



# 4<sup>th</sup> Annual MAV Student Challenge Final Guidelines: January 6, 2016



AHS International  
72<sup>nd</sup> Annual Forum and Technology Display  
May 16-19, 2016, West Palm Beach, Florida USA

**New additions are marked in red.**

## Overview

The American Helicopter Society (AHS) International invites student teams to participate in the 4<sup>th</sup> Annual Micro Air Vehicle (MAV) Student Challenge. This electric-powered vertical take-off and landing (VTOL) MAV competition awards prizes for both “form” and “function” of the MAV. With respect to “form,” teams with unique, innovative and robust VTOL MAV design are awarded points. With respect to “function,” teams that demonstrate the best flight and autonomy capabilities are awarded. Overall, teams showing superior system integration of vehicle flight systems, sensors and remote-operation-station are considered for final awards. Teams can receive multiple awards based on these aspects.

**Point of Contact:** Please address any questions to:  
Jacquelyn Banas (jdbanas@gmail.com)

**Criteria:** A panel of judges will select awardees based on the following tasks:

**A. Design Presentation and Flight Demo:** The team shall do a presentation showcasing various aspects of their design, including innovation or uniqueness of a) air vehicle design, b) system integration, and c) ground control capabilities. The team shall perform a short flight demonstration (free-style) of relevant capabilities and highlight their best design attributes.



Figure 1. Task A - Poster Presentation and Free Flight Demo

**B. Indoor Target Search & Obstacle Avoidance Mission:** As shown in Figure 2, the flight demo consists of a sequence of phases that involve demonstrating steady-state hover, obstacle avoidance, target searching and acquisition, and return to base in an efficient manner. Teams may conduct either a fully-autonomous mission or a remotely-piloted mission (manual flight) using an onboard vision system. For manual flight, teams will switch to camera-based flight after crossing a line-of-sight (LOS) boundary. All aircraft must remain within the Mission Boundary during flight.

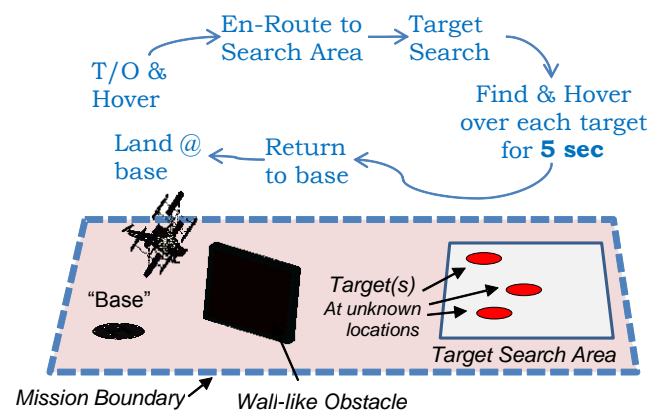


Figure 2. Task B - Target Search Mission

**Prizes** – The judges will select teams for the following three prizes:

- **Best Autonomous Target Search**
- **Best Manual Target Search**
- **Most Innovative Vehicle Design**

Several participant awards may also be awarded.

In the past three competitions, up to \$10,000 was available for winning teams. As in past years, the total prize money this year will be based on the contributions received from various event sponsors, but will be between \$5,000 and \$10,000 USD. Final award amounts will be announced in **February, 2016**.

# Who Can Apply

## Team Restrictions

Competition is restricted to teams with full-time university and/or high-school students. At least one member of the team must be a current AHS Student Member at the time of entry. High-school teams are encouraged to find a university or industry mentor to help guide progress through various competition milestones. Teams must have at least one member registered for the AHS Forum. Teams may request waivers and discounts for AHS Forum registration fees, for student participants in the competition. If there are more than two teams per university, the selectors reserve the right to disallow participation to limit the number of teams.

## Vehicle restrictions

The competition is restricted to aircraft with the following properties:

Configuration:

- Must have vertical takeoff and lift (VTOL) capability
- Single/multiple rotors/propellers
- Onboard flight-stabilization
- Onboard camera(s) needed for mission – Multiple cameras are allowed.
- Standard communication (preferred 2.4 GHz)

Space, Weight and Power (SWAP):

- Electric-powered vehicles only (no gas powered vehicles)
- Weight < 500g (17.6 oz) including batteries
- Size <45 cm (17.7 inches) in any dimension

Safety:

- “Kill Switch”: Dedicated hardware RC kill switch or remote-operation button command. Vehicle equipped to instantly cut power upon receiving “kill” command.

## Selection and Competition Schedule

The team applications will undergo a gated review process involving paper submission of design approach, a video submission of capabilities, followed by the final competition at AHS Forum. These stages are described below.

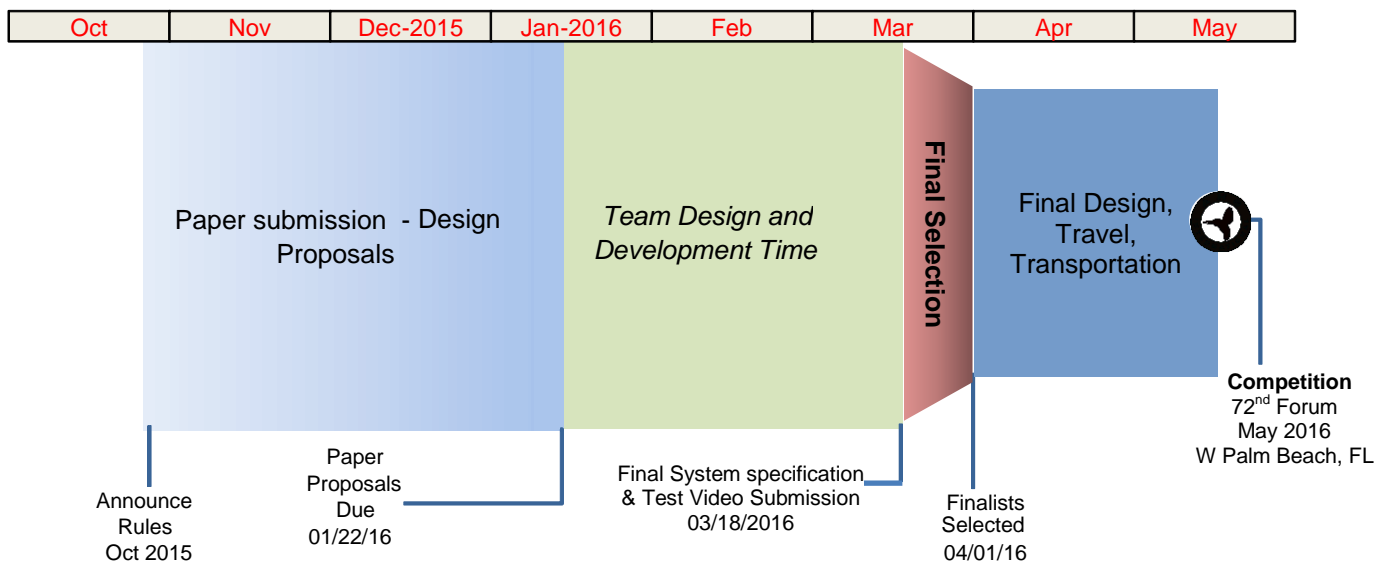


Figure 3. Schedule of Events and Selection Timeline

## **Gate 1: Paper Submission (Due by January 22, 2016)**

Each participant team shall submit a completed **team information form** and an abstract with the following information: Team description with key student and faculty members (1 page), Vehicle specification and capabilities (1 page), Onboard-System & Remote-Operation development proposal (2 pages), Preliminary plan to final demo (1 page). This information will be used to judge relative progress of the teams and a preliminary ranking of teams. Preliminary ranking results will not be disclosed, but will be incorporated into final selection. Please send a completed team form along with your paper proposal to Jacquelyn Banas (jdbanas@gmail.com) by 5 p.m. (GMT-5) January 22, 2016, with subject "AHS MAV competition."

## **Gate 2: Video Evidence of Competition Readiness (Due by March 18, 2016)**

Each participant team shall submit a system design document with the following information: Final vehicle & system configuration description (2 pages), Vehicle Autonomy and Remote operation capabilities including target tracking results (2 pages), Gaps to address before final demo (1 page).

Additionally, teams will **submit a video** showing a) measurement of vehicle dimensions and weight, and b) vehicle acquiring a stable hover over a known target using onboard vision. If remotely operated, the video shall clearly show takeoff from a nearby base location, and the operator transitioning from line-of-sight operation to using only onboard cameras as visual cues to hold target hover. If autonomous, the video should show the real-time ground-station or recorded target-feedback information relevant to the tracking performance. These results should be included in the paper submission as well for Gate 2.

## **Finalists Teams Selection (Announced by Friday, April 1, 2016)**

The AHS competition finalists will be selected by a panel of judges using the following criteria a) Prior experience, b) Team diversity, c) Proof of vehicle readiness, d) Vehicle weight/size and constraints, and e) Plan realism. Additionally, the video evidence submitted at Gate 2 will be used to assess vehicle readiness and performance and ascertain vehicle weight/size and constraints. The panel will select **SIX FINALISTS** on April 1 for participation in the AHS Forum competition.

## **Final Competition**

The final competition will take place in conjunction with the 72<sup>nd</sup> AHS International Annual Forum & Technology Display in West Palm Beach, Florida. The event is planned for Monday, May 16, 2016 at 4 p.m. at the Palm Beach County Convention Center.

During the final competition, the teams will conduct Task A and Task B discussed earlier, in two separate, competing categories: fully-autonomous aircraft will be scored against each other, separate from the manually-controlled vehicles. Teams will be rated according to the following metrics by an independent panel of judges from industry and academia.

## **Ratings Structures**

### **Task A – Design Presentation and Flight Demo**

For Task A, poster presentation and free-flight demo, the metrics are provided in table below. The rating IDs A1-A5 will be combined in a specific weighted formula (to be disclosed later) in order to construct an overall score.

<b>Task A</b>	<b>Design and Innovation Metrics</b>	<b>Rating ID (0-5)</b>
Originality	Not off-the-shelf, involves innovative engineering, solved challenging integration issues, unique capabilities	A1
Flight Performance	physical design, stabilization approach, aerodynamics and flight-stability, agility	A2
System Engineering	sensor-integration, remote pilot & GCS capabilities; antenna/wiring/sensor installation, craftsmanship.	A3
Maturity	Ruggedness, Field readiness, completeness of design, autonomy-readiness, potential for sensors.	A4
Teamwork	Inter-disciplinary teams, team "intangibles," leadership shown.	A5

## Task B – Indoor Target Search & Obstacle Avoidance Mission

Task B consists of executing a target “search & monitor” obstacle avoidance, and return-to-base mission — using only an onboard set of cameras. The 2016 Challenge will include three (3) targets as well as a wall-like obstacle between the base and the target search area. Points will be awarded for successful completion of each stage of the mission and successful identification of each target. Maximum award points for completion of each phase are specified below. An additional qualitative assessment similar to the one used in previous years will be conducted for each mission phase, but this will only be used for tie-breaking purposes.

Teams will have a maximum of 10 minutes for setup and flight. More than one attempt at completing the mission is possible within that time, and the team’s intent to start a second attempt should be clearly announced. Each attempt must start from the home base and include all the mission elements in order. Each flight will be separately scored by the judges.

Aircraft are expected to conduct the following mission (max 15 points), **in this order**:

1. Liftoff and hover above the home base at a height of 2 m (6.6 ft) above ground level (AGL). (1 point)
2. Takeoff and fly towards the target search area, avoiding any obstacles. (2 points)
3. Search for targets in the designated target search area. Once a target is found, the aircraft must perform a surveillance hover above the target for a minimum of 5 seconds. (2 points per target)  
There will be three (3) targets in the area, and the 5-second hover must be performed for each target for it to be counted as “found.” Each target can only be “found” once. The hover height above the target is unspecified but must remain within the general competition limit of 4.5 m (15 ft) AGL.
4. Return to base, avoiding any obstacles. (3 points)
5. Perform a stable hover over the home base at 2 m (6.6 ft) AGL for at least 5 seconds. (2 points)
6. Perform a controlled landing on the home base. (1 point)

Figure 4 shows the details of the competition area. The “Line of Sight” (LOS) boundary is the threshold beyond which an operator located near the base switches to onboard-camera-based control, as the vehicle moves into the right. The base, target and mission boundary markings will remain the same as the 2015 designs, and details for each are depicted in Figure 5, Figure 6, and Figure 7, respectively. For autonomous operation, these “images” can be used by video-processing algorithms for target and home-base search and hover-hold operations. Although the target location area is roughly known, the exact location of each target is unknown and may change from team to team. Further information about the wall-like obstacle will be determined by January 29, 2016.

Under no circumstance shall a vehicle overshoot the mission boundary by more than 1 m (3 ft). Vehicle altitude is **strictly limited** to 4.5 m (15 ft) AGL. Note that the overall dimensions in the diagram below are approximate and are subject to change based on space availability at the Forum location. Final dimensions should be available by January 29, 2016.

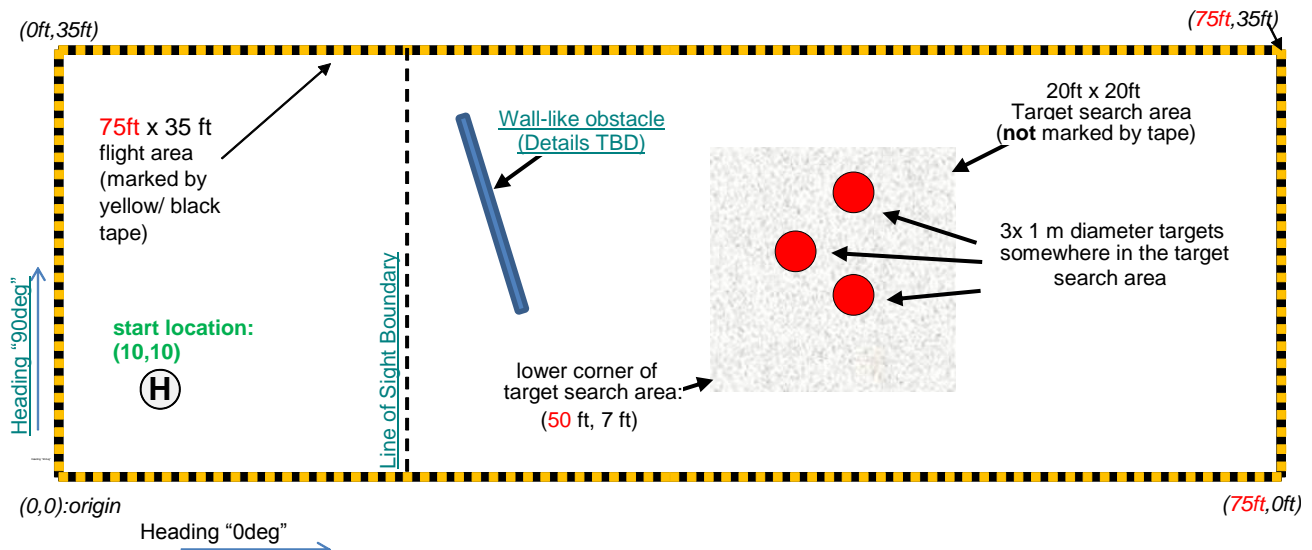


Figure 4: Approximate Layout of the Competition and Areas of Interest.

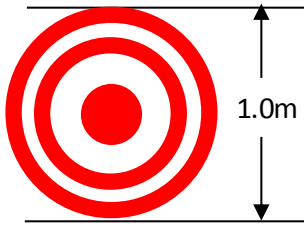


Figure 5: Floor-Painted Target (1m diam)



Figure 6: Floor-Painted Home Base (1m diam)



Figure 7: Mission Boundary Marking Tape

For Task B, an additional qualitative assessment of the vehicle will be recorded for tie-breaking purposes. The panel of judges will use the following criteria (rating ID Q1-Q7) during each of the mission phases to rate the vehicle. All teams are encouraged to use the following criteria to guide their design.

Task B/ Mission Phase	Qualitative Criteria	Rating ID (0-5)
Take off & Hover	2 m (6 ft) hover height above base. Metrics: Time to stable hover & Hover stability.	Q1
En Route to Search Area	Transition to this phase with clearly-announced user signal. Metrics: Qualitative smoothness of transitions and Time to reach search area.	Q2
Obstacle Avoidance	Avoid obstacles between the home base and the target search area. Metrics: Successful avoidance, Smoothness of flight around obstacles.	Q3
Target Search	Remote operator or Autonomous system will <u>use only onboard camera</u> to find each target. Metrics: Time to find target, Operator involvement	Q4
Target Surveillance	Establish a stable hover for at least 5 seconds over each target. Smoothly transition between hover and searching. Metrics: Lateral target tracking error, Stable roll/pitch performance	Q5
En Route Return to Base	Transition to this phase with user signal. Remote operator can use LOS. "Base" can use homing beacons for autonomous RTB. Metrics: Qualitative smoothness of transitions, Time to acquire stable hover over base	Q6
Hover and Landing	Acquire stable hover 2 m (6 ft) above base before landing. Metrics: Hover and landing performance, distance from center.	Q7

The disqualification rating will be given in case the vehicle violates the vehicle and demonstration limits. The following criteria will disqualify a team during final competition and nullify all mission points for the team.

Disqualification Criteria	DQ Number
Vehicle weight or size outside of stipulated limits.	DQ1
Flight above 4.5 m (15 ft) AGL	DQ2
Airspeeds above 1.5 m/s (5ft/sec)	DQ3
Overshooting the mission boundary by >1 m (3 ft).	DQ4
Failure for the Remote Operator to: <ul style="list-style-type: none"> <li>- Use only the onboard camera to stay within bounds.</li> <li>- Switch to onboard camera beyond the LOS boundary.</li> </ul>	DQ5

The ratings A1-A5 and points from the mission will be combined in a specific weighted formula to decide the three prize winners for the AHS competition. Ties will be determined using criteria Q1-Q7. Runners-up will receive participation awards. All prize awards are subject to availability of competition sponsors and award funds.

## ***Travel***

AHS will not provide any travel or accommodation support for finalist teams. Teams are responsible to raise funds for travel, accommodation, equipment transportation, customs and storage if necessary. AHS will provide onsite storage, power supplies and desk space for equipment checks and repair. Additionally, AHS will provide easels or other poster-mounting means for displaying team presentation artifacts. Teams can contact AHS to consider a waiver or discount for AHS Forum registration fees for student participants. It is recommended that three team members attend the final demonstration in order to provide necessary support and safety operations.

## ***Disclaimers***

AHS assumes no responsibility for any actions caused by any participants of the MAV Student Challenge. These rules are subject to changes. Final rules will be published on or before January 29, 2016.

Participation in the completion explicitly gives permission to AHS International to use photographic, video, documentation or other records of the competition for educational and promotional purposes.



## 4<sup>th</sup> Annual MAV Student Challenge Team Information Form

Team Name: \_\_\_\_\_

School/Department Name: \_\_\_\_\_

(Limit of 2 teams per university. If more, AHS *may* decide to accept only first two entrants.)

Point of Contact (Faculty, Email, Phone No.): \_\_\_\_\_

\_\_\_\_\_

Forum Tech Session Presentation? (if any): \_\_\_\_\_

### Electric MAV Details

Type (Quadrotor, Helicopter, etc.): \_\_\_\_\_

Weight (without batteries): \_\_\_\_\_

Weight (with batteries): \_\_\_\_\_

Dimensions (all inclusive): \_\_\_\_\_

GCS Interface (data-link, RC, etc.): \_\_\_\_\_

Sensor Payload: \_\_\_\_\_

Max Speed (if known): \_\_\_\_\_

Describe implementation of remote-control operated power-kill switch:

Current Autonomous/Control Capabilities:

**Submission:** Please send a completed team form along no later than (NLT) January 22, 2016 to Jackie Banas (jdbanas@gmail.com), with subject "AHS MAV Competition". Teams will have to submit a follow-up Gate-2 "paper & video" proposal NLT March 18, 2016. Large file should be transmitted via the team's preferred method (e.g. Dropbox, Google Drive, iCloud, OneDrive, etc.). Teams will be notified of final acceptance NLT April 1, 2016.