44th Annual Student Design Competition

2026-2027 Request for Proposal (RFP)

25 August 2026

[Rev 1: Changes Highlighted in Blue]

VTOL Aircraft Supporting South American Offshore Oil and Gas Production

Sponsored by

Bell Textron Inc

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Note: there are new eligibility rules and changes to milestone information and deadline dates for the 44th (2026-2027) Annual Student Design Competition. These changes are highlighted in yellow throughout the RFP. Please read thoroughly and completely.

1. Basic Proposal Information

Bell and VFS extend their greetings and invite universities to participate in the 44th Annual Student Design Competition (SDC) of the *Vertical Flight Society* (VFS). This year's proposal will challenge student teams to design a vertical takeoff and landing (VTOL) aircraft to support oil and gas production off the South American coast.

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 Bell sponsor and VFS.

1.1 Rules

1.1.1 Who May Participate

***NEW*: Undergraduate and graduate students enrolled at a college or university. The university must be a current Vertical Flight Society (VFS) educational member in good standing to be eligible to participate in this competition. A list of current educational members is available at VFS Educational Members**

Universities that are not VFS educational members may join for an annual fee of $350. Information on membership benefits and enrollment is available at VFS Educational Membership.

The university must be an educational member in good standing at the time of the Letter of Intent submission and must maintain active membership status throughout the duration of the competition.

Participation is subject to all applicable United States export control laws and regulations. ***Individuals or entities prohibited by the United States Government are not eligible to participate***.

1.1.2 Team Information: Roles, Size and Number of Teams

The forming of project teams is encouraged and follow these rules:

- **ALL teams MUST name at least one (1) faculty advisor to compete**
- Maximum number of students on a single-university team is ten (10)
- Minimum team size is one (1), an individual, in addition to at least one faculty advisor
- Schools may form more than one team, and each team may submit a proposal, but each team is limited to a maximum of ten (10) students
- A student may be a member of one team only
- Students may be full or part-time
- **Teams are allowed to include up to two (2) industry and/or two (2) government advisors to mentor/advise on the design.**

VFS looks 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*.**

1.1.3 Letter of Intent & Request for Information Round 1

The LOI is drafted by the team captain and members of a team must be named in the Letter of Intent (LOI).

***NEW*:** In addition to the LOI, teams can include a separate list of requests for information/questions for clarification by the sponsor**. Both documents should be submitted to the VFS POC (Section 1.4) by October 26, 2026**. All milestone dates and deadlines are specified in Section 1.3 Schedule.

The Letter of Intent must include:

- **Name of the university or universities forming the team**
- **Confirmation that the university is a VFS educational member**
- **Team Name**
- **Printed name of each student member of the team including**
    - Email
    - Education Level (Undergraduate or Graduate)
    - Affiliation of each student in the case of multi-university team

- **Identify the team captain and faculty advisor(s):** ***the team captain and faculty advisor will be the POC for all SDC communications.***
- **Printed name, affiliation and email address of any industry or government advisors**

1.1.4 Categories and Classifications

The competition has three categories, that are eligible for prizes, 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*.

1.1.5 Language of Proposal

Regardless of the nationality of the teams, all submittals, and communications to and from VFS shall be in English.

1.1.6 Units Used in Proposal

All teams must submit using both SI and English units. The primary SI units are to be followed by the secondary English units in parentheses. The use of units shall be consistent throughout the proposal. All engineering units shall be expressed in the units of:

- **Force:** Newtons (N), Pounds, (lb)
- **Mass:** Kilograms (kg), 1kg=0.06852 slugs. The units of measure for aircraft / system weights shall be reported in kg for SI units, and lb for English units where the conversion is 2.204 lb per kg [1]
- **Maximum Takeoff Weight (MTOW) and Payload Weight**: kilograms (SI), lb (English)
- **Time:** Seconds, minutes, or hours as appropriate
- **Length or distance:** Meters, m, or kilometers, km as appropriate (SI). Feet, inches or Nautical Miles (English) as appropriate
- **Velocity/speed:** Meters per second, m/s (SI) as appropriate, ft/s or knots (English)
- **Power:** Watts, W, or Kilowatts, kW as appropriate (SI), Horsepower, HP, for mechanical systems (English), Watts for electrical systems (English)

[1] Note: The proposal shall not use slugs as a unit of mass unless absolutely necessary. Per European norms, quantities such as aircraft weight (a force) are typically reported as kg (mass). i.e., no Europeans know their weight in Newtons. Similarly, slugs are rarely used in the US, so Americans do not know their mass.

1.1.7 Proposal Format, Length and Medium

Two separate files comprise the Final Submittal and both must be present for a submission to be considered complete. The judges shall apply a penalty if either file is missing.

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

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

- Undergraduate Final Proposals: no more than 50-pages
- Graduate Final Proposals: 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 1.1.8)
- Posting permission page (see section 1.1.11)
- 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 Adobe PDF and follow these guidelines:

- Limited to twenty (20) pages for both undergraduate and graduate teams
- Can be in the form of a viewgraph-style presentation
- No additional technical content should be introduced in the Executive Summary, but a summary of technical narrative shall be included with the figures.
- 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 (including figure text)

- 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

All submissions shall be made via e-mail to the VFS contact or by upload to VFS (instructions will be provided by VFS).

1.1.8 Signature Page

All submittals must include a signature on page two (2). 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 Advisors.**

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

1.1.9 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 SDC point of contact in writing immediately.

1.1.10 Special Sponsor Rules

See Section 2.0 for Bell Textron (sponsor) - Specific information.

1.1.11 Permission/Proposal Posting

VFS will publish the Executive Summaries of each of the winning entries in the undergraduate and graduate categories on the SDC website *hence written permission MUST appear on the signature page* – this permission page will <u>not</u> count against the page count.

Therefore, neither the Executive Summaries nor the Final Proposals are considered confidential. The Society does not share or publish any of the non-winning proposals but does keep a record of all proposals. VFS makes no claims on the Intellectual Property or ownership rights of the proposals, which remains with the student team members (or the university if it asserts rights to student products), who are free to republish or use all or part of the proposal in future works. The permission page merely gives VFS the right to publish the executive summary and other parts of the proposal (e.g., images of the proposed aircraft) for the press release and other promotional purposes.

1.2 Awards

Bell Textron is very pleased to sponsor the VFS Student Design Competition this year and will provide the funds for the awards and travel stipends through VFS.

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

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 and undergraduate (up to two students under each category) teams are expected to present a technical summary of their design at the Vertical Flight Society's 84th Annual Forum in May 2028 during an Aircraft Design Technical Session.
- The students presenting the winning design will receive complimentary registration to the Forum.
- In addition, the first-place graduate and undergraduate team's university will be provided a $1,000 stipend to help defray the cost of the team's Forum attendance – the additional travel stipend amount will be included in the first place award disbursement to the school.

The Vertical Flight Society and the Student Design Competition Committee reserve the right to decline to make all the awards in the above categories if there are not enough 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 the RFP	August 2025
NEW 1. Teams Submit **Letter of Intent (LOI) to Participate** 2. Teams Submit **First Round Request for Information (RFI)***	**NLT October 26, 2026**
Bell Responses to Team First Round RFIs	**November 20, 2026**
Teams Submit **Second Round Request for Information (RFI)***	**NLT February 1, 2027**
Bell Responses to 2nd Round RFIs/Questions*	Feb. 22, 2027
Teams Submit Executive Summary and Final Proposal	**NLT May 31, 2027**
SDC Committee & Sponsor Reviews/Scores Final Proposals	June 1 to July 31, 2027
Bell notifies VFS of results	August 2027
VFS announces winners	August 2027
Winning Graduate and Undergraduate Teams present at VFS Forum 84 (2028)	Forum 84: May TBD, 2028 Huntsville, AL

***Questions/answers will <u>not</u> be communicated on a case-by-case basis. VFS will distribute ALL questions/answers collectively to all participating team captains.**

1.4 Contacts

All correspondence should be directed to:
Julie M Gibbs, Technical Programs Director
VFS – *the Vertical Flight Society*
2700 Prosperity Ave., Ste. 275
Fairfax, Va. 22031
Phone: (703) 684-6777 x 103
E-mail: jmgibbs@vtol.org

1.5 Evaluation Criteria

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

1.5.1 Technical Content (40 points)

The Technical Content of the proposal requires that:

- The 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

1.5.2 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

1.5.3 Originality (20 points)

The originality of the proposal shall be judged on:

- Innovation, simplicity and elegance of the solution
- Imagination and ingenuity of the ideas investigated with the trade studies
- Vehicle/system aesthetics

1.5.4 Organization & Presentation (15 points)

The organization and presentation of the proposal require:

- A Self-contained Executive Summary that must be a separate file, containing all pertinent information and a compelling case as to why the proposal should win
- 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 with readable fonts, and appropriate labeling of all key dimensions

- Proposals shall include a 3-View drawing, comprised of an orthographic view from the Top, Front and Side with all key dimensions clearly labelled in both metric and English units)
- Complete citations of all previous relevant work (the State-of-the-Art)
- Professional quality and presentation
- A proposal that meets all format and content requirements
- A summary weight table and cg diagram
- Bell-specific design objectives are contained in Section 2 of the RFP

1.6 Proposal Requirements

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

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 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.

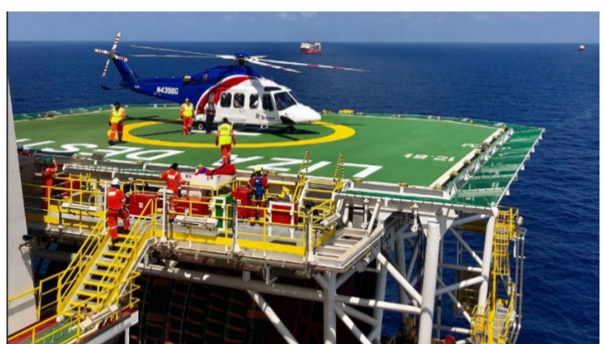
2. System Objectives

2.1 Background

In the context of rising global energy demand, oil and gas play the central role in worldwide economic stability and industrial capacity. These resources remain a primary heating source for many homes and buildings, and worldwide about 24% of electric power plants rely on natural gas and heavy fuels—rising to 43% in the United States. Massive AI data centers are accelerating this demand, drawing an estimated 55 GW in the United States, 30–35 GW in China, and 21 GW in Europe, where only a fraction of electricity is sourced from renewables. The transportation sector, including rail, trucking, and automotive, relies heavily on refined fuels. Even as electric vehicles become more widespread, many depend on grid electricity. In the aerospace sector, jet fuel's unmatched energy density - roughly 40–50 times greater per kilogram than lithium-ion batteries – is essential. Domestic and international air travel could not exist without oil production. Similarly, petrochemical manufacturing would face severe disruption, as nearly all plastics (~ 99%) and nitrogen-based fertilizers originate directly from the constituents of oil and gas feedstocks. This ties global food prices and a vast range of everyday products directly to this industry, making oil and gas production essential to supporting the planet's 8.3 billion people.

In 2015, roughly 100 miles off the South American coastline, a massive oil reserve now proven to exceed 11 billion barrels, was discovered. At current production rates of nearly 1 million barrels per day, the oil reserve will remain active, producing oil and gas, for at least 30 years. In one region, production rates are sustained by four Floating Production Storage and Offloading (FPSO) vessels. These massive ships remain moored to the seabed infrastructure for continuous oil/gas extraction and basic processing. The stabilized crude oil is stored on the FPSO until it can be emptied by tankers for transport to land-based refineries. There are expectations to operate increasing numbers of FPSOs off the South American coast. To sustain ongoing operations, these vessels require logistics support from rotorcraft fleets comprised of VTOL aircraft.

FPSOs, such as the newly constructed Liza Destiny, are essential to offshore oil and gas production. (SBM Offshore)



Heavy and Medium Helicopters support multiple passenger flights to/from the FSPO each day. (ExxonMobil)

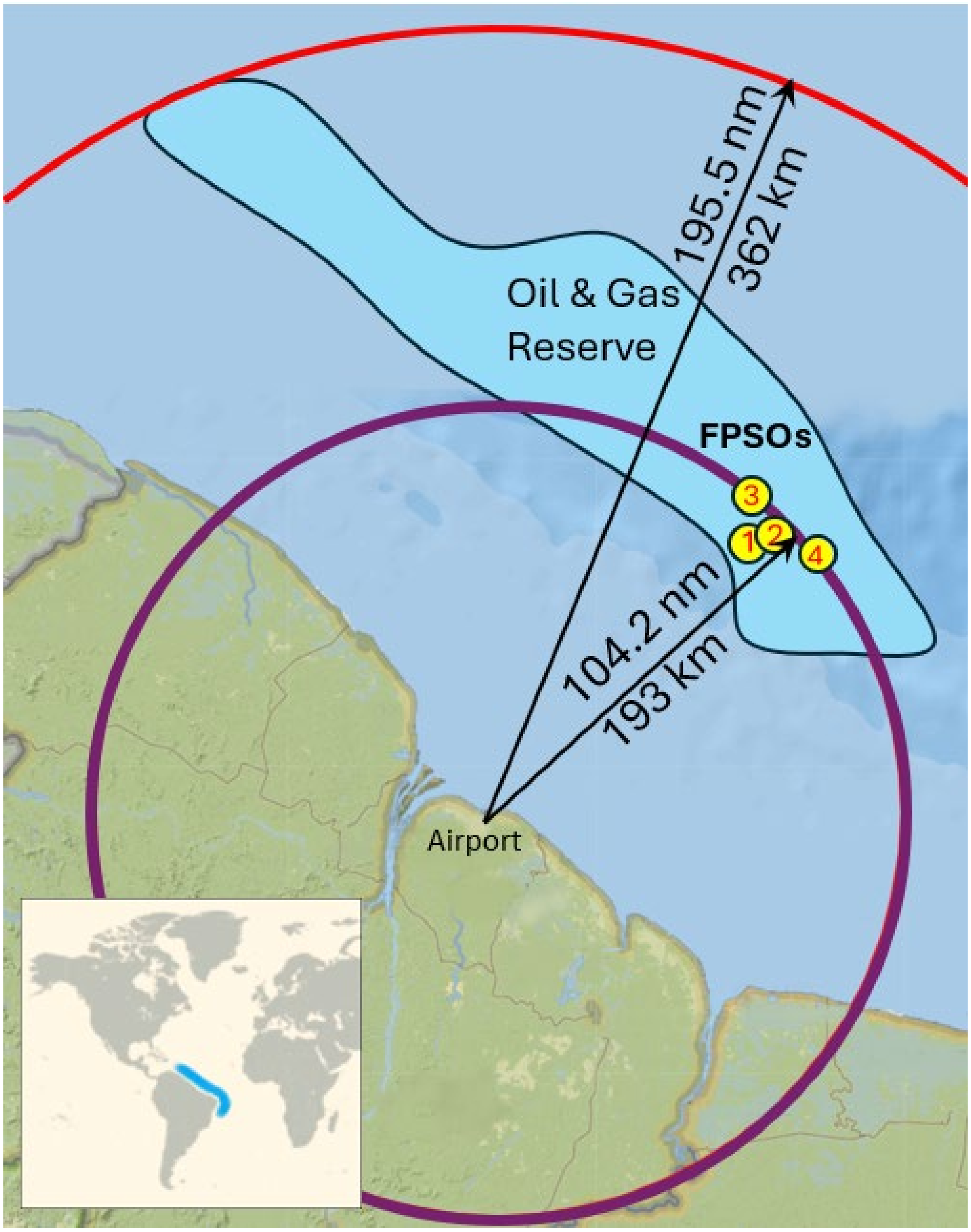
2.2 Operating Concept

Rotorcraft serving the FPSOs off South America's coast provide crew changes, supplies, medevac, and delivery of critical components for sustained operation. Each FPSO is equipped with a certified D-rated helideck to receive heavy and medium rotorcraft. Other vessels developing the oil reserve include drilling rigs, ships with heavy lift cranes, ROV operators and many other Multi-Purpose Support Vessels (MPSVs) that have similar helidecks. The rotorcraft's design mission shall be FPSO support, but it is understood that the rotorcraft would support other unspecified offshore vessels, resulting in additional daily missions.

For a FPSO, the height of the helideck off the waterline varies with the production crude oil load, but for the proposal response section regarding Category-A Rejected Landing / Continued Takeoff (discussed later) it shall be assumed that the height of the vessel's helideck off the water is fixed at 35 m (115 ft). Responders shall take note that the D-Value of the helideck, at 20.88 (68.5 ft), represents the largest overall dimension that can be accommodated for a rotorcraft with rotors turning. The proposed rotorcraft shall fit this D-Value for the FPSO Helideck, accommodating a maximum weight of 12 Metric tons (26,455 lb) or less.

FPSO helideck height off the water shall be taken as 35 m, 115 ft

For mission orientation, the map below illustrates a section of the South American coastline and the notional oil-field discovery. Current FPSO locations are shown within a 193-km (104.2 nm) range ring. Rotorcraft serving the FSPOs shall operate from the indicated airport. For reference, a typical helicopter flight to the inner range ring would take about 60 minutes, assuming a typical helicopter's long-range cruise speed, V_{LRC}. To capture future needs for the oil reserve's development, an outer range ring at 362 km (195.5 nm) shall serve as the maximum design mission radius.



Mission Map: Two missions are represented by the two range rings. The immediate need is to service four FPSOs operating within 193 km (104.2 nm) of the airport. The larger range ring represents anticipated development of the Oil & Gas reserve.

2.3 Mission Requirements

High-level mission requirements: The two missions below will each impact the rotorcraft design. To make sure this is understood, a discussion is appropriate, but first, here are the missions:

Mission 1 – Range Ring 1: Starting at the maximum gross weight and a Category A runway takeoff at the Airport, the rotorcraft shall carry the crew plus a full 16 passenger and baggage load to the inner range ring (193 km, 104.2 nm). At the FPSO, the rotorcraft shall perform a Category A, elevated helipad landing. Without taking on fuel, the rotorcraft shall conduct a Category A vertical takeoff from the FPSO helideck with a full passenger/baggage load and return to the Airport, where a Category A Runway landing shall be conducted.

Mission 2 – Range Ring 2: Starting at the same maximum gross weight as Mission 1, with full fuel tanks, crew, and a "to be determined" passenger/baggage load, the rotorcraft shall conduct a Category A runway takeoff from the Airport and fly to the maximum radius of 362 km (195.5 nm), where a Category A, elevated helipad vertical landing shall be conducted at the FPSO. Outbound passengers/baggage will be swapped with the same number of passengers/baggage as the inbound flight. Without taking on fuel, the rotorcraft will depart the FPSO using a Category A, elevated helipad takeoff and return to the Airport for a Category A Vertical Landing. For Mission 2, students shall determine the maximum number of passengers (with their assigned baggage) that can be transported for the flight to the FPSO.

Discussion: The Maximum gross weight is the same for both missions and, for purposes of the RFP, is comprised only of the fixed empty weight, the fuel required for the mission, and the crew + passengers/baggage. The aircraft Maximum Gross Weight will be determined by Mission 1, where the crew plus a 16 passenger/baggage load (see passenger/baggage requirements later) is carried with partially filled fuel tanks to the smaller mission radius (193 km, 104.2 nm) as defined above. Mission 1 thus sizes the cabin, but Mission 2, at 362 km (195.5 nm) sizes the fuel tanks. Once the Maximum Gross Weight is determined in Mission 1, that weight is fixed to be the same for Mission 2, and thus, for purposes of the RFP, the take-off weight at the Airport always starts at the same Maximum Gross Weight.
To determine the fuel tank size, Mission 2 must be analyzed for its greater radius. Since the Maximum Gross Weight is fixed, and the fuel tanks are full, the Airport take-off for Mission 2 will have fewer passengers than Mission 1. For Mission 2, the student teams shall report the reduced number of passengers that can be carried to the FPSO, factoring the Category A Elevated Helipad landing at the FPSO.

Both mission profiles shall assume ISA+15°C conditions for all mission segments as identified below:

1. Onshore runway (Category A) "rolling" take-off at sea level
    - For purposes of weight calculation, fuel burn for the take-off shall assume AEO Take-Off Power for 1 minute. (See Powerplant detail in the DDN section for powerplant

rating structure)

2. Climb at Max Continuous Power (MCP) at best climb speed to 1830 m, (6000 ft)
3. Cruise at 1830 m, (6000 ft) altitude, at long range cruise speed (V_{LRC})
4. Descent at 222 km/h True Air Speed, (120 KTAS) and 152 meters/min (500 ft/min) to sea level
5. Offshore elevated heliport landing (Category A) at sea level
   - For purposes of weight calculation, fuel burn for the landing shall assume AEO Take-Off Power for 1 minute
6. 15 min at 10% MCP AEO to determine fuel consumption during loading and unloading of passengers at the FPSO
7. Offshore elevated helipad takeoff (Category A) at sea level
   - For purposes of weight calculation, fuel burn for the take-off shall assume AEO Take Off Power for 1 minute.
8. Climb at MCP at best climb speed to 1,830 meters, (6000 ft)
9. Cruise at 1,830 meters, (6000 ft) at V_{LRC}
10. Descent at 222 km/h True Air Speed, (120 KTAS) and 152 meters/min, (500 ft/min) to sea level
11. Vertical landing at the Airport (Category A) at sea level
    - For purposes of weight calculation, fuel burn for the landing shall assume AEO Take Off Power for 1 minute
12. At the end of the mission, there shall be a reserve fuel weight to fly the following profile: First, cruise at 915 m (3,000 ft) at best range speed (V_{BR}) for 50 km (27 nm) to an alternate airport and then cruise at 915 m (3000 ft) altitude at best endurance speed (V_{BE}) for 30-minutes.

The following assumptions shall be used for all missions:

- Passenger weight, at 115.6 kg, 255 lb (each) includes baggage.
- Crew weight (Pilot and Copilot), at 90.7 kg, 200 lb (each) no baggage.

2.4 Design Requirements

Guidance: Outstanding proposals will focus on explanations of design decision drivers and methodologies used directly to size, analyze, and iterate on the system. Students are advised to give attention to any portion of the RFP containing the word "shall."
To differentiate design concepts (Helicopter, Tiltrotor, eVTOL, etc.), proposals shall consider a daily need to transport 200 passengers and their baggage for Mission 1, plus 200 passengers and their baggage for Mission 2. Since this number must be transported each day, student teams shall report the total number of rotorcraft (of their design) needed to operate at this pace. Students shall assume that each rotorcraft conducts 12 hours of daily operation. For the time estimate, students shall assume 40 minutes are spent at the Airport (refueling, unloading/loading). This analysis response shall be entered into in the Cost Section discussed next.

Cost Analysis: Due to historically wide-ranging dollar-cost assumptions among competing student teams, cost estimating shall not be dollarized but shall be projected in terms of mission cost factors described below. In general, student proposals shall explain why their design is cost-effective in terms of mission cost factors. This conversation is about design simplicity, low empty weight, acceptable risk, technological and manufacturing readiness, ease of maintenance, and mission effectiveness. Students shall tabularize the major mission cost factors, including the following:

Mission Cost Factors:

- Number of aircraft required to support the pace of operations (as stated in the Design Requirements above)
- Mission 1 time: hours, minutes
- Mission 1 Fuel required: kg, lb
- Mission 2 time: hours, minutes
- Mission 2 Fuel required: (kg, lb)
- Sum of fuel required (all aircraft) per day of paced operation
- Sum of mission hours flown per day (all Aircraft for paced operation)
- Maintenance hours per flight-hour: (hours per flight hour)
- Aircraft empty weight: (kg, lb)
- Others as deemed appropriate by student team

Student teams shall make appropriate adjustments of the fuel cost factor (with explanation) if alternate fuel / power systems are selected.

Specification Requirements: Students shall design a rotorcraft to serve the full extent of the oil & gas reserve for the missions specified in Section 2.3.

- Students shall design a Transport Category A rotorcraft sized to accommodate 16 passengers at 115.6 kg (255 lb) each, which includes their baggage. Students shall provide their rationale for the rotorcraft's baggage bay volume.
- For each specified mission, students shall account for the cg of all weight items, including fixed weights (pilots, cabin, seats, drive system, fuel, landing gear, offshore kits, etc.) and variable items (passengers, baggage, and fuel).
- In addition to the major configuration items (cabin, rotors, drive system, fuel…) the rotorcraft shall be configured for offshore oil and gas production (OGP) with the following required kits:
  - Emergency Egress lighting system
  - Floats for ditching
  - Two 18 passenger life rafts
  - Automatically Deployable Emergency Locator Transmitter
  - Weather Radar
  - Air Conditioning

- Students shall report on a ditching scenario and generally describe the process of float and raft deployment, confirming their plan for passenger egress and raft entry. Students shall assume calm seas for this task and shall describe both upright and inverted egress, or whether inversion-prevention floats are used. This is a notional exercise to be explained with diagrams and words. Any additional weight impact to prevent roll-over/inversion shall be stated and accounted for in the weight items.
- Loading the OGP aircraft (pilots, passengers, baggage, fuel) between the minimum and maximum take-off weight will typically change the rotorcraft's center of gravity. Students shall track the aircraft cg and confirm that the main rotor has the control authority (cyclic feathering / flapping) to manage the gross weight/cg range for an OGE hover in 65km/hr (35-knot) winds from any direction. For yaw control authority, the rotorcraft shall be shown to capable of maintaining its heading during OGE hover in 65 km/hr (35-knot) winds from any direction for their proposed range of cg at both the minimum and maximum gross weight.
- For each of the two missions, the aircraft shall be shown capable of landing or continuing safe flight following a single engine failure upon arrival at the FPSO. For landing at the offshore elevated FPSO helipad (previously defined), students shall assess a Category-A landing scenario. Students shall determine the landing profile and the Landing Decision Point (LDP). Students shall note the helipad height off the water to assess continued OEI flight with the single engine failure occurring at the LDP. Students shall also assess the OEI landing on the helideck with the single engine failure at the LDP. An energy/power analysis that considers the loss of one engine and 30 second OEI power on the remaining engine(s) is sufficient to determine any gross weight limitation that would ensure a safe landing. For the OEI landing, students shall confirm that the sink rate at landing is no greater than 3 ft/sec. For this exercise, students are encouraged to consult FAA regulatory material.

Design Decision Notifications (DDNs): While much attention is paid to the functioning of the holistic system, past SDC RFPs placed less emphasis on the subsystem decision-making process. Although the full system must be analyzed to ensure the mission can be performed, this RFP asks for a deeper dive into subsystem decision-making during the Preliminary Design phase. For this reason, we introduce the Design Decision Notification.

For a rotorcraft OEM, a "clean-sheet" rotorcraft design is typically initiated from an established base of existing knowledge. Technical experts who have seen aircraft in operation will understand the limitations of previous designs – particularly concerning new mission requirements. New requirements provide the opportunity for an all-new design, leading to a series of about 50 critical design decisions to launch the concept into pre-design and beyond. Because no one person or team has the encompassing knowledge to capture all ramifications of an emergent complex system, a systematic top-down decision-making process often fails to meet expectations. For this reason, the ideal design process exercises an iterative, high-communication environment, facilitated by notifications to the entire team on design decisions that are underway or that have just been made. As the system evolves, assessments of the rotorcraft performance against the requirements proceed and the resulting information brings clarity - both on the design decisions and on the full ramifications of the requirements. Occasionally, a previous design decision may need to be revisited as iterations proceed to the final configuration. The high-communication environment is facilitated by DDNs, which are written in plain English for the entire team (Engineering, Manufacturing, Supply Chain, etc.) to be easily absorbed and acted upon. A DDN communicates the agreed path forward for the entire design team.

A well written DDN will communicate the following:

- Who (i.e., which engineering group(s) or other disciplines) made the decision and what precipitated it? This output is for traceability that connects decision-makers to any downstream revisions.
- What is the decision? This output can vary but would include relevant dimensions, operating specifications, power required, RPMs, torque, and other key information that other teams would need to incorporate that design decision.
- What were the criteria used in making the decision? This would typically include the specific requirement(s) being met and options considered (if any) that led to the decision. Requirements can take the form of a lower-tier requirement that is decomposed (rationalized) from a top-level requirement. For example, there is no specific RFP requirement for a rotor. However, there is an RFP-stated requirement for vertical lift (VTOL). Thus, a DDN that defines a rotor is considered a Tier 2 requirement, decomposed from a top-level requirement in the RFP. Any trade studies related to a DDN are briefly summarized to show why one option was selected over competing options. The ability to meet the requirement is foremost, but rational considerations of cost, technical risk, weight impact, ride quality, noise, corrosion resistance, reliability, functionality, etc. can be used to favor one option over another.

While an OEM would have numerous DDNs, students responding to this RFP shall develop six DDNs (below) to explain their rationale for each identified element. In a straightforward manner, students shall provide statements that capture the logic for each element of the decision. For example, consider the main rotor (or rotors): What factor(s) sized the diameter? Why did you pick X number of blades instead of 2X? What tip speed and why? Why that planform shape – what drove that decision? Some of the rationale might factor Cost, Reliability, Robustness, Performance, noise, etc. The Proposal has a page-count limitation so keep the conversations tight and focused on meeting the RFP (no sustainability arguments or lengthy Systems Engineering discussions are needed). DDN's should be concise – Consider averaging about 1 page each. A more complex decision with figures might be 2 pages. Don't go over the page count limitation.

To help teams facilitate the objective of completed DDNs, student teams shall assign one team-member's job title as "DDN communication specialist" on the signature page. That person's job is to keep things simple and repeat the following to his/her team members daily:

"A DDN is a Preliminary Design decision - emphasis on preliminary." As such, it cannot possibly be asking you for a complete design of that subsystem because subsystem design happens in the Detail Design phase - well after the Preliminary Design Review (PDR). The DDN is desperately seeking the rationale, the approach, and the factors that a designer must account for to start the actual design task. It is NOT asking for the actual Detail Design.

The DDN communication specialist and fellow students shall provide succinct, plain English DDN rationale for the enumerated items below, covering all bullets:

1. **Overall Configuration**
   - Describe the helicopter, Tiltrotor, or other configuration and the factors/rationale that led to the configuration.
2. **Configuration of Main Rotor(s):**
   - Number of rotors
   - Rotor Diameter
   - Number of blades
   - Planform Shape
   - Blade chord, rotor solidity, disk loading
   - Tip speed / RPM, and direction of rotation
   - Hub type, Flapping range relative to mast (deg – forward, lateral, aft)
   - Mast tilt angles relative to the airframe
3. **Tail Rotor Configuration (if used), or any other rotor not previously presented.** If a yaw control rotor is not used, the student team shall provide a DDN concerning the yaw control approach (all modes of flight) under similar guidelines.
   - Tail rotor diameter
   - Tail Rotor Tip Speed / RPM, and direction of rotation
   - Tail rotor orientation (mast angle)
   - Mounting of Tail rotor with respect to vertical fin
   - Vertical fin selection
   - Horizontal tail configuration/size
   - Flare Angle to ground contact (with main gear on ground, extended)
4. **Cabin Layout**
   - Cockpit seating
   - Cabin seating
   - Egress (doors, aisles, push-out windows) normal and in a water ditching scenario
   - Baggage compartment volume, accessibility, cg
   - Height, width, length (also, specify seated leg room, seat dimensions)
   - Substructure and attachment of: wing (if any), transmission, engines, tail (boom)
5. **Fuel Tank(s) Layout**
   - Capacity and number of tanks
   - Interconnect tubes, valves, pumps

- Fuel burn (does the aircraft cg stay within limits as fuel is burned?)
- Tank Locations with respect to aircraft reference (top, side, & possibly rear view)
- Energy attenuation approach (to sustain 50-ft drop with no leaks – including interconnect tubes) – a dynamic analysis is not required, just an explanation.
- Fueling port location

6. Powerplant Selection

It is acceptable to use the specifications of known commercially available engines for the design. This includes the known engine's weight, its maximum continuous power (MCP) rating, and the fuel flow rate at MCP. To level the playing field, power ratings for 5-minute takeoff power and 30 second OEI power shall not use the known engine ratings. Rather, students shall determine their 5-minute Takeoff Power and their 30 second OEI power ratings as follows:

- 5-minute Power = 110% of MCP Power
- 30-second Power=137% of MCP Power

To simplify engine selection, students may define an engine scaled from a known commercial engine to deliver the desired MCP for their design - within reasonable limits that are to be explained in the team's DDN. This scaling option requires examining an appropriate (known) commercially available engine as the basis for their scaled engine weight, scaled MCP fuel flow rate, and any other critical parameters. The scaled engine shall determine its "above MCP" rating structure as noted above.

The powerplant DDN shall require rationale and explanations for the following entries:

- Number of engines
- Engine power structure - per engine (kW, HP) using the above instruction
- Engine weight
- Fuel flow rates for each power rating, per the above instruction
- Fuel flow rate at V_{LRC}, V_{BR}, and at V_{BE} (needed for mission segments)

For purposes of the RFP, installation losses shall be assumed to be 4.5% of the rated power. While other sources of propulsion/fuel/electric may be considered. Students should be mindful of weight and size and give due consideration for the destination CAT A Helipad landing, noting that jet fuel, once burned off, weighs nothing.

Student Teams shall make every effort to consolidate their configuration data in a tabular format to include the information below and any other important design parameters.

Table XX: Final Configuration Parameters				
1	Maximum Gross Weight	kg	Lb	
2	Empty weight[2]	kg	Lb	
3	Maximum Fuel Capacity (Usable)	kg	lb	
4	Total Passenger weight Fully Occupied, including baggage* for Minimum Radius Mission (@ 115.6 kg 255 lb each)	kg	lb	
5	Total Passenger weight including baggage* (@ 115.6 kg 255 lb each) for Max Range Mission	kg	lb	
6	Installed Power (MCP) at SL ISA+15°C	kW	HP	
7	Number of Engines	#		
8	5-min TOP rating at SL, ISA+15°C (installed)	kW	HP	
9	30 sec OEI power at SL, ISA+15°C (installed)	kW	HP	
10	Rotor Diameters	Rotor 1	Rotor 2	…
		m, Ft	m, Ft	…
11	Number of Blades per rotor	Rotor 1	Rotor 2	…
		#	#	…
12	Blade Moment of Inertia: $I = \int_0^R m\,r^2 dr$, m=mass/length	kg-M^2	Slug-Ft^2	
13	Ideal hover power required, MTOW Sea Level, ISA+15°C	kW	HP	
14	Hover Figure of Merit, Sea Level, ISA+15°C	#		
15	Thrust Weighted Blade Chord ** $c_{equiv} = \frac{3}{R^3}\int_0^R c(r)\cdot r^2 dr$	Rotor 1 (m, in)	Rotor 2 (m, in)	…
	* Passenger weight = 102.3 kg, 225 lb			
	* Baggage weight = 13.6 kg, 30 lb			
	Crew weight (Pilot and Copilot) 90.7 kg, 200 lb (each), no baggage.			
	** Within certain assumptions, this calculation yields the chord of the equivalent rectangular blade that produces the same thrust as the designed planform.			

[2] For purposes of this RFP, the empty weight shall be taken as the Maximum Gross Weight minus Payload and fuel. Payload consists of passengers and their baggage, plus the crew (pilots with no baggage).

2.5 Graduate Team Rotor Design Task

Graduate teams shall provide a detailed design and analysis of the main rotor system(s). The following data shall be presented.

- Rotor hub type (e.g., articulated, gimbaled, rigid, bearingless, etc.) and rationale
- General layout including
  - Location of pitch change axes relative to the centers of rotation
  - Locations of any coning, flapping and/or lead-lag hinges (either physical or virtual)
  - Attachment of pitch links and dampers, if included
- Section structural layouts and properties including
  - Locations of shear centers and neutral axes
  - Stiffness properties derived from elastic moduli and area moments of inertia
- Blade geometric and aerodynamic parameters
  - Blade chord, twist, airfoil section, location of airfoil aerodynamic center relative to pitch change axis
  - Charts of lift, drag and pitching moment coefficients for all airfoil sections chosen
- Spanwise mass distribution

Graduate teams shall conduct a rotor dynamic analysis to identify the fundamental beamwise, chordwise and torsional modes and show that their stiffness and mass properties result in the modal natural frequencies being properly separated from the rotor rotational frequency and likely forcing frequencies up to the Nth harmonic, where N is the number of blades.

Graduate teams should ensure that the rotor mass properties provide sufficient rotational inertia to limit the loss of rotor rotational speed to less than 10% in the first second of a single engine failure that occurs during a normal (5-min) takeoff-power climb. After one second, it is assumed that the single engine failure is recognized and the pilot has lowered collective to restore rotor RPM. The Graduate team shall assume that the helicopter is trimmed in a takeoff-power climb at the time of the single engine failure and that the rotor controls are maintained in the trimmed position for one second following the engine failure. In that 1-second time, the rotor speed shall not droop more than 10%. The remaining engine(s) can be assumed to go to the 30 sec OEI power rating upon the single engine failure. Well-communicated simplifying assumptions are encouraged by the teams.

2.6 US ABET Accreditation Information

In the US, ABET accreditation is a formal quality assurance process used to evaluate engineering, technology, and related academic programs against established educational standards. Most participating universities can best engage students through a required or optional rotorcraft/vertical flight design class given the depth of the SDC RFP guidelines.

ABET accreditation is the standard that sets the undergraduate capstone design curriculum in Aerospace/Aeronautical Engineering, and many universities also apply that standard as a guide for their graduate design course curriculum as well. For Aerospace or Aeronautical Engineering degrees, while the language changes with ABET updates, capstone design is required to be a major, open-ended design experience that must include the following curricular topics in sufficient depth for engineering practice:

- Aerodynamics
- Aerospace materials
- Structures
- Propulsion
- Flight Mechanics
- Stability and Control

The purpose of the proposed RFP Technical Specification guidelines is therefore to help the SDC sponsor define projects with sufficient engineering content and design rigor to support courses seeking to satisfy ABET accreditation expectations.

These guidelines are advisory only. The sponsor remains fully responsible for the technical content, scope, feasibility, and accuracy of the Technical Specification, while the academic institution retains responsibility for determining whether a project satisfies ABET-related academic and accreditation requirements.

3. Glossary

AEO	All Engines Operating
AI	Artificial Intelligence
CAT A	Category A
DDN	Design Decision Notification
FAA	Federal Aviation Administration
FPSO	Floating Production Storage and Offloading (ship)
GW	Gross Weight
HIGE	Hover in ground effect
HOGE	Hover out of ground effect
HP	Horsepower
IGE	In ground effect
ISA	International Standard Atmosphere
kg	Kilograms
KTAS	Knots True Airspeed
kW	Kilowatts
LB	Pounds
LDP	Landing decision point

LOI	Letter of intent
MCP	Maximum continuous power
MDO	Multidisciplinary design optimization
MPSV	Multi-Purpose Support Vessel
MSL	Mean sea level
MTOW	Maximum takeoff weight
NM	Nautical Miles
OEI	One Engine Inoperative
OEM	Original Equipment Manufacturer (Bell, Sikorsky, Leonardo, Airbus, Boeing…)
OGE	Out of ground effect
OGP	Oil & Gas Production
PDF	Portable document format
PDR	Preliminary Design Review
RFI	Request for information
RFP	Request for proposals
ROC	Rate of climb
RPM	Revolutions Per Minute
SDC	Student Design Competition
SI	Système Internationale
TOGW	Takeoff gross weight
US	United States
V	Velocity/speed
V_{BE}	Best endurance speed
V_{BR}	Best range speed
V_{climb}	Climb speed
$V_{descent}$	Decent speed
VFS	Vertical Flight Society
V_{LRC}	Long Range Cruise speed (Speed that is higher than V_{BR} with 1% less fuel efficiency)
VTOL	Vertical takeoff and landing