29th Annual American Helicopter Society
Student Design Competition

2012 Request for Proposal (RFP)
For

Rotary Winged Pylon Racer

Sponsored by

Sikorsky
A United Technologies Company

And

AHS International

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1.0 Basic Proposal Information

Sikorsky Aircraft extends greetings and invites you to participate in the 29th Student Design Competition (SDC) of the American Helicopter Society, International (AHS). This Request For Proposal (RFP) is divided into two sections. Section 1 (this section) provides a general description of the competition and the process for entering. This section covers the rules (both general and proposal specific) and schedules that the sponsor requires of the participants. It also describes the awards and provides contact information. Section 2 describes the specific challenge by Sikorsky Aircraft

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, regardless of nationality. A student may be full-time or part-time; their education level will be considered in the classification of their team (see 1.1.3).

1.1.2 Team Size and Number of Teams

We encourage the formation of project teams. The maximum number of students on a 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 multi-university teams for the added experience gained in education and project management. The maximum number of students for a multi-university team is twelve (12), distributed in any manner over the multi-university team.

The members of a team must be named in the Letter of Intent. The Letter of Intent is drafted by the captain of a team and sent to the American Helicopter Society by the date specified in section 1.3. Information in the Letter of Intent must include the name of the university or universities forming the team, the name of the team, the printed names of the members of the team from all the universities in the team, the e-mail addresses and education level (undergraduate or graduate) of each team member, the affiliation of each student in the case of a multi-university team, and the printed names and affiliations of the faculty advisors.

1.1.3 Categories and Classifications

The competition has two categories that are eligible for prizes. They are:

- Undergraduate Student Category

- Graduate Student Category

The classification of a team is determined by the highest education level currently pursued by any member of the team.

A “new entrant” is defined as any school (undergraduate or graduate) that has not participated in at least two of the prior three competitions. An additional prize will be awarded for the best proposal by a new entrant.

1.1.4 Language of Proposal

Regardless of the nationality of the teams, all submittals and communications to and from the American Helicopter Society will be in English. All technical data shall be presented in English units

1.1.5 Proposal Format, Length and Medium

At least two separate files comprise the Final Submittal for the Undergraduate Category while three separate files comprise the Final Submission for the Graduate Category. All files must be present for a submission to be considered complete. The judges shall apply a significant penalty if any file is missing.

The files are the Executive Summary, the Final Proposal, and the Simulation Package. Each are described herein.

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

Undergraduate category Final Proposals shall be no more than 50 pages and graduate category Final Proposals shall be no more than 100 pages. This page count includes all figures, diagrams, drawings, photographs and appendices. In short, anything that can be read or viewed is considered a page and subject to the page count, with the following exceptions. The cover page, acknowledgement page, signature page, posting permission page (see section 1.1.9), table of contents, list of figures, list of tables, nomenclature, reference pages and the Executive Summary are excluded from the page count for the Final Proposal. See sections 1.1.6 for specific information about the signature page.

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

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

The second file is a PDF file called the Executive Summary. This is a self-contained "executive" briefing of the proposal. Both undergraduate and graduate category Executive Summaries are limited to twenty (20) pages measuring 8 ½ x 11 inches, with no more than four (4) larger fold-out pages of a maximum size of 11 x 17 inches. The Executive Summary can take the form of a viewgraph-style presentation, but it must be a PDF file readable with Adobe Acrobat. No additional technical content may be introduced in the Executive Summary. The judges shall apply the same page count penalty to the Executive Summary score as with the Final Proposal. The Executive Summary shall account for no more than 10% of the total score of the complete submission.

The third file is called the Simulation Package. This package is comprised of those files necessary to run the X-Plane simulation. These files are optional for the Undergraduate Category and are mandatory for the Graduate Category. The package shall include video documentation necessary to complete the requirements of this RFP. All Simulation Package files shall be compressed into a single .zip file and sent along with the two report files described above.

All submissions shall be made on a compact disc (CD). A back-up submission via e-mail to the AHS may also be provided by a team, but the submission will not be considered executed without receipt of a compact disc by the submittal deadline.

1.1.6 Signature Page

All submittals must include a signature page as the second page, following immediately after the cover page. The signature page must include the printed name, e-mail addresses, education level, (undergraduate or graduate), and signature of each student that participated. In the case of a multi-university team, the page must also indicate the affiliation of each student.

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

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

1.1.7 Withdrawal

If a student withdraws from a team, or if a team withdraws their project from the competition, that team must notify the AHS National Headquarters Office in writing immediately.

1.1.8 Special Sponsor Rules

For the optional simulation, teams must submit any necessary electronic files needed to run their model in the X-Plane environment.

1.1.9 Proposal Posting

The AHS will post the winning entries in the undergraduate and graduate categories on their web site. Other entries will be posted if the teams provide written permission by their team captain or designated point of contact and a faculty advisor at the time of submission. The written permission shall appear on a separate page immediately following the signature page. This permission page will not count against the total page count.

1.2 Awards

Sikorsky Aircraft is very pleased to sponsor the AHS Student Design Competition this year. Sikorsky Aircraft will provide the funds for the awards and travel stipends.

Submittals are judged in two (2) categories.

Undergraduate category:

- 1st place - $800
- 2nd place - $400

Graduate category:

- 1st place - $1300
- 2nd place - $700

In addition, the best "New Entrant" (defined in section 1.1.3) will be awarded $300.

Certificates of achievement will be presented to each member of the winning team and to their faculty advisors for display at their school. The first place winner or team representative for the graduate and undergraduate categories will be expected to present a technical summary of their design at the 2013 AHS International Annual Forum. Presenters receive complimentary registration and will be provided up to $1000 in expenses to help defray the cost of attendance.

1.3 Schedule

Schedule milestones and deadline dates for submission are as follows:

Milestone	Date
AHS Issues a Request For Proposal	August 8, 2011
Submit Letter of Intent to Participate	No Later Than (NLT) February 17, 2012
Submit Requests for Information/Clarification	Continuously, but NLT March 2, 2012
AHS Issues Responses to Questions	NLT March 24, 2012
Teams submit Final Submittal (Final Proposal and Executive Summary)	NLT June 1, 2012
Sponsor notifies AHS of results	August 3, 2012
AHS announces winners	August 10, 2012
Winning team presents at AHS Forum	May, 2013

We reiterate; if you intend to participate, your Letter of Intent must arrive at the American Helicopter Society, International no later than February 17, 2012. The signature page must include all of the information requested in section 1.1.6.

All questions and requests for information/clarification that are submitted by teams to the AHS will be distributed with answers to all participating teams and judges. Entrants' requests for information and clarification will be answered as soon as possible. All of the questions and answers will also be distributed collectively to all entrants no later than March 24, 2012.

The Final Submittal must be postmarked by June 1, 2012.

1.4 Contacts

All correspondence should be directed to:

Ms. Kay Brackins, Deputy Director
AHS International
217 N. Washington Street
Alexandria, Va. 22314
Phone: (703) 684-6777
Fax: (703) 739-9279
E-mail: kbrackins@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 …

- The design meets the RFP technical requirements
- The assumptions are clearly stated and logical
- A thorough understanding of tools is evident and necessary correlation presented
- 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
- The simulation is of high quality and correctly portrays how the actual vehicle would operate (graduate mandatory, undergraduate optional)

B. Application & Feasibility (25 points)

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

- Justify and substantiate the technology levels that are used or anticipated
- Direct appropriate emphasis and discussion to critical technological issues
- Discuss how affordability considerations influenced the design process
- Discuss how reliability and maintainability features influenced the design process
- Discuss how manufacturing methods and materials were considered in the design process
- Show an appreciation for the operation of the aircraft
- Show and substantiate the course completion time and the aircraft's efficiency metric – as defined below in section 2.2.8 – which will be compared to other participants' values

C. Originality (15 points)

The originality of the proposal shall be judged on …

- How innovative and original is the presented solution
- Vehicle/system aesthetics

D. Organization & Presentation (20 points)

The organization and presentation of the proposal requires …

- A self-contained Executive Summary that contains all pertinent information and a compelling case as to why the proposal should win. It must be a separate file.
- An introduction that clearly describes the major features of the proposed system
- A well organized proposal with all information presented in a readily accessible and logical sequence
- Clear and uncluttered graphs, tables, drawings and other visual elements
- Complete citations of 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 contest and the requirements. Schedule, page count and other limits, and the basic rules are part of the RFP and will be judged under section 1.5, D.

1.6 Proposal Requirements

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

A. Demonstrate a thorough understanding of the RFP requirements.

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

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

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

E. Section 1.1.5, 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 at least two files (three for graduate category) transmitted on a Compact Disc. 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. The second file is an Executive Summary, which presents a compelling story why the sponsor 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. The third file shall be the Simulation Package. This compressed file will be comprised of all files required to run the undergraduate optional, graduate mandatory X-Plane simulation and any video documentation necessary.

F. Judging will focus on innovative solutions, system performance, and system value.

2.0 System Objectives

2.1 Operating Concept

With the revitalization of public interest in air racing due to the introduction of the Red Bull Air Races and increased popularity in Reno, it has come to the realization of the rotorcraft industry that there is no equivalent in the rotorcraft world. In order to spark interest in a helicopter sport to rival Reno and the Red Bull series, AHS is asking students to design a purpose built helicopter to race on a prescribed pylon course.

One of the main challenges faced by the rotorcraft industry is the unprecedented maneuverability required to complete such a course. For instance, Red Bull series pilots regularly pull 9g turns during a race, a load factor unheard of for a rotor system. It will be up to the designer to decide what load factor is required to complete the course in as fast of a time as possible while keeping in mind that they must strike a balance between load factor, forward speed, and fuel efficiency, all while maintaining safety for the pilot and spectators.

2.2 Specific Objectives

2.2.1 Location of Course

In order to attract the most spectators, the course will be constructed and flown over the Hudson River between New York City and Weehawken, NJ in early Fall. At this time of the year temperatures will be relatively mild and will allow the competition organizers to maximize the number of spectators along the banks of the river.

Segment	0	1	2	3	4	5	6	7	8	9
Maneuver	Staging	Start	Slalom	Short Stop	Straight Away	Quad Pylon	Slalom	Hover, Pirouette, Pickup	Side Flight	Finish
Altitude	<200 ft AGL	< 200 ft AGL	<200 ft AGL	<500 ft AGL	< 200 ft AGL	< 200 ft AGL	< 200 ft AGL	Sea Level	<200 ft AGL	< 200 ft AGL
Temp	80°F	80°F	80°F	80°F	80°F	80°F	80°F	80°F	80°F	80°F

2.2.2 Description of Course

(0) Staging for the event will take place at a local football field where participants will be required to hover-taxi their aircraft to the starting point. For safe ground operations, the vehicle must fit between the forty yard lines at center field leaving a 15 foot safety zone around rotating components. The aircraft must perform a HOGE takeoff.

(1) The pilot must pass the start markers at a speed at or below 100 kts. At that time, the course timer will begin.

(2) The aircraft will be maneuvered through a slalom course; the passage side of the first pylon is at the pilot's discretion although the aircraft must be maneuvered alternately through the three pylons.

(3) After passing through the pylons, the pilot has 300 feet to change direction of the helicopter and pass through the adjoining pylons. For this maneuver, altitude

restrictions are lifted to 500 feet AGL so that – if necessary – the pilot can pull a hammerhead-type maneuver.

(4) A straight-away follows where the aircraft can reach V_H.

(5) The pilot then must enter the quad pylon where a left turn will take the aircraft back through the pylon

(6) The aircraft will be maneuvered through a second slalom course; the passage side of the first pylon is at the pilot's discretion although the aircraft must be maneuvered alternately through the three pylons.

(7) The pilot must then bring the aircraft to a stable hovering stop no more than 25 feet over a landing platform and maintain a hover over the designated "H" for no less than 30 seconds. After 30 seconds have elapsed, the pilot must perform a 360° pirouette over the landing pad in the opposite direction of the main rotor rotation, if applicable. A slung load will then be automatically attached to the vehicle and the rest of the course will be flown with this additional weight.

(8) In front of the Intrepid Sea, Air, and Space museum, to show off the capabilities of their machine, the pilot must perform a side flight 90° off course line and facing the crowd on the decks. The distance traveled between the last two yellow course pylons will be 500 yards.

(9) To stop the course timer, the aircraft must pass through the end pylons and then return to the staging area for a HOGE landing, taxi, and shutdown.

2.2.3 Course Rules and Regulations

- The aircraft must carry at least one occupant at 225lb who has full control of the vehicle during the entire run.
- Although the pylons will be made of a light fabric to reduce the effects of a rotor strike, the hitting of a pylon will result in immediate disqualification from the race.
- At no time during the flight shall the aircraft be banked past 90°.
- When passing through the pylons, the aircraft must be at or below the top of the pylon.
- Crossing the 300 ft mark at segment 7 will result in a 30 second penalty.
- For every second the aircraft is over the permitted altitude during the race an additional 30 seconds will be applied to the course completion time.
- Pilots and crew will be required start their engines before given the rotors turning signal to allow warm-up and system check-out. There will need to be at least 10 minutes of warm up time.
- In order to avoid delay at the staging area, pilots will be required to takeoff within 5 minutes of being given the rotors turning signal.
- 10 minutes will elapse between the rotors turning signal and the crossing of the start pylons.
- There must be enough fuel onboard for 15 minutes of flight at TOGW at V_{BR} to account for staging and traffic pattern flight.
- The mid-mission payload pickup will be performed by an automated hookup system. All that is required of the pilot is to guide his receiving hook into a prestrung loop that is

attached to the load. The load will be a concrete block weighting 300 lbs at the end of a 15 foot Kevlar cable.

2.2.4 Sizing

All teams, although not restricted to the exact same engine, must use the same level of technology; below are tables of engine data at 3 ambient conditions for the uninstalled, scalable engine. Teams must use this data to ensure the same levels of technology are maintained. Proper installation factors should be accounted for and power draw for subsystems should be subtracted from the power available for dynamic flight components.

Table 1: Uninstalled Engine Data for SL/ISA Conditions

Engine Rating	Duration	Power Available [SHP]	SFC [lb/hp·hr]
OEI	30 Seconds	1049	0.360
MRP	2 minutes	1002	0.361
IRP	30 minutes	934	0.365
MCP	Continuous	764	0.379
Part Power	-	501	0.426
Idle	-	200	0.672

Table 2: Uninstalled Engine Data for SL/103°F Conditions

Engine Rating	Duration	Power Available [SHP]	SFC [lb/hp·hr]
OEI	30 Seconds	867	0.373
MRP	2 minutes	820	0.377
IRP	30 minutes	758	0.384
MCP	Continuous	619	0.404
Part Power	-	410	0.466
Idle	-	164	0.784

Table 3: Uninstalled Engine Data for 6K/95°F Conditions

Engine Rating	Duration	Power Available [SHP]	SFC [lb/hp·hr]
OEI	30 Seconds	707	0.371
MRP	2 minutes	664	0.376
IRP	30 minutes	611	0.383
MCP	Continuous	504	0.402
Part Power	-	332	0.463
Idle	-	133	0.777

Ram power increases with forward airspeed and may be estimated with the following equation:

$$\frac{P_V}{P_{Static}} = \left(1 + 0.195 \cdot {M_\infty}^2\right)^{3.5}$$

where P_V is the power available at speed, P_{Static} is the power available at zero velocity and M_∞ is the Mach number the aircraft is traveling at during that segment of flight.

The designer will have to scale their engine on the data above as baseline using the following scaling parameters:

$$\gamma = \frac{MRP_{SL/ISA\,Scaled}}{MRP_{SL/ISA\,Baseline}} = \frac{MRP_{SL/ISA\,Scaled}}{1{,}002\ SHP}$$

$$SFC_{Corr} = \frac{-0.00932 \cdot \gamma^2 + 0.865 \cdot \gamma + 0.445}{\gamma + 0.301}$$

The same scaling factor γ is then applied to power available across all ambient and ratings while the same SFC correction factor SFC_{Corr} is applied to SFC across the board.

There are effects on fuel consumption and power available when the RPM of the engine (Np) is deviated from the design point at 100%. The effects of variation are captured in the following equations:

$$SFC_{Corr} = -1.211 \cdot \left(\frac{\omega_{actual}}{\omega_{100\%}}\right)^3 + 4.281 \cdot \left(\frac{\omega_{actual}}{\omega_{100\%}}\right)^2 - 5.104 \cdot \left(\frac{\omega_{actual}}{\omega_{100\%}}\right) + 3.034$$

$$SHP_{Corr} = 1.143 \cdot \left(\frac{\omega_{actual}}{\omega_{100\%}}\right)^3 - 3.907 \cdot \left(\frac{\omega_{actual}}{\omega_{100\%}}\right)^2 + 4.580 \cdot \left(\frac{\omega_{actual}}{\omega_{100\%}}\right) - 0.816$$

Nominal operating $\omega_{100\%} = 18{,}000\ RPM$.

The factors SFC_{Corr} and SHP_{Corr} are applied to the power available and the SFC across the board just as the engine scaling factor and associated SFC scaling factor were applied.

Residual thrust from the engine can be estimated using:

$$T_{Residual} = 0.094 \cdot SHP$$

Along with power and SFC compliance, the engine will also be checked for weight compliance. The weight of the engine must not be less than:

$$W_{Engine} = N_{eng} \cdot \left[\frac{0.1054 \cdot \left(\frac{MCP}{N_{eng}}\right)^2 + 358 \cdot \left(\frac{MCP}{N_{eng}}\right) + 2.757 \times 10^4}{\left(\frac{MCP}{N_{eng}}\right) + 1180}\right]$$

where N_{eng} is the number of engines that are installed on the aircraft and MCP is the uninstalled power of the scaled engine at sea level standard with no RPM or ram effects.

Not associated with the technical inspection before the race, but beneficial to the design and integration of the scaled engine, the dimensions of the engine follow the following trending:

$$Diameter = 2.117 \cdot \left(MRP_{Unninstalled,SL/ISA}\right)^{0.3704}$$
$$Length = 2.622 \cdot \left(MRP_{Uninstalled,SL/ISA}\right)^{0.4148}$$

It is up to the sizing analyst to either derive or use appropriate component weight equations for all other aircraft components. A detailed weight breakdown of all components to Mil Standard 1374 is required.

The aircraft to be designed will need to be able to hover out of ground effect at S.L./103°F at TOGW as well as be able to cruise at a minimum of 125 kts at 90% MCP. To demonstrate the benefits of a helicopter, the vehicle must be able to demonstrate a side flight of 60 kts at S.L./103°F, TOGW. When sizing for this maneuver, the more stringent of +90° or -90° off of the nose should be used. A faster cruise speed and/or a higher ambient hover capability while staying within the size constraints are encouraged.

2.2.5 Design

The purpose of this aircraft is to complete the timed course as quickly as possible while maintaining the hover and side flight capabilities of a helicopter. Thus, the designer should take this into consideration when laying out the design. Pilot visibility is very important to safe operations and a cockpit layout should show that the pilot has adequate visibility during hover, sideward flight, and in forward flight. Visibility from the pilot's position must adhere to MIL-STD-850B which defines the minimum angles of visibility for military aircraft.

Inboard and outboard profiles of the aircraft showing locations of major components will be required as well as a weight, inertia, and C.G. analysis of the aircraft throughout its flight.

Preliminary structural design should show safe load paths for the major systems on board the aircraft and attention should be paid towards what happens to components in the unfortunate event of a crash.

Since the staging area is a confined and possibly busy environment, safety constraints dictate that departing aircraft have a minimum clearance of one rotor radius around rotating components. Forms of auxiliary propulsion are permitted in the design.

2.2.6 Minimum Equipment List

For safe flight and FAA compliance, each aircraft must be configured with an avionics suite that meets minimum FAA requirements for flight within the NY VFR corridor. Although this is a race and the aircraft may be registered as an experimental aircraft, the aircraft will be flown to the staging area from a local airport. Night flight will not be required for these machines, so the MEL does not have to include those components required for dusk-to-dawn flight. Appropriate weight allocation should be made for all components.
Flotation for the pilot is required at a minimum as well as fire protection. Since this race will be held over water in order to minimize spectator risk, special consideration should be taken with respect to emergency equipment. Rescue boats will be at the ready to assist in the unfortunate event of a crash; however, response times for rescue divers could extend to 5 minutes.

2.2.7 Optional Simulation (Undergraduate Category Only)

As an optional component for undergraduate participants in this competition, the design team may create a flight simulation of the aircraft and the course in X-Plane so that a pilot may fly it in a simulator and give feedback to the team. A video may be made showing the team's vehicle completing the course with accompanying plots of altitude, velocity, heading, pitch, and bank on a time scale. Teams should make note on these charts when they pass through each of the pylons. This will be used to verify the completion time of the course and assess any penalties.

2.2.8 Finishing Place Metrics

For the design competition, teams must estimate the performance of their vehicles by citing an estimated course completion time using their designed aircraft. This value will be compared to other teams to place a *Fastest Time* winner which will count towards a small portion of the total point value awarded in the design competition.

The teams must also estimate the fuel burned during the mission, which will be combined with other parameters in the following metric to place a *Most Efficient* winner which will also count towards a small portion of the total point value awarded in the design competition.

$$\eta = 2 \cdot Course\ Time[sec] + 5 \cdot Fuel[lbs] + MRP_{S.L./ISA,Uninstalled}\,[SHP]$$

Where the goal is to minimize η.

2.2.8 Additional Tasks (Graduate Category Only)

The graduate design teams will be required to create a flight simulation of the aircraft and the course in X-Plane so that a pilot may fly it in a simulator and give feedback to the team. A video should be made showing the team's vehicle completing the course with accompanying plots of altitude, velocity, heading, pitch, and bank on a time scale. Teams should mark on these charts when they pass through each of the pylons.

Graduate teams will also be required to design the aircraft described above taking into consideration alternative forms of propulsion, and compare its benefits and detriments to the use of the engine described above in Section 2.2.4. The architecture of the alternate propulsion system is to be selected by each team but must be accompanied by a robust description of operation, a substantiation of the power system, and a realistic power, weight, and size.

Appendix

A-1 Pylon/Gate Dimensions and Layout

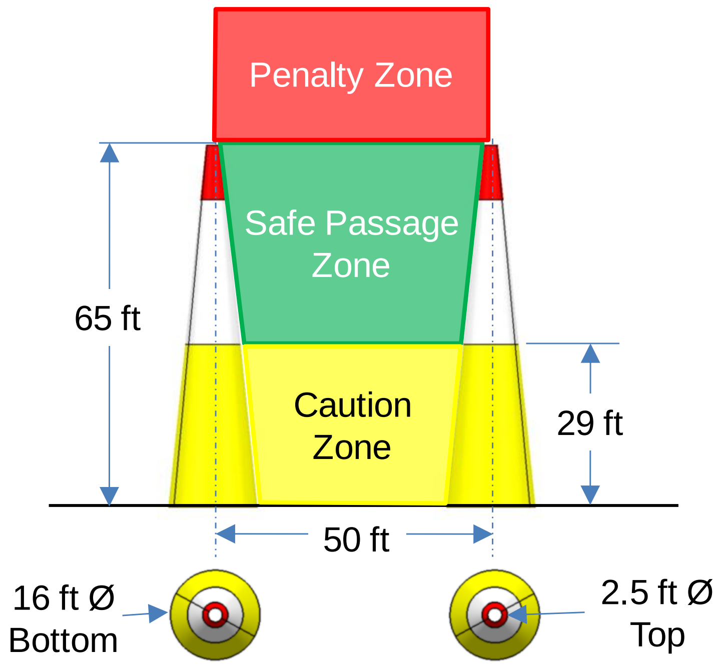

Figure 1: Dimensions and flight zones for a standard set gate pylons.

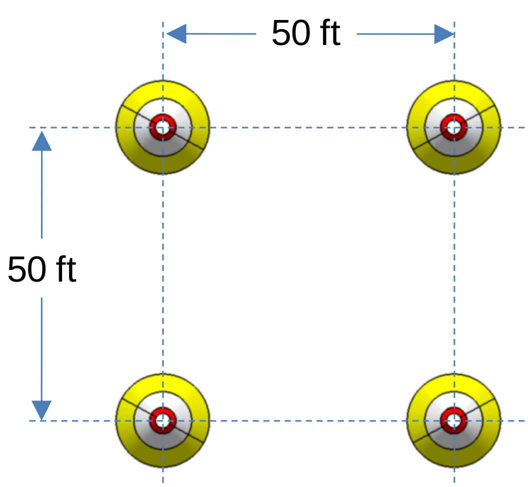

Figure 2: Layout of the quad pylon gate.