2023-2024 ASME IAM3D Competition Rules: Unmanned Aerial Racing Cargo Vehicle

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Do you have the need for speed? The 2023-2024 ASME IAM3D Unmanned Aerial Racing Cargo Vehicle (U.A.R.C.V.) competition tasks university students to use additive manufacturing and an iterative design process to create an unmanned aerial racing vehicle capable of picking up and dropping off a payload on each lap. One document submittal, a design report showing your team's design process, and a detailed drawing will be required prior to participating in the physical obstacle course.

Pay special attention to the Safety Requirements & Safety Equipment portion of the rules. All teams must be in compliance with safety in order to compete.

1. **Objective**

   The objective is to design, manufacture, and test a U.A.R.C.V. using additive manufacturing and an iterative design process that will race in up to five team heats for three laps through an obstacle course picking up and delivering one payload per lap.

2. **Questions**

   Questions about the IAM3D competition may be directed to iam3d@asme.org

3. **Deadlines and late submissions**

   Registration - Varies per event and will be available on the EFx website: https://efests.asme.org/efx

   Design Report - The submission due date is one month prior to the first competition date. Details are located in the submission of the design report section.

   Design deport deadline example:

   Competition first day is 4/5/2023

   Design report due 3/5/2023 by midnight at your university's local time.

   Late report submission - Late submissions will be accepted for as long as possible but a penalty of 30 points per day late will be applied. Due to time constraints, scoring of late submissions will be attempted but is not guaranteed.

4. Registration

All team captains & team members are required to register for BOTH the competition AND the EFx they are attending through the EFx website. Any associated registration fees will be published on the EFx website. Registration dates are different for each EFx event. **Not all EFx events will have every competition available. Check that the IAM3D® is available at that event before registering. A minimum of three competing teams must be registered for the event to occur.**

5. Eligibility

Every participant must be a student member of ASME who is enrolled as an undergraduate in a baccalaureate or associate engineering/engineering technology degree program or was enrolled in one of those programs within one year of the competition date (must still be a dues-paying member). All competitors agree to abide by the ASME Engineering Code of Ethics.

6. Safety Requirements & Safety Equipment

All team members must wear safety glasses while assembling and working on vehicles and while within 10 feet of the course net. Teams will not be allowed to compete without safety glasses. Teams are required to provide their own safety glasses. It's suggested to bring comfortable safety glasses as you will be wearing them all day. Additional personal protection equipment (PPE) is recommended but will not provided.

7. Design Report

The design report should address at a minimum the following points in individual sections:

1. Individual CAD drawings for every part
2. Formal vehicle CAD assembly drawing with a bill of materials that ties in all individual CAD drawings
3. Exploded CAD assembly drawing of all parts
4. Analyses: Expected vehicle performance, part specifications, structural simulations
5. Detailed implementation of design for manufacture and assembly analysis (DFMA)
    a. Example: https://en.wikipedia.org/wiki/DFMA
6. Detailed implementation of design for additive manufacturing analysis (DFAM)
    a. Example: https://en.wikipedia.org/wiki/Design_for_additive_manufacturing
7. A record of the design process used and a record of all design Iterations that includes the reasons for those iterations.
8. All aspects of your testing. Describe in detail why you tested, how you tested, what you tested, what was the outcome, and what changes it prompted in your design. Provide all relevant data and outcomes.
9. Lightweighting design description - Altair lightweighting design competition (more info. in the Altair section below).

Design reports should be professional and contain sufficient detail to recreate your process/design. Reports should not exceed 80 pages of written material. The 80-page limit does not include CAD drawing submissions and will not be counted toward the 80-page limit. Each section listed above should be covered in separate organized sections. Each section should show that you understand and that your team used a developed engineering process in the design, manufacture, and testing of the vehicle.

8. Design Report Submission

To officially submit your design report, ASME will email the **REGISTERED TEAM CAPTAIN** a link to a Google upload form to submit your document in PDF format along with other team information.

9. Altair Lightweighting Webinars

Teams are highly encouraged to attend two Altair Lightweighting webinars (dates TBA) either live via Zoom or via a Zoom post-event recording. Webinar attendance is not required to be eligible for free software, however, attendance is strongly encouraged for industry-level lightweighting training.

Teams that use lightweighting in their U.A.R.C.V. design will account for 250 points of the design report score.

If any team lightweights any part of their vehicle using Altair Inspire, then they are eligible to enter Altair's Student Lightweighting Contest with prizes of $750 and $7500 USD.

Scan the QR code below to learn more and download free Altair software:

10. Use of Additive Manufactured Parts

This competition strives to provide experience in additive manufacturing and an iterative design process. To ensure the spirit of the competition, scoring will be heavily weighted on what percentage of parts on your team's vehicle were produced using additive manufacturing. Teams will be required to design and construct their vehicle's airframe using additive manufacturing. All designs of additive manufactured parts must be original, designed, and created by the competing team. The use of preexisting designs will be grounds for disqualification. If an unnecessary number of additive parts are used to serve one function, it would be left under the judges' discretion to reduce the number of parts counted for the additive manufacturing score.

Score weighting equation:

$$\left(\frac{Number\ of\ parts\ created\ using\ additive\ manufacturing}{Total\ number\ of\ parts(minus\ exceptions)}\right) \text{ X } (Total\ Final\ Score)$$

Example:

$$\left(\frac{30\ parts\ created\ using\ additive\ manufacturing}{50\ Total\ number\ of\ parts(minus\ 10\ exceptions)}\right) \text{ X (Total Final Score of 500) = 375 points}$$

Additive manufacturing through any traditional form of line-fed or powder-based process will be allowed. Any form of commercially available additive manufacturing material/process will be allowed.

Alternative forms of additive production that are found to reduce structural integrity enough to be considered unsafe may be disqualified and will be left to the judge's discretion.

11. Required Commercially Purchased Parts

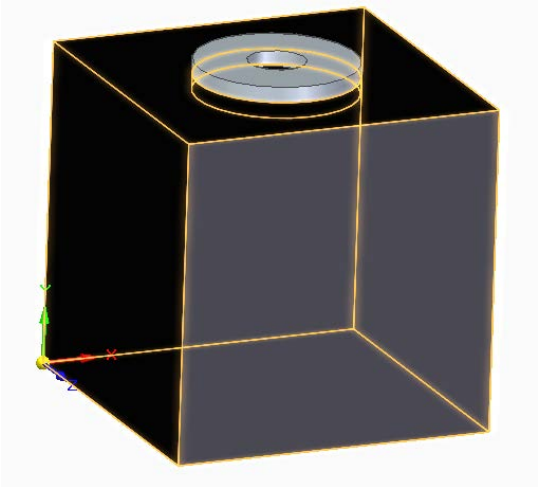
Safety is a criterion that nearly every engineering design considers. For this reason, some parts of this competition will require commercially purchased parts and are considered to be exceptions to the use of additive manufacturing parts score.

Required Commercial Parts:
All Electronics (example: flight controllers, cameras, FPV…)
use of student designed Arduino like controllers for flight controls will not be permitted.
Wire
Electric Motors
Propellers
Batteries

Other parts may be deemed exceptions to the use of additive manufacturing parts score and will be left to the judge's discretion.

12. Payload

The payload will be a 3D printed (PLA) one-inch cube with 30% infill and four outer shells. A ferromagnetic metal (steel) washer smaller than one inch and larger than one-half inch diameter will be attached to the top of each payload. All competition payloads are identical and will be provided by ASME.



13. Vehicle & Vehicle Size Constraints

The vehicle size constraints are as follows:

- 33 cm measured diagonally from motor center to motor center
- 25 cm height

A judge will measure dimensions to ensure that your vehicle dimensions are compliant. This does not include the device hand controller, FPV equipment, or payload. Vehicles are allowed to transform to any dimensions as long as it does so while on the course and only by doing so on its own and under its own power. Keep in mind the course and obstacle dimensions!

14. Vehicle Safety Provisions

1. A safety briefing will be held during the first day of the competition. All team members are required to attend.
2. Vehicles must pass an airworthiness/wiring inspection. Once vehicles are inspected, they may not be altered without re-inspection.
3. No one will be allowed on the course during the race.
4. Race viewing will only be allowed from outside the netted course area and will require the use of safety glasses.
5. All pilots must have an arming switch feature on their controller.
6. Vehicles must have a physical kill switch / battery quick disconnect located on the vehicle.
7. Pilots will not power up video transmitters or vehicles unless instructed to do so by a Judge or race official.
8. All Propellers must have blade guards
9. Pilots must use FPV to pilot the vehicle. Goggles and ground stations are allowed.
10. Pilots will not be allowed to fly outside of the designated competition area. Flying outside of the designated competition area is STRICTLY prohibited and will result in immediate disqualification.
11. All batteries must be transported and stored in a LiPo safe bag or an approved fire-resistant container.
12. All powered wires must be connected via commercial connectors or permanently soldered in place.
13. All wire termination points must be insulated using shrink wrap or electrical tape. No bare solder / connector points will be allowed.
14. Batteries that show signs of wear or damage will not be allowed to be removed from battery safe bags while in the competition facility.
15. Ex: Battery bloating, signs of overheating, signs of excessive age, or signs of damage that might cause battery failure.
16. Vehicles may not fly higher than a 10-foot altitude. Any breach of 15 ft will result in immediate disqualification.

Failure to adhere to the above provisions constitutes a possible disqualification. Disqualifications or required modifications will be at the discretion of the Judging team.

15. Energy Sources

All electrical energy for the device must be provided by commercially produced rechargeable batteries. Student designed and manufactured energy sources will not be allowed.

- Maximum battery specs:
  - 4S
  - 4.2 Volts per cell
- Springs may be used with the following static size constraints.
  - ½ Inch diameter maximum
  - 2-inch length maximum

Battery charging stations will not be provided by ASME.

16. Controls

Devices may be controlled via remote control through a transmitter/receiver radio link. As an exception to the rechargeable battery rule, a radio transmitter may have its own batteries and these batteries do not have to be rechargeable. The transmitter/receiver radio link may be any commercially available model controller. All radio controllers will be impounded and shut off during the competition, except during the team's race. Umbilical controls may not be used.

17. First Person Visual (FPV)

No one will be allowed on the physical course while vehicles are in flight. Due to this requirement, FPV is required for all vehicles/pilots. Please be prepared to record your flights and provide your flight videos to the judging staff. FPV video may be used to settle race disputes. Providing your video to the judging staff will signify your permission for ASME and IAM3D to use all provided videos for advertisement purposes. If you do not wish to have your videos used, please inform the judges at the competition before submitting your videos.

18. Course

Each team will be given 5 minutes to ready their vehicle. Physical intervention once the ready time expires will not be allowed. Individual heats will include up to 5 teams per race and may be scaled down based on the number of teams at an individual event. Vehicles will fly 3 laps. On the first lap, the vehicle will be staged on the ground in their respective lane. The vehicle will be required to pick up a payload without physical intervention from a section of the same lane before entering the obstacle course. After clearing the last obstacle, the vehicle must deposit the payload in the same staging lane. The second lap will start with payload pickup, obstacle course, and payload drop off in the same fashion as the first lap but will not be required to land. The final lap will stop when the vehicle comes to rest on the empty payload lane where the payloads started off. Placement of payloads in another team's lane will not be counted. Any race that results in a tie for first place will be settled in a two-lap face-off. Payload deposit is required for the lap to count in face-offs. If a race results in a tie for second place both teams will receive a score for second place and third place will not be awarded. On the race day after first-round races, a maximum of 20 teams with the highest scores will participate in an additional semi-final race. The top 5 team scores after the semi-finals will participate in a final race. Initial, semi-final races, and final racing structure may be altered due to low participation at the discretion of the Judging team.

There will be many races involved. It is suggested to make your vehicle modular and bring multiple backups to everything. Crashes are inevitable and rebuilt/backup vehicles will be permitted to race.

Course dimensions and obstacle descriptions can be found in Appendix 1.

19. Scoring

Practice runs will be organized on the first day of competitions.
There will be three ways to score points and a final score use of additive multiplier.

- Design Report - 2750 Points possible
- Use of Additive Manufacture Parts – Scales final score
- Obstacle course - 1600 points possible per round
    - Payload Score: 200 points per successfully deposited payload
    - Race ranking score
        - 1st place - 1000 points
        - 2nd place - 500 points
        - 3rd place - 250 points

Pilots that prematurely start or miss going through an obstacle will be required to run one additional lap per occurrence. Missed obstacles will only be penalized if the vehicle completes a lap without going back to complete the missed obstacle.

In the event that a payload is dropped, the penalty will be not receiving the payload score for that individual payload. Payloads may not be recovered if they fall outside of the designated pickup area.

Teams that fail to meet the following requirements will receive an obstacle course score of zero but will keep the design report and use of additive manufacture parts scores.

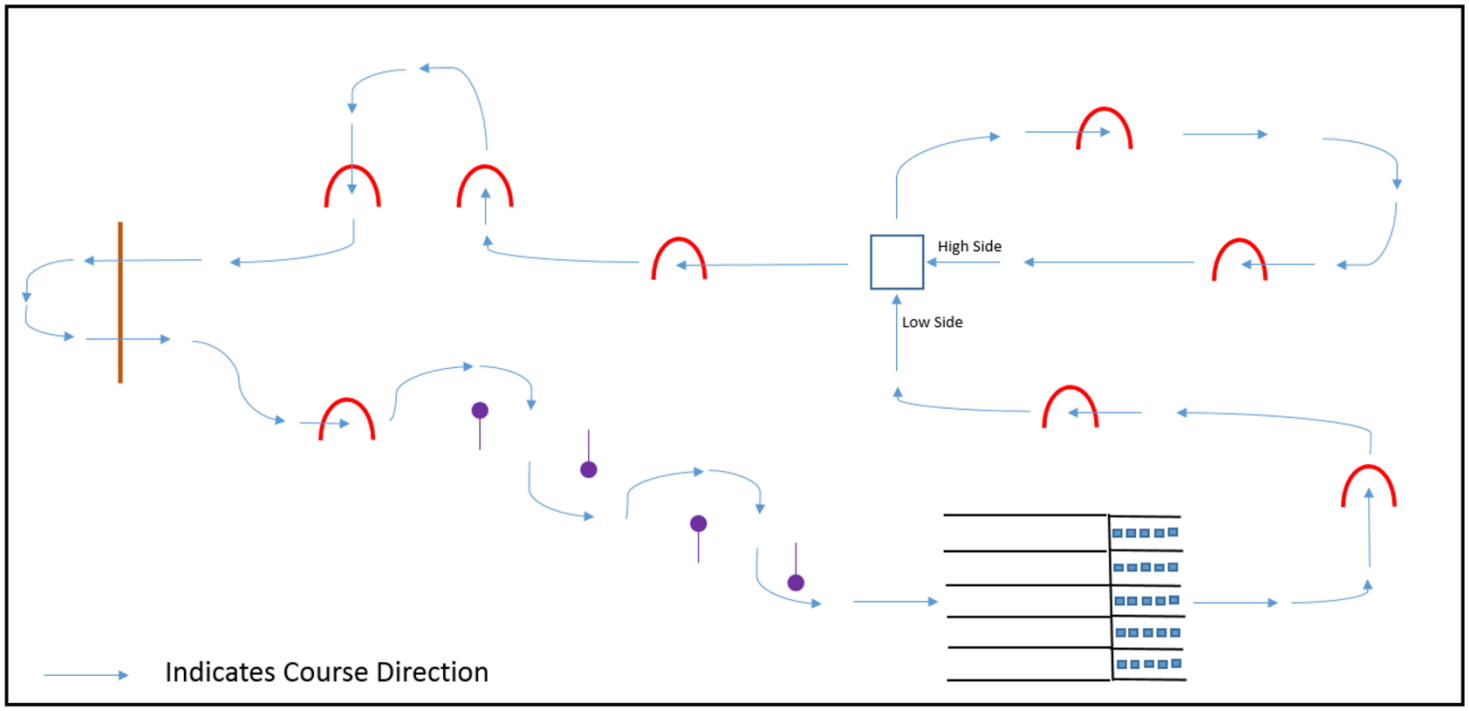
- Teams must be physically present at the time of their scheduled race.
- Finish all 3 laps in under 15 minutes.
- Vehicles must stay within the outer course boundary and under an altitude of 10 feet.
- Intentional vehicle collisions are prohibited. Teams that intentionally cause a crash will be disqualified at the discretion of the Judging team. Pilots can resume the race if they are able to fly without physical intervention. The pilot not at fault may be granted a makeup run. Make-up runs should not be expected and are at the discretion of the Judging team.
- Vehicles that crash during their race in the first heat (not semifinals/final) will be allowed a second-scored run in place of the original race. This does not include vehicle failures such as running out of battery power and will be selected at the discretion of the Judging team. Each team is only eligible for one crash rerun and will be grouped with other crash eligible vehicles at the end of the original race runs.

20. Prizes & Winners

- 1st place - $500
- 2nd place - $300
- 3rd place - $150
- IAM3D® competition winners will be announced at the local EFx event.

Appendix 1: Competition Course and Obstacle Dimensions

IAM3D 2024 Course



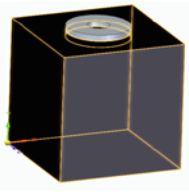
*Course outer dimension is intended to be 100x50 ft. Obstacles are not shown to scale. Number of obstacles, obstacle placement, and course size may vary drastically based on the availability of university facilities. Course legend is on following pages.

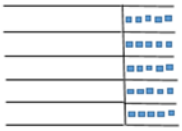
Course Legend

Race Gate

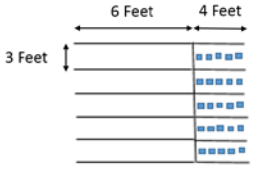
Turn Flag

1 Inch Cubed Competition Payload



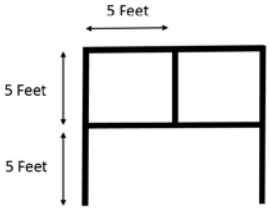


Payload Pickup/Drop off Lane

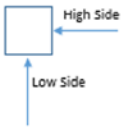


All Dimensions are approximate

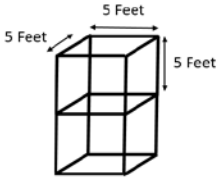
Field Goal Obstacle



Constructed of PVC Pipe



High/Low Cube



Constructed of PVC Pipe