



42nd Annual Student Design Competition

2024–2025 Request for Proposal (RFP)

Pioneering Hydrogen-Electric VTOL

Sponsored by

AIRBUS

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1. Basic Proposal Information

Airbus extends greetings and invites you to participate in the 42nd Annual Student Design Competition (SDC) of the Vertical Flight Society (VFS) to design a pioneering hydrogen-electric vertical takeoff and landing (VTOL) aircraft.

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 Airbus and VFS.

1.1 Rules

1.1.1 Who May Participate

All undergraduate and graduate students from any school (university or college), ***with the exception of countries or persons prohibited by the United States Government***, are eligible to submit a proposal. A student may be full or part-time; their education level will be considered in the classification of their team (see 1.1.3).

1.1.2 Team Information: Roles, Size and Number of Teams

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

- **ALL teams MUST name at least one (1) faculty advisor in order 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 (1) 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
- **Teams are allowed to include up to two (2) industry and/or two (2) government advisors to mentor/advise on the design.**

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). 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 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

1.1.3 Categories and Classifications

The competition has two categories, which are:

- Undergraduate Student Category
- Graduate Student Category

NOTE: The classification of the team is determined by the highest educational level currently pursued by any member of the team.

Additional prizes can be awarded to the best new entrant team in each category. **A new entrant is defined as any school (undergraduate or graduate) that has not participated in the last three competitions.**

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 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 should be expressed in the units of:

- Newtons, N (force)
- Kilograms, kg (mass)
- Seconds, minutes, or hours as appropriate (time)
- Meters, m, or kilometers, km, as appropriate (length or distance)
- Meters per second, m/s (velocity/speed)
- Watts, W, or Kilowatts, kW as appropriate (power)
- Maximum Takeoff Weight (MTOW) and Payload Weight may be expressed in kilograms

1.1.6 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 two mandatory files are the Executive Summary and the Final Proposal: teams that do not submit both mandatory files will not be reviewed by the SDC Review Committee. 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 as an Adobe Acrobat Reader-compatible portable document file (PDF) 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 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.

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

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

- Limited to twenty (20) pages for both undergraduate and graduate category and can take the form of a PowerPoint-style presentation
- No additional technical content should be introduced in the Executive Summary
- All pages are to be numbered
- Pages should measure 8½ 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

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

1.1.7 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 and industry advisors may provide guidance. **The signature page must also include the printed names, e-mail addresses and signatures of the faculty and industry 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, the team captain must notify the VFS SDC point of contact in writing immediately by email.

1.1.9 Minimum Expectations

The Vertical Flight Society and the Student Design Competition Committee reserve the right to decline to disburse all of the awards in the listed 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 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 not count against the page count. See the executive summary of past SDC winners at www.vtol.org/sdc-winners.

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, magazine article(s) and other promotional purposes.

1.2 Awards

Airbus is very pleased to sponsor the VFS Student Design Competition this year. **Airbus** will provide the funds for the awards through VFS. 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

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 82nd Annual Forum, May 5-7, 2026, in West Palm Beach, Florida, during an Aircraft Design Technical Session.
- The student(s) 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 defray some of 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.

1.3 Schedule

Schedule milestones and deadline dates for submission are as follows:

Milestone	Date
VFS issues the RFP	August 2024
Teams submit Letter of Intent (LOI) to Participate	February 1, 2025
Teams submit Questions for RFP Clarification Note: 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.	Continuously, but NLT Feb. 24, 2025
Sponsor Review of Team RFP Questions	Feb. 24 to March 24, 2025
VFS issues / Sponsor Responses to Team Questions	NLT March 26, 2025
SDC Committee & sponsor reviews/scores final proposals	June 1 to July 31, 2025
Sponsor notifies VFS of results	August 2025
VFS announces winners	August 2025
Winning Graduate and Undergraduate Teams present at VFS Forum 82 (2026)	Forum 82: May 5-7, 2026, West Palm Beach, FL

1.4 Contacts

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: (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.

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 requires:

- Self-contained Executive Summary that contains all pertinent information and a compelling case as to why the proposal should win and 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):

- Demonstrate a thorough understanding of the RFP requirements.
- 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.
- 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.

- 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 aircraft concept design and capabilities.

2 System Objectives

2.1 Operating Concept

In the context of growing environmental concerns, the aviation sector is seeking to reduce its global carbon footprint. One promising research field is the use of hydrogen as an energy carrier instead of the current fossil fuel energy. In commercial aviation, Airbus has, for example, launched its [ZEROe](#) project to explore hydrogen propulsion in different airliner configurations.

For electric vertical takeoff and landing (VTOL) aircraft, hydrogen (H₂) may become an alternative energy carrier to curb carbon emissions of this transportation sector. **The goal of the RFP is to conceptually design an electric VTOL using hydrogen-only propulsion, while meeting several requirement constraints.**

Due to their currently low demonstrated Technology Readiness Level (TRL), NO_x emissions, and safety concerns regarding the hydrogen supply system of H₂-burning turbines, only Proton Exchange Membrane Fuel Cell (PEMFC) systems will be used in this study — hence a fully electrically powered VTOL aircraft. In terms of H₂ storage, the liquid H₂ option (cryogenic) is discarded. **Consequently, only gaseous H₂ at high pressure is considered for this study.**

As flights of hydrogen-powered aircraft have already been demonstrated in some cases even with pilot onboard, this RFP is a unique opportunity for you to **understand and overcome the specific challenges and requirements of a passenger carrying hydrogen-powered VTOL aircraft.**

2.2 Pioneering Mission

In consideration of the first controlled airplane flights by the Wright Brothers, the required mission will begin in the surroundings of Kitty Hawk, North Carolina, USA, at the [Wright Brothers National Memorial](#).

The goal of the pioneering mission is to transport the full required payload (cf. section 2.3 Aircraft Requirements and Constraints) at the designed MTOW, for the longest endurance.

Referring to section 2.3, the zero-emission aircraft includes a loitering time at the entrance of the Alligator River, where the chance of observing several very interesting [species of animals is high](#). This loitering time must therefore be maximized, after which the VTOL aircraft must return to its take-off point.

At the takeoff/landing location, the ground level is at mean sea level (MSL). All mission points are considered at zero wind speed, hence the ground reference frame is the same as the aerodynamic frame. All the mission segments are done at the International Standard Atmosphere (ISA) with no temperature deviation.

The minimum required mission is as follows (a glossary of abbreviations is given at the end of this document):

Mission Segment	Segment Characteristics
1. Normal vertical takeoff to HIGE, at MSL ISA	Full payload on board. Starting coordinates: 36.0169559530632, -75.66835144625382
2. HIGE at MSL	15s
3. Vertical climb to 60 m above MSL	Vertical ROC = 0.76 m/s (OGE
4. HOGE at 60 m above MSL	10s duration
5. Steady climb to 300 m above MSL	9° Flight Path Angle with Respect to Ground Horizontal speed V_{climb} to be determined
6. Cruise at 300 m above MSL	V_{be} to be determined
7. Steep descent to 30 m above MSL	-7.6 m/s descent rate at same V_{climb} : Autorotation Mode Authorized; no shaft required power considered
8. HOGE at 30 m above MSL	30s sustained hover. Coordinates: 35.89899991035759, -75.9681462216371 Distance between segment 1 and 8 is 30 km.
9. Loitering at 30 m (100 ft) above MSL	Loitering flight at best endurance speed V_{be} , to be determined. Horizontal speed only. Try to spot the alligators in the river. Cruise endurance time T_9 to be maximized. T_9 shall be ≥ 0 second.
10. Steady climb to 30 m above MSL	Heading back to the Wright Brothers National Memorial . 9° flight path angle with respect to ground, Horizontal speed V_{climb} to be determined
11. Cruise at 30 m above MSL	V_{be} to be determined.
12. Steady descent to 60 m above MSL	Angle of descent = 5°, $V_{descent}$ to be determined.
13. HOGE at 60 m above MSL	10s duration for contingency planning Distance between segment 9 and 13 is again 30 km.
14. Vertical descent to HIGE MSL	Rate of descent = 0.50 m/s OGE
15. HIGE at MSL	15s duration
16. Normal vertical landing from HIGE	Landing coordinates: 36.0169559530632, -75.66835144625382



Figure 1: *First part of the required mission, starting from the Wright Brothers National Memorial. (Courtesy of Google Maps)*

2.3 Aircraft Requirements and Constraints

The design teams shall conceptually design a manned VTOL aircraft with the following requirements:

- Full-electric aircraft, powered by PEM fuel cells, with pressurized gaseous H₂ storage
- Carry 1 pilot and 1 passenger with luggage, equivalent to a total payload of 185 kg
- Complete aircraft with full rotor disk(s) must fit within a rectangular prism of dimensions 10 m x 10 m x 4 m
- A minimum interior usable cabin floor dimension of 1.25 m (width) x 1.5 m (length)

There is no aircraft configuration imposed. The VTOL aircraft could be a single main rotor helicopter, a multi-rotor, a compound rotorcraft, etc., as long as it fulfills the requirements.

Using a “buffer” battery in conjunction with the fuel cell for peak power shaving is permissible.

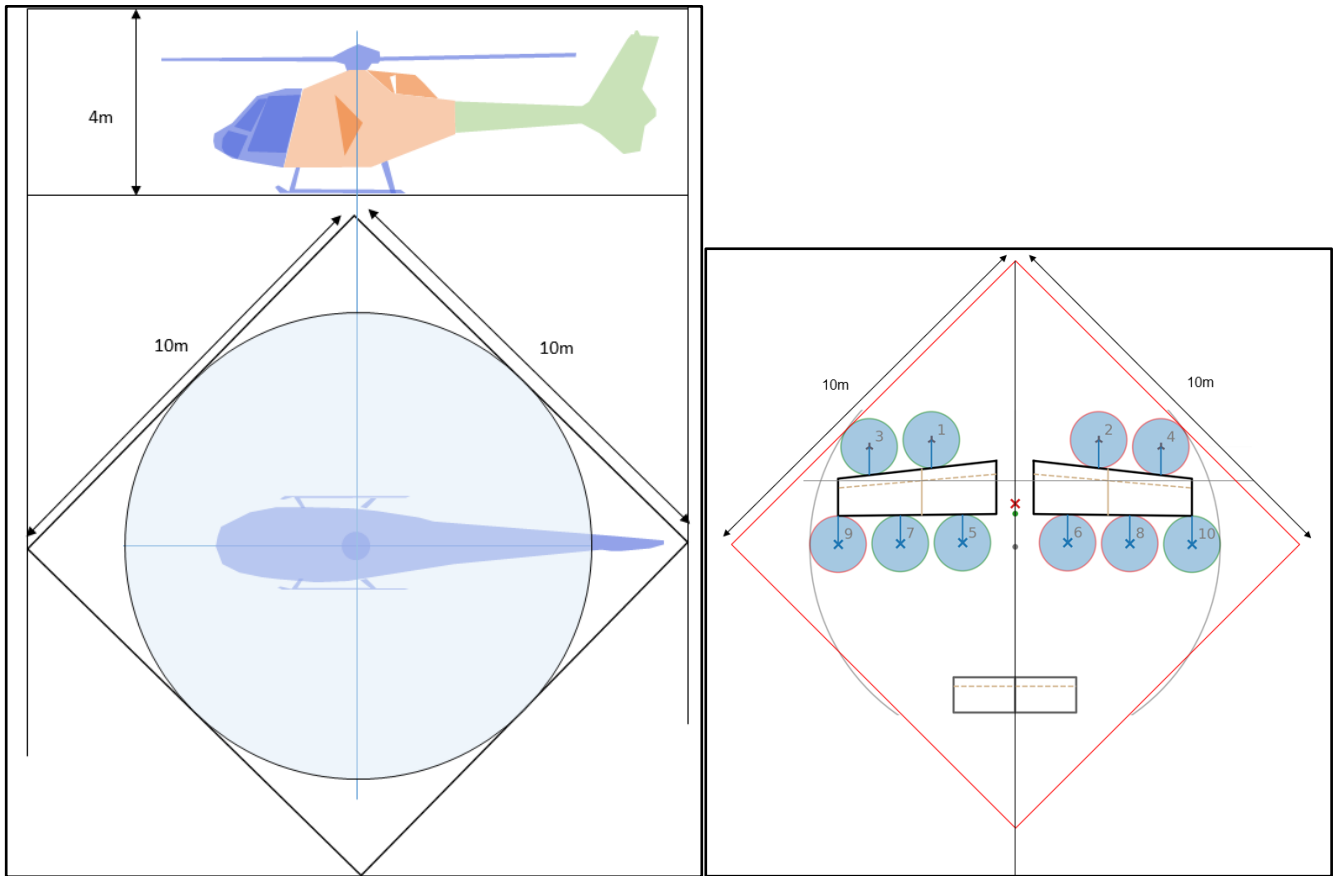


Figure 2: *Examples of conceptual VTOL aircraft that fulfill the dimension requirements*

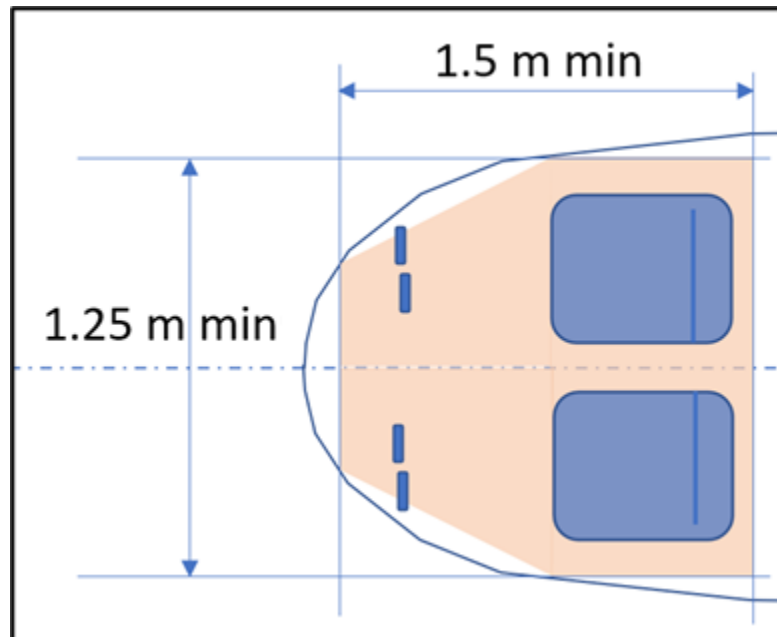


Figure 3: *Minimum internal useable cabin floor area illustration*

The PEM fuel cell and all the associated systems must be carefully sized. The design teams are advised to read the reference ([Datta 2021](#)) to get an initial overview of the necessary systems to design such a PEMFC system.

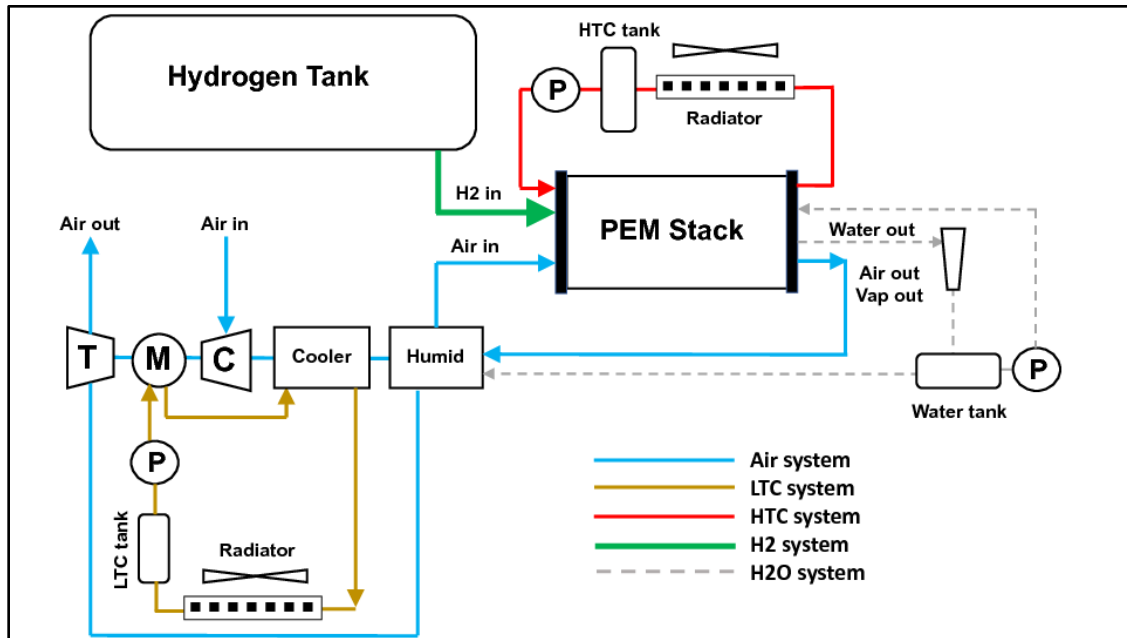


Figure 4: Example of a PEM fuel cell system ([Datta 2021](#))

Specific requirements of the PEMFC system are as follows:

- Reach a high-voltage (HV) network maximum of 840V
- The PEM stack should not operate at a steady-state temperature of more than 90°C
- The H₂ tank pressure should not exceed 700 bar ($7 \times 10^7 \text{ N/m}^2$)

Hydrogen storage systems, high-temperature / low-temperature cooling systems, air and water management systems must be sized accurately and completely.

For purposes of the student proposals, only steady-state performance of the PEM systems are expected. However, if transient power limitations are identified due to fuel cell dynamic response, additional electrical supply devices should be considered.

A particular focus must be placed on the physical integration of all these systems, with credible volume allocations and defined load paths for the airframe. Airframe surface locations of air inlets and outlets must be provided in detail.

Airbus asks the teams not to use forward-looking statements for weight opportunities on e.g. airframe structure, rotor systems, engines, etc. but only use credible widely used civil-certified helicopter or airplane references.

2.4 RFP Objectives and Deliverables

Each student team must ensure delivery of a comprehensive aircraft architecture meeting the 2.2 Pioneering mission and 2.3 Aircraft Requirements and Constraints. A non-exhaustive list of deliverables is given below.

2.4.1 Conceptual Design Trade Studies

The design teams shall provide conceptual design trade studies and associated analysis to substantiate their design decisions. At a minimum, trade study topics must include the following:

- Vehicle configuration choice (e.g., classical helicopter, compound, etc.)
- Rotor/propeller design (number of blades, hover and cruise tip speed [rotational speed times radius], mean aerodynamic chord, radius, twist, airfoil 2D aerodynamic characteristics)
- Powerplant selection
- Transmission design (if applicable)
- Wing design (if applicable)
- Fuselage design
- Any other analysis that the design team used to come to its final design

2.4.2 Vehicle Performance

The design teams shall provide vehicle performance analysis for the sizing mission. The analysis must include but is not limited to:

- Vehicle total power required for all mission segments.
- Vehicle aerodynamic power required (e.g., for a helicopter this would be rotor shaft power required) for all mission segments.
- Vehicle transmission efficiency for all mission segments.
- Electric motor(s) RPM- torque during the mission
- Vehicle PEM Fuel cell efficiency for all mission segments.
- Hydrogen flow rate and consumption during the mission

The following performance metrics are required:

- Maximum level flight speed at SL ISA. Performance constraint to be precise (required torque, power).
- HOGE ceiling diagram, at SL ISA and ISA+20, i.e. the maximum takeoff altitudes plotted versus the range of gross weights, based on the maximum continuous power (MCP) available from the drive system / electrical power available (C-rate limited), being equal to the power required for HOGE at those altitudes.
- Required shaft(s) power breakdown in a trim from HOGE to the maximum level flight speed at SL ISA. Provide the different sources of rotor required power. Include a graph showing the equivalent lift-over-drag ratio over the range of speeds.

$$(L/D)_e = MTOW \cdot g \cdot V_\infty / P_{shafts,tot}$$

- Identify the best endurance speed, and best range speeds on these graphs.

2.4.3 Weight & Balance

The design teams shall provide details about the Weights & Balance of the selected aircraft meeting the requirements. This includes:

- Weight breakdown (according to Military Standard MIL-STD-1374, SAWE RP-A7 or RP-8 or similar format). A clear focus should be made on the weight groups associated to the PEM Fuel Cell and balance of powerplant items
- Weight and center of gravity evolution during the sizing mission
- A center of gravity analysis (laterally, longitudinally and vertically).

2.4.4 Aerodynamic Metrics

Design teams shall include the following aerodynamic metrics describing the airframe. The airframe excludes rotors, wings and empennage, but does include rotor hubs:

- Drag area (D/q) at zero degrees vehicle pitch and yaw angle.
- Pitching moment volume (M/q) is estimated at zero degrees vehicle pitch and yaw angle.
- A drag estimation methodology shall be presented and substantiated.
- The associated airframe aerodynamic L/D could be provided, alongside the performance graphs.

2.4.5 Vehicle Drawings

Design teams shall provide (at a minimum) the following drawings:

- Three-view external geometry including vehicle dimensions for all vehicle configurations. Include the required minimum inscribed circle of the aircraft, showing that the aircraft fits in the rectangular prism constraint
- Fuselage internal layout including center of gravity location
- If necessary, PEMFC-related system drawings, including external cooling exchangers

A compelling image of the aircraft in an environment (e.g. in flight or on the ground) is not required but is encouraged for promotional purposes.

2.4.6 Constrained Multidisciplinary Design Optimization Task: **Graduate Students Only**

For the Graduate teams, the RFP includes a multidisciplinary design optimization (MDO) problem, as follows:

$$\begin{aligned} &\max T_9(x_{DV}) \\ &\text{w.r.t } x_{DV} \\ &\text{s.t. every constraints} \end{aligned}$$

The objective function is to maximize the 9th segment cruise time of the 2.2 Pioneering mission. Achieving the objective is with respect to (w.r.t) the design variables x_{DV} , which are all the aircraft relevant parameters, e.g. MTOW, disk loading, number of rotors, solidity, fuel cell design current density, wing aspect ratio, tip speed, number of electrical motors, cabin volume, etc. The design is subject to (s.t.) constraints stated in section 2.3 Aircraft Requirements and Constraints.

For the graduate teams, a design optimum with respect to at least the aircraft MTOW (alternatively,

disk loading) must be shown. The optimum design variables x_{DV}^* and objective function T_g^* must be provided as the final result. Use of additional design variables to maximize the endurance time, would be considered more favorable.

This being said, the emphasis should not be on the multidisciplinary coupling and optimization itself, but rather explaining thoroughly the design sensitivities of the different aircraft components with respect to the design variables — the latter drives real industry trade-offs for the launch of such a vehicle.

3. References

Datta, Anubhav. 2021. “PEM Fuel Cell Model for Conceptual Design of Hydrogen eVTOL Aircraft.” NASA Technical Reports. <https://ntrs.nasa.gov/citations/20210000284>.

4. Glossary

- HIGE hover in ground effect
- HOGE hover out of ground effect
- IGE in ground effect
- LOI letter of intent
- MCP maximum continuous power
- MDO multidisciplinary design optimization
- MSL mean sea level
- MTOW maximum takeoff weight
- NLT no later than
- OGE out of ground effect
- PDF portable document format
- RFI request for information
- RFP request for proposals
- ROC rate of climb
- SAWE Society of Allied Weight Engineers
- SDC Student Design Competition
- SI Système Internationale
- TRL Technology Readiness Level
- TOGW takeoff gross weight
- USA United States of America
- V velocity/speed
- V_{be} best endurance speed
- V_{climb} climb speed
- $V_{descent}$ descent speed
- VFS Vertical Flight Society
- VTOL vertical takeoff and landing