International Airship Racing at LARC (IAR-LARC) 2026

Category Rules

March 27, 2026

Competition Chair: Diego Salazar D'Antonio. E-mail: dantonio@oakland.edu
Website: [https://sites.google.com/oakland.edu/iar-larc/home]
Join the slack channel: [https://join.slack.com/]

Contents

1 Introduction **2**

2 General Rules **3**

3 Technical Rules **4**
- 3.1 Vehicle specifications . . . 4
- 3.2 Arena specifications . . . 5
- 3.3 Game Fairness . . . 6

A Baseline Design **7**

B Simulator **7**

C Commercial Airship vehicles **7**

1. Introduction

Lighter-than-air (LTA) vehicles, such as blimps and balloons, offer unique advantages for applications that require long endurance, low energy consumption, and safe operation near humans (see Fig. 5). They are increasingly explored for environmental monitoring (e.g., air quality and wildfire plume tracking), infrastructure inspection, precision agriculture, and persistent surveillance, where their ability to hover for extended periods provides a significant benefit over conventional aerial robots. In addition, LTA platforms are well-suited for communication relays and distributed sensing in large-scale robotic systems due to their payload capacity and stability. However, these advantages come with important challenges: their dynamics are strongly affected by wind and turbulence, leading to limited maneuverability and control authority; their large size and buoyancy constraints complicate deployment and indoor-outdoor transitions; and accurate modeling for control and estimation remains difficult due to nonlinear aerodynamics and environmental disturbances. Furthermore, coordination of multiple LTA vehicles introduces additional complexity in terms of communication, collision avoidance, and robustness. Addressing these challenges requires advances in robust control, adaptive estimation, and cooperative autonomy tailored to the unique physics of buoyant flight.

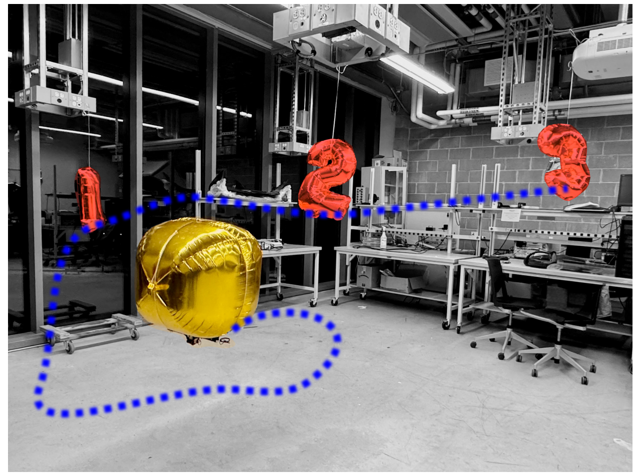

Figure 1: Conceptual overview of the arena and objective.

Mission of the Competition: The mission of the International Airship Racing competition is to inspire and train the next generation of researchers and engineers in aerial robotics through a hands-on, accessible, and educational experience. The competition challenges undergraduate and early-stage graduate students to design, build, and operate autonomous robotic airships, fostering the development of interdisciplinary skills spanning mechanical design, embedded systems, sensing, control, and decision-making. By emphasizing practical implementation, teamwork, and creative problem-solving, the competition seeks to bridge theory and real-world deployment. At the same time, it promotes fairness, reproducibility, and rigor through well-defined tasks and evaluation protocols, ensuring a meaningful and comparable experience for all participating teams.

Objective: The objective of the competition is to design, build, and deploy an autonomous robotic airship capable of navigating a predefined circuit composed of multiple waypoints. Each waypoint is represented by a small red balloon tethered to the ground, which the vehicle must physically touch to be considered successfully reached. The airship must complete the circuit fully autonomously, demonstrating reliable navigation, control, and sensing capabilities. Teams are allowed up to three attempts (loops) to complete the course. The fastest successful loop wins.

2. General Rules

1. **Autonomy Requirement**: All airships must operate fully autonomously during the race. No manual control or remote piloting is allowed once the run has started. Onboard or offboard computation is permitted, but no human intervention is allowed during execution.

2. **Course Definition**: The race course consists of a sequence of waypoints defined by red balloons tethered to the ground. The order of the waypoints will be specified prior to each run, and teams must follow the prescribed sequence.

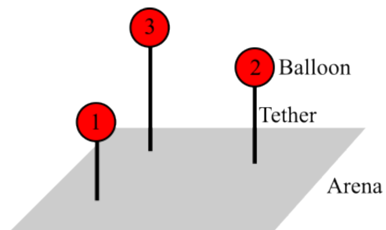

Figure 2: Example of tethered target balloons.

3. **Waypoint completion**: A waypoint is considered successfully reached only if the airship physically touches the corresponding balloon. Passing near a waypoint without contact does not count.

4. **Timing**: The timer starts when the airship touches the first waypoint and stops when the final waypoint is successfully touched.

5. **Loops:** Each team is allowed up to **three loops in a sequence without any human intervention.** The best valid completion time across all loops will be recorded.

6. **Scoring**: The competition consists of two courses. For each course, the best valid completion time across all attempts is recorded. The total time is computed as the sum of these two times. The final time determines the ranking. **The team with the lowest total time is declared the winner.**

7. **Failure Conditions**: A run will be considered invalid if:
   - The airship does not complete all waypoints in the correct order
   - The vehicle requires human intervention
   - The airship leaves the designated competition area
   - Safety rules are violated

8. **Safety Requirements**: All systems must comply with safety guidelines. Airships must use safe propulsion systems, have securely mounted components, and avoid hazardous materials. The organizers reserve the right to disqualify any unsafe design.

3. Technical Rules

3.1 Vehicle specifications

9. **Vehicle Type:** The robot must be a **lighter-than-air (LTA) robotic airship**, using helium as its primary lifting mechanism and electric propulsion for actuation and control.

10. **Helium Volume Limit**: The maximum helium volume is limited to that of a 50-inch diameter balloon (e.g., https://www.amazon.com/dp/B0CJB5F7MZ?ref=fed_asin_title&th=1). This corresponds approximately to **1 cubic meter** of helium . Teams may use any balloon shape or configuration, as long as the total buoyant volume does not exceed this limit.

11. **Buoyancy Requirement:** The airship must be approximately neutrally buoyant (zero buoyancy). The net vertical force, defined as the difference between buoyant force and total weight, must lie within a tolerance of ± 10 g (grams-force). This condition ensures that the vehicle neither significantly ascends nor descends when propulsion is inactive.

12. **Vehicle Size Constraints**: There are **no explicit size limitations** on the airship. However, teams are responsible for ensuring that their vehicle can operate safely within the competition space.

13. **Vehicle Thrust Limit**: The total available thrust is limited to **100 grams-force (gf)**. This thrust budget can be distributed across any number of motors. For example:

    - 1 motor $\rightarrow$ 100 gf
    - 2 motors $\rightarrow$ 50 gf each
    - 5 motors $\rightarrow$ 20 gf each

    Teams must ensure that the combined thrust of all propulsion units does not exceed this limit. Servos are not considered propulsion motors.

14. **Robot Size Constraints:** The maximum allowable dimensions of the airship are $1\,\mathbf{m} \times 1\,\mathbf{m} \times 1.5\,\mathbf{m}$, measured as the smallest axis-aligned bounding box that fully contains the vehicle in its operational configuration. All components, including the envelope, gondola, sensors, and propulsion system, must remain within these limits at all times during operation.

15. **Onboard Sensing:** All sensing used for navigation and task execution must be performed onboard the robot.

16. **Tether Integrity:** Robots must not sever, damage, or intentionally lift the tether anchor for waypoints.

17. **Safety — Structural Constraints:** The robot must not include sharp edges, pointed components, or rigid protrusions intended to puncture or damage objects. All external surfaces and contact elements must be designed to minimize the risk of puncturing the waypoint balloons or causing harm during operation.

3.2 Arena specifications

18. **Course Configuration:** The competition consists of two courses. Each course is defined by four target balloons arranged in a rectangular configuration.
19. **Course 1 (Rectangular Path):** The airship must autonomously visit and touch the four waypoints following a sequence that traces the perimeter of the rectangle.

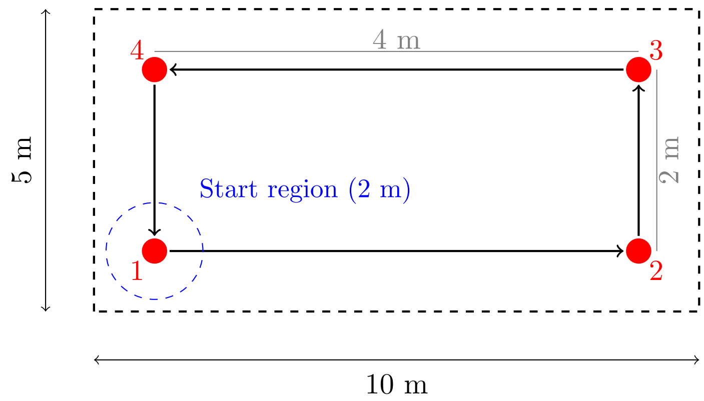

Figure 3: Course 1

20. **Course 2 (Infinity Path):** The airship must autonomously visit and touch the four waypoints following a sequence that forms a figure-eight (infinity) trajectory.

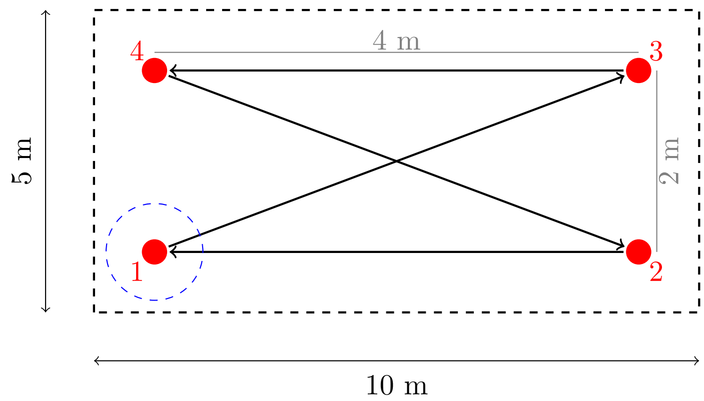

Figure 4: Course 2.

21. **Waypoint Balloons:** The waypoints are defined by red mylar balloons, commercially available 22-inch balloons such as `https://www.amazon.com/dp/B08TCBMHNJ`. When fully inflated, the balloons have an approximate diameter of 50–60 cm and are filled with helium. Each balloon is tethered to the ground using a lightweight, flexible cable. The tether allows limited motion of the balloon due to air disturbances while ensuring that it remains within a bounded region around its designated waypoint.
22. **Waypoint Height:** Each waypoint balloon is positioned at a height of **2 m** above the ground, measured from the ground to the center of the balloon. A small tolerance may be applied by the organizers to account for environmental conditions and tether variability.

3.3 Game Fairness

23. **Environment and Repeatability**: The competition will be conducted under consistent and repeatable conditions as much as possible. All teams will compete under the same setup to ensure fairness.

    Scheduling: Each team shall receive scheduled ‘dedicated practice time‘ to test and troubleshoot prior to the first game. During this time, no vehicles from other teams are permitted in the team’s designated end of the arena.

24. **Penalties and Disqualification**: Any violation of the rules, unsafe behavior, or attempts to gain unfair advantage may result in penalties or disqualification at the discretion of the organizers.

25. **Authority:** The judges and organizers have final authority over rule interpretation, scoring disputes, and any unforeseen or exceptional situations that may arise during the competition.

Appendix

A. Baseline Design

The baseline design, known as Mochiswarm https://arxiv.org/abs/2503.03077 with Documentation https://lehighblimpgroup.github.io/BlimpSwarm/bicopter/, is a bicopter robotic platform. This platform features an ESP32 microcontroller capable of controlling up to 6 actuators via 6 channels, enclosed within a spherical envelope.

The list of recommended items to construct the baseline includes:

- ESP32 Microcontroller board
- Coreless brushed DC motors (x2)
- Mylar or latex spherical balloon envelope (approx. 36-inch diameter)
- Motor drivers and step-down voltage regulators
- Small LiPo battery (e.g., 1S 500mAh)

This design utilizes a mix of lightweight materials. You are encouraged to iterate on this baseline using 3D-printed PLA/PETG mounts, balsa wood, or carbon fiber rods.

B. Simulator

To support development and testing, a simulation environment is publicly available https://github.com/TongshuWu1/mochi-swarm-sim.git, allowing teams to validate control strategies, sensing, and navigation before deployment on the physical platform.

C. Commercial Airship vehicles

(a) LTA Research (USA) (b) Hybrid Air Vehicles (UK) (c) Aeros Corp (USA)

Figure 5: Representative examples of modern lighter-than-air (LTA) aerial vehicle platforms from industry and research institutions.