight Society 38th Annual Student Design Competition (SDC). VFS was founded in 1943 as the American Helicopter Society, Inc. and is the world's largest and longest-serving educational and professional organization supporting the advancement of vertical flight.

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.

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 or part-time; their education level will be considered in the classification of their team (see section 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 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 (LOI) to participate. 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**
- **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 that are eligible for prizes, as well as an optional bonus task:

- Undergraduate Student Category (1st, 2nd and 3rd place awards)
- Graduate Student Category (1st, 2nd and 3rd place awards)
  NOTE: The classification of the team is determined by the highest educational level currently pursued by <u>any</u> 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 or more 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 (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 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:

- Force: Newtons (pound-force)
- Mass: Kilograms (pound-mass)
- Time: Seconds, minutes or hours as appropriate
- Length: Meters (feet)
- Velocity: Kilometers per hour/meters per second, (knots/feet per second)
- Power: kW (horsepower) — Note: for electrical power, there is no need to provide the English equivalent

1.1.6 Proposal Format, Length and Medium

Three separate files — four if the team is participating in the optional Structural Weight Optimization bonus task — comprise the Final Submittal and all three must be present for a submission to be considered complete. The judges shall apply a penalty if any file is missing.

The first file is called the Final Proposal. It is the complete, self-contained proposal from the team and must be submitted in PDF readable with Adobe Acrobat (exceptions will be considered but only with advance request) and 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 shall 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 be submitted in PDF readable with Adobe Acrobat and follow these guidelines:

- Limited to twenty (20) pages for both undergraduate and graduate category and can take the form of a PowerPoint-style slide presentation
- No additional technical content should be introduced in the Executive Summary
- All pages are to be numbered
- Pages shall 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 Safety Analysis. This file includes detailed backup Functional Hazard Assessment Analysis (FHA) or Fault Tree Analysis (FTA) assumptions. The final proposal shall include the top level details and impacts on the design, whereas this file contains more detailed analysis inputs/assumptions.

- Limited to five (5) pages for undergraduate and seven (7) pages for the graduate category
- All pages are to be numbered
- Pages shall measure 8 ½ x 11 inches

The fourth, optional, file is called the Structural Weight Optimization Summary. It is related to the Altair Structural Weight Optimization task, if performed, must be submitted in PDF readable with Adobe Acrobat and follow these guidelines:

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

With the Vehicle Structural Weight Optimization Summary, HyperWorks and CAD models of the structure must be also be provided.

All submissions shall be made via by upload to VFS. The VFS POC will notify team captains instructions on how and where to upload their final 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
- E-mail 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, e-mail addresses and signatures of the Faculty Advisor(s).**

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 contact 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 your entry online if selected as a winner. *Therefore written permission must appear on a separate page immediately following the signature page.* This permission page does not count against the page count.

1.2 Awards

Boeing is pleased to sponsor this year's VFS Student Design Competition and will provide the funds for the awards and travel stipends via VFS, 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 **Altair Structural Weight Optimization** task, judged independent from the design portion)
- $1,000 (awarded to one *graduate* team completing the **Altair Structural Weight Optimization** task, judged independent from the design portion)

Additional award information:

- 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 78th Annual Forum (May 2022) during an Aircraft Design Technical Session. The students(s) presenting the winning design teams will receive complimentary full registration to the Forum.
- Student representatives from the first place graduate and undergraduate teams are each expected to work with Altair to create a case study document.
- In addition, the first place graduate and undergraduate team's school will be provided a $1,000 stipend to help defray the cost of the team's attendance. The additional travel stipend amount will be included in the first place award disbursement to the school. Actual travel expenses are the responsibility of the winning school(s).

1.3 Schedule

Schedule milestones and deadline dates for submission are as follows:

Milestone	**Date**
VFS issued this Request For Proposal	August 2020
Submit Letter of Intent to participate	by February 1, 2021
Submit requests for information/clarification	Continuously, but NLT February 25, 2021
VFS issues responses to questions	By March 28, 2021
Teams submit Final Submittal (Final Proposal, Executive Summary and)	May 31, 2021
Sponsor and SDC Committee notifies VFS of results	August 2021
VFS announces winners	August 2021
Winning team presents at VFS Forum 78	May 2022

To reiterate:

- Letter of Intent must be received by VFS by **February 1, 2021.** 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 25, 2021**.
- VFS will distribute ALL of the questions and answers **collectively to ALL entrant team captains** by **March 28, 2021.**
- **Final proposals must be submitted by May 31, 2021**.

1.4 Contact

All correspondence should be directed to:

Julie M Gibbs, Technical Programs Director
The Vertical Flight Society
2700 Prosperity Ave., Ste. 275
Fairfax, Va. 22031
Phone: +1-703-684-6777 x103
E-mail: 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:

- Standard Criteria
  - 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
  - Well-balanced and appropriate substantiation of complete aircraft and subsystems is present
  - Technical drawings are clear, descriptive, and accurately represent a realistic design

- Emphasized This Year
    - Appropriate trade studies are performed to direct and support the design process. Scoring is more heavily weighted compared to previous years to emphasize the trade studies.
    - Emphasis on system safety evident throughout the proposal. The emphasis is on the process and the impact it has on the final vehicle design and not necessarily the specific assumptions.

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 and operating environment of the aircraft
- Show that the resulting solution has high productivity

C. Originality (20 points)

The originality of the proposal shall be judged on:

- Original/innovative solutions investigated during the trade studies.
- How does the solution improve end-user experience for the operator and customer?
- Vehicle/system aesthetics (“looks right, flies right”).

D. Organization & Presentation (15 points)

The organization and presentation of the proposal requires:

- 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 previous relevant work (a “state of the art” review)
- Professional quality and presentation
- The proposal meets all format and content requirements

- The RFP describes the proposal requirements (Section 1.6) an 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 RFP:

1. Demonstrate a thorough understanding of the RFP requirements.
2. 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.
3. 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 more important is the process and substantiation.
4. 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.
5. Emphasis on system safety at each part of the design process from initial design and configuration trades, through conceptual design and overall design descriptions as part of the submission.

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 these files submitted via email or upload:

6. 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.
7. 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.
8. The third file is the ***Safety Analysis*.** This file includes detailed backup Functional Hazard Assessment Analysis (FHA) or Fault Tree Analysis (FTA) assumptions. The final proposal shall include the top level details and impacts on the design, whereas this file contains more detailed analysis inputs/assumptions.

9. 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

Autonomous aerial delivery of supplies and commodities has been of high interest in recent years. Many companies/organizations have been developing and testing vehicles of various sizes and capabilities to address various delivery needs, such as point-to-point package delivery and pesticide distribution.

The COVID-19 pandemic has amplified the need for fast autonomous delivery to precise locations. Among many impacts to daily life, the pandemic has forced a re-examination of how medical and basic supplies are distributed within large communities or between different communities, especially if a lockdown is in place. Vertical lift technology can aid the worldwide community through safe distribution of medical supplies and other commodities through runway independent 'contactless' delivery. Other applications include disaster relief and eventual commercial applications.

This year's RFP has the goal of developing an unmanned vertical lift concept that can deliver, at high speed, up to 50 kg payloads to end-user customer sites up to 50 km radius, and to logistics centers up to 200 km away. The sizing is such that the vehicle can make a difference within a future pandemic or natural disaster. Responses shall include only current year (2020) technologies in order to support an initial entry into service in 2025.

Air vehicle system safety is as important to the operating concept as the potential medical benefits this delivery system will offer. System safety must be considered throughout the design process. Concepts that can have enhanced safety aspects will be scored higher than those that do not. Examples (not requirements) of aspects include:

- Fail-safe design practices in which a single failure does not result in an uncontrolled emergency landing (reference advisory circular AC25.1309-1A for the US Federal Aviation Administration (FAA) fail safe design concept).
- Identification of critical parts that will be subject to a critical parts program.
- Features, such as power line detection, that reduce chances of catastrophic events.
- Flight envelope restrictions that align with design assumptions, including safe landing in the event of a powerplant failure.

Safety is paramount for any aircraft design but a certification basis is not readily available for the design of small unmanned aircraft system (UAS) or for their operation. Safety has historically not been a tradable design constraint within the aerospace industry. Civil aviation authorities, specifically the FAA, are moving towards performance-based consensus standards. In many circumstances, the responsibility to develop safe vehicles for the desired operating conditions is shouldered by the design authority. The design authority develops the certification basis and means of compliance and the civil aviation authority will review and disposition the proposed certification basis. This requires that today's (and tomorrow's) configurators require system safety analysis as part of their design philosophy and is the basis for an increased emphasis on safety in this year's competition.

2.2 Specific Objectives

2.2.1 **Task 1: Vehicle Conceptual Design (ALL Participants)**

The teams shall develop a system to deliver packages/payloads to a precise location

- Significant configuration trade-off analysis shall be conducted to develop an acceptably safe system for the mission.
- Vehicle shall be capable of continued safe flight and landing after any single failure or combination of failures not classified as catastrophic:
    - Threshold: Continued safe operation with prescribed emergency procedures for 15 minutes at best range speed, with full payload, prior to a controlled landing at a contingency landing site located in the vicinity of the planned flight path. Controlled landing must not result in damage to the aircraft or aircraft systems beyond acceptable maintanence limits. The aircraft must be able to confirm if the landing site is clear and safe for landing operations. Creative solutions are sought to eliminate consequences of landing at an unprepared location.
    - Objective:
        - Local Delivery Mission: Return to launch site or launch site from destination with full payload.
        - Logistics Mission: Return to launch site or destination from destination with full payload.
- Mission
    - Vehicle shall be capable of executing both Local Delivery Mission and Logistics Mission described below without any reconfiguration.
    - Vehicle operation shall be over rural and medium density suburban populations. Trees and other obstacles shall be sensed avoided.
    - The vehicle cannot be refuelled/recharged at the delivery site.
    - The vehicle shall operate in flight conditions consistent with visual flight rules operation, both day and night.
- Ground Operations
    - Vehicle ground operations should be considered as part of the solution.
    - Vehicle configuration features like rotor height or shrouds, system features like warning alarms or lights, and infrastructure features like fenced, local landing sites that protect people/customers should be discussed.
    - Emergency landings not covered by other design requirements in which the vehicle may land on an unprepared surface should be discussed, including safety of people/animals on the ground.
- Vehicle Aspects

- The vehicle operational size shall be less than or equal to:
    - Threshold: 6.1m x 6.1m (20' x 20')
    - Objective: 4.6m x 4.6m (15' x 15')
- Powerplant is not specified. Proposals shall elaborate on the trades leading to the powerplant(s) and energy storage system(s) selection.
- System shall be autonomous. An operator “on” the loop shall be considered. The operator would be physically located at a remote site to monitor status and act by exception to machine decisions.
- System features, such as obstacle sensing technologies and all technologies required for autonomous flight shall be described and SWaP (space, weight and power consumption estimated).

- Payload
    - The payload size and weight is dictated in the mission definition tables below. The payload can be considered to be packaged in a single container with appropriate mounting points for carriage by the aircraft.
    - The payload can be carried internally or externally as long as range and block time requirements are met.
    - Payload handling is of primary concern — the design and/or operational concepts shall emphasize convenience as well as rapid loading/unloading. The payload shall be autonomously released from the vehicle.
- Delivery Site
    - Delivery site can be assumed to be 15.25m x 15.25m (50' x 50') of flat, clear space.
    - Vehicle shall be equipped with sensors to enable obstacle detection in the vicinity delivery site.
    - Design and/or operational concepts to minimize risk to people, animals, etc. in vicinity of the vehicle.

As an integral part of the aircraft configuration selection and sizing, the design teams will have to develop system architectures that create an acceptably safe system for the intended use. Undergraduate teams must show, at a high level, a “path-to-certification” for cargo operations. The path-to-certification will require design teams to assess the primary aircraft functions and the critical systems and interconnection of systems supporting those functions and provide a discussion as to how their design has a path to certification using any combination of civil aviation guidance, as needed. Safety assessment can generally follow the philosophy of the Functional Hazard Assessment as described in SAE ARP4761.

Table 1: Local Delivery Mission - Residential and Commercial

#	Segment	Time [min]	Range [km]	Final Altitude	Airspeed	Power Available Limit
1	Load package(s)	5	-	1200 m	-	
2	Warmup	5	-	1200 m	-	Ground Idle
3	Takeoff HOGE	2	-	1200 m	-	95% Maximum Rated Power
4	Climb	-	Note 4	1350 m	Best Climb	100% Maximum Continuous Power
5	Cruise	-	50 km	1350 m	Note 5	100% Maximum Continuous Power
6	Descent	-	Note 4	1200 m	-	100% Maximum Continuous Power
7	Land HOGE	1	-	1200 m	-	95% Maximum Rated Power
8	Unload package(s)	Note 8	-	1200 m	-	- / -
9	Takeoff HOGE	1	-	1200 m	-	95% Maximum Rated Power
10	Climb	-	Note 4	1350 m	Best Climb	100% Maximum Continuous Power
11	Cruise	-	50 km	1350 m	Note 5	100% Maximum Continuous Power
12	Descent	-	Note 4	1200 m	-	100% Maximum Continuous Power
13	Land HOGE	1	-	1200 m	-	95% Maximum Rated Power
14	Reserve	20	-	1350 m	Best Endurance	100% Maximum Continuous Power

Notes:

1. HOGE = hover out of ground effect
2. Design payload 50 kg
3. Payload dimensions: 70 cm x 70 cm x 70 cm *and* 140 cm x 50 cm x 50 cm
4. Block Time = 28 min to end of segment 8 or faster
5. Climb and descent distances credited to cruise range requirement.
6. Cruise speed is greater of best range speed or airspeed required to meet package delivery window and constrained to continuous power rating.
7. Ambient temperature for all segments = ISA+20C
8. Flight shall be operated at 150 m above ground level (AGL)

9. Cargo unloading method and time requirement determined by proposer with goals to ensure safety while meeting the delivery window and maximizing operational flexibility and customer experience.

Table 2: Logistics Mission

#	Segment	Time [min]	Range [km]	Final Altitude	Airspeed	Power Available Limit
1	Load package(s)	5	-	1200 m	-	- / -
2	Warmup	5	-	1200 m	-	Ground Idle / -
3	Takeoff HIGE	2	-	1200 m	-	95% Maximum Rated Power
4	Climb	-	Note 4	1350 m	Best Climb	100% Maximum Continuous Power
5	Cruise	-	200 km	1350 m	Note 5	100% Maximum Continuous Power
6	Descent	-	Note 4	1200 m	-	100% Maximum Continuous Power
7	Land HOGE	1	-	1200 m	-	95% Maximum Rated Power
8	Unload cargo	Note 9	-	1200 m	-	- / -
9	Reserve	20	-	1350 m	Best Endurance	As Required

Notes:

1. HIGE = hover in ground effect
2. Design payload 50 kg
3. Payload dimensions: 70 cm x 70 cm x 70 cm *and* 140 cm x 50 cm x 50 cm
4. Block Time = 75 min to end of segment 8 or faster
5. Climb and descent distances credited to cruise range requirement.
6. Cruise speed is greater of best range speed or airspeed required to meet package delivery window and constrained to continuous power rating.
7. Ambient temperature for all segments = ISA+20C
8. Flight shall be operated at 150 m above ground level (AGL)
9. Cargo unloading method and time requirement determined by proposer with goals to ensure safety while meeting the delivery window and maximizing operational flexibility and customer experience.

2.2.1.1 Desired Data Deliverables

As described in Section 1.5, the conceptual design will primarily be evaluated by means of the following metrics:

- System safety philosophy/approach. Specific emphasis will be on how safety considerations influenced the design.
- Productivity for each mission, defined as [(payload * block speed) / gross weight], with gross weight as the surrogate for cost.

The following deliverables are required for the undergraduate teams and shall be provided in the format described in Section 1.1:

1. General description of the proposed vehicle which highlights how it meets the stated requirements.
2. Design trades to substantiate safety philosophy and claims.
3. Description of specific design decisions used to achieve acceptable safety. A simple assessment/commentary of the system safety after the end of the vehicle description does not meet the intent of the philosophy.
4. Clear documentation/presentation of the productivity metric.
5. Segment by segment summary of the mission performance including flight speed, energy consumed and power required for the entire vehicle system.
6. Performance data at the individual component level (rotor/propeller, transmission, etc) that substantiates the total power required in each segment of the mission, including emergency procedures, as required.
7. Three-view drawings of the vehicle in its major phases of deployment, including the placement of major components.
8. Description of the payload sequence - identifying any and all assumptions / features / equipment / provisions at launch, delivery and recovery sites.
9. Description of the turn-time procedures (between operations), including refuel/recharge, any inspections, scheduled maintenance, repairs.
10. Validation of the design and/or the aircraft elements by analysis, simulation or scaled models
11. A detailed weight statement with substantiating analysis.

2.2.2 **Task 2: Detailed Design (Graduate Teams ONLY)**

The graduate teams shall consider the following, in addition to all of the items described in Section 2.2.1.

Graduate teams must show a “means-to-certification” for cargo commercial operations over rural and suburban environments. The means-to-certification will require design teams to analyze the primary aircraft functions and the critical systems and interconnection of systems supporting those functions. The graduate team’s safety analysis should demonstrate an understanding of the FAA's fail safe design concept (described in advisory circular AC25.1309-1A) in all phases of flight (not just static equilibrium in hover).

Consideration must also be given to certification in the current regulatory environment, where small unpiloted small rotorcraft are certified for specific operations on a case-by-case basis for a specific vehicle design and associated operating restrictions. For example, the Schiebel Camcopter S-100c has been certificated by the European Union Aviation Safety Agency (EASA) via a Special Condition developed specifically for the aircraft and intended usage, reference EASA SC-S100c.

Development of critical component replacement/overhaul schedule (in terms of flight hours) is an important part of any certification approach, as well as to inform eventual operating cost models. Reliability of any vehicle is critical.

2.2.2.1 Additional Design Requirements/Deliverables

- Detailed assessment of safety claims.
    - Safety assessment should be accomplished to a commensurate level as a Preliminary System Safety Assessment as described in SAE ARP4761. All assumptions shall be clearly documented. It is important to note that the process is more important than the assumptions and other approaches are possible/acceptable. It is understood that failure rates of specific components will not be readily available to students.
    - It shall be clearly shown how the assessment process influenced the design process. Simply assessing the final design does not satisfy the intent of this exercise.
- Assessment of critical parts operational life and description of proposed component replacement/overhaul schedules.
    - Critical parts are to be determined by the team, but rotor system(s), drive system(s) (if applicable) and powerplant(s) should be considered.
    - An estimate of the system dispatch reliability, and probability of mission abort due to mechanical malfunction is an important input into the assessment.

2.3 Optional Bonus Task: Structural Weight Optimization — sponsored by Altair

ALTAIR

Reduction of vehicle weight would enable a vertical lift UAS to deliver a higher number of payload kg-km between recharges. Additionally, reduced structural weight offers the potential for using a smaller powerplant, which adds to weight reduction. Structural weight reduction can be achieved most efficiently by applying advanced structural optimization technology. Most modern aircraft are designed using such technology for weight reduction while delivering fail-safe structural designs.

Altair will form a judging committee consisting of experts from Altair and the vertical flight industry, and **will provide two prizes for the best application of structural weight optimization: one prize each of $1,000 for undergraduate and graduate teams.**

Entries will be judged using the following criteria:

- **Part Selection**: Select part(s) that offer significant weight savings potential.
- **Problem Formulation**: Quality of optimized design depends heavily on optimization problem formulation.
- **Engineering**: The optimization software delivers the best design for the problem one formulates. However, not all design criteria can be included in a structural optimization problem. Hence, optimization results must be augmented with sound engineering to address criteria not included in the optimization formulation. Good engineers use optimization technology to get insight into structural performance and use the results as a guideline rather than a final design.
- **Communication:** description and discussion of assumptions, approach, techniques, results in a formal report as well as in a presentation.

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 the HyperWorks models and with a proper presentation of the simulation work done.

Participants seeking the bonus task must use Altair HyperWorks for weight optimization. Additional products may be used if the capability offered by that product is not offered by any Altair product.

In addition to HyperWorks models, the winning teams for this task will be required to provide Altair with a three-dimensional computer aided design (CAD) model of the optimized parts that can be 3-D printed or manufactured using traditional methods. The winning teams will also be required to present their findings at an Altair-sponsored webinar and work with Altair to write a case study. Altair will be free to use the material submitted by participants for Altair’s training tutorials as well as marketing purposes.

Altair will provide the following on-request assistance to all the participants:

- A required 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

3.0 Glossary

- 3D three dimensional
- ART Advanced Rotorcraft Technology, Inc.
- AGL above ground level
- CAD computer aided design
- EASA European Union Aviation Safety Agency
- FAA Federal Aviation Administration
- FHA functional hazard assessment analysis
- FTA fault tree analysis
- HIGE hover in ground effect
- HOGE hover out of ground effect
- ISA International Standard Atmosphere
- LOI Letter of Intent
- NLT no later than
- PDF Portable Document Format
- RFP request for proposals
- SI International System of Units (Système international [d'unités])
- SDC Student Design Competition
- UAS unmanned aircraft system
- USA United States of America
- VFS Vertical Flight Society
- VTOL vertical take-off and landing

REMINDERS

The Vertical Flight Society, Boeing and Altair wish you success in your endeavors to meet the challenges of this RFP. Please remember the following important deadline dates:

- Letter of Intent to participate no later than **February 1, 2021**
- Request for Information no later than **February 25, 2021**
- Responses to RFI issued by **March 28, 2021**
- Final Proposal Submission **May 31, 2021**

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

Good luck!