FIRA Air - Autonomous Race Competition Rules (U19)

Version: 5 December 2025

Farzad Ahmadinejad [1], Mir Alireza Athari[1], Amirali Setayeshi [2], Soroush Sadeghnejad [1], and Jacky Baltes [3]

[1] Bio-Inspired System Design Laboratory
Biomedical Engineering Department
Amirkabir University of Technology
Tehran, 158754413, Iran

[2] Real-time System Laboratory
Electrical Engineering Department
Amirkabir University of Technology
Tehran, 158754413, Iran

Amirali Setayeshi

[3] Educational Robotics Center
Department of Electrical Engineering
National Taiwan Normal University
Taipei, 10610, Taiwan

FIRA-Air Autonomous Race Competition 2019

Abstract

The goal of the FIRA Air - Autonomous Race (U19) competition is to introduce high school students to develop autonomous navigation software for drones for racing in a 3d track. A suitable drone for this situation should be capable of vision-based navigation in the presence of obstacles. In the FIRA AIR competition, the track would have multiple markers to help the autonomous navigation of drones. Participant teams should use autonomous drones and FPV drones cannot participate in the main competition.

Latest Version of the Rules

The most recent official version of the rules of the FIRA Air is always available here.

FIRA Air - Autonomous Race

The goal of the FIRA Air - Autonomous Race competition is encouraging research teams to design an agile and autonomous navigation system for drones which can compete against human pilots in a 3D race track.

Right now, a manually controlled drone with a skilled pilot is capable of agile maneuvers. As a result, there is a considerable gap between the performance of an autonomous navigation system and a human pilot exists. To reduce this gap and help the participant teams develop an agile navigation system, we planned the Autonomous Race competition.

In the FIRA Air - Autonomous Race (U19), we will have a main competition for the autonomous only drones, and two side competitions. For the main competition, we designed a relatively simple track and teams can place their own custom marker on each gate for easier navigation.

Rules of the Game

These rules are directed to develop an autonomous system for racing drones using computer vision and machine learning algorithms for indoor environments without relying on any

GPS/GNSS data.

The physical specifications of the drones must abide by the rules below. Otherwise, the drone is not allowed to take part in the competition.

- The size of the drone (including propellers) should be smaller than 60cm.
- The weight of the drone (when flying) should be less than 2kg.
- Only electric motors and actuators are allowed, using fuel-based motors is not allowed.

There is no limitation on the type of drone (airship, helicopter, …) except that the drone should be capable of vertical flight.

For general specifications relevant to all FIRA events (e.g., playing field, lighting, and responsibility of the referees) please refer to General - FIRA Air Rule.

[FA-1]: Game Structure

The drone must take off from the landing pad and navigate through a series of gates in a strict predefined order, finishing by landing precisely on the "H" sign at the end of the course. The track may be divided into one or more zones, depending on the map design and the Technical Committee's discretion. Teams have a total of 15 minutes to complete the course, with unlimited attempts permitted during this time. However, each unsuccessful attempt, such as crashing, missing a gate, passing through gates out of sequence, and any landing outside the landing pad will result in a penalty. If a team is unable to precisely land inside the landing pad, the last successfully completed zone will be important for scoring (see the "method of scoring" section).

Upon entering the field, the team's 15-minute timer begins. During this period, teams are permitted to calibrate sensors and cameras anywhere on the course, and may perform ground testing without taking off. A Safe Zone is defined around the Takeoff Point. Teams are only permitted to take off and perform flight tests within this zone. However, once the drone crosses the vertical boundary of the Safe Zone, the attempt is officially counted as a trial.

Teams must explicitly declare their intent to attempt to the referee; the moment the propellers begin rotating after this declaration, the attempt is logged, and penalties apply for failures (e.g., crashes, missed gates). The referee will record each trial's outcome and time, with the clock continuously running until the 15-minute window elapses.

Based on the number of participating teams, the competition arena, and the overall schedule, there may be one or multiple qualification rounds, a semi-final, and a final. The exact number and organization of each round will be determined by the technical committee and outlined in the competition schedule.

[FA-2]: Field of Play

Field of play is a simple field consisting of a take-off pad, landing pad, and several gates. Gates are colored but not necessarily magenta (5cm wide) to make the detection easier for the teams. There will be a placeholder (A5 paper size) on the bottom edge of the gate for the team's custom

markers. We recommend the teams to use Apriltag (36h11) as their marker but teams are free to bring their own custom marker (passive and smaller than A5 paper) and place it on the placeholder. To facilitate marker replacement, teams must use a non-adhesive mechanism (e.g., clips) to attach their markers to the gate placeholders. Markers must be installed by team members during the 15 minute period.

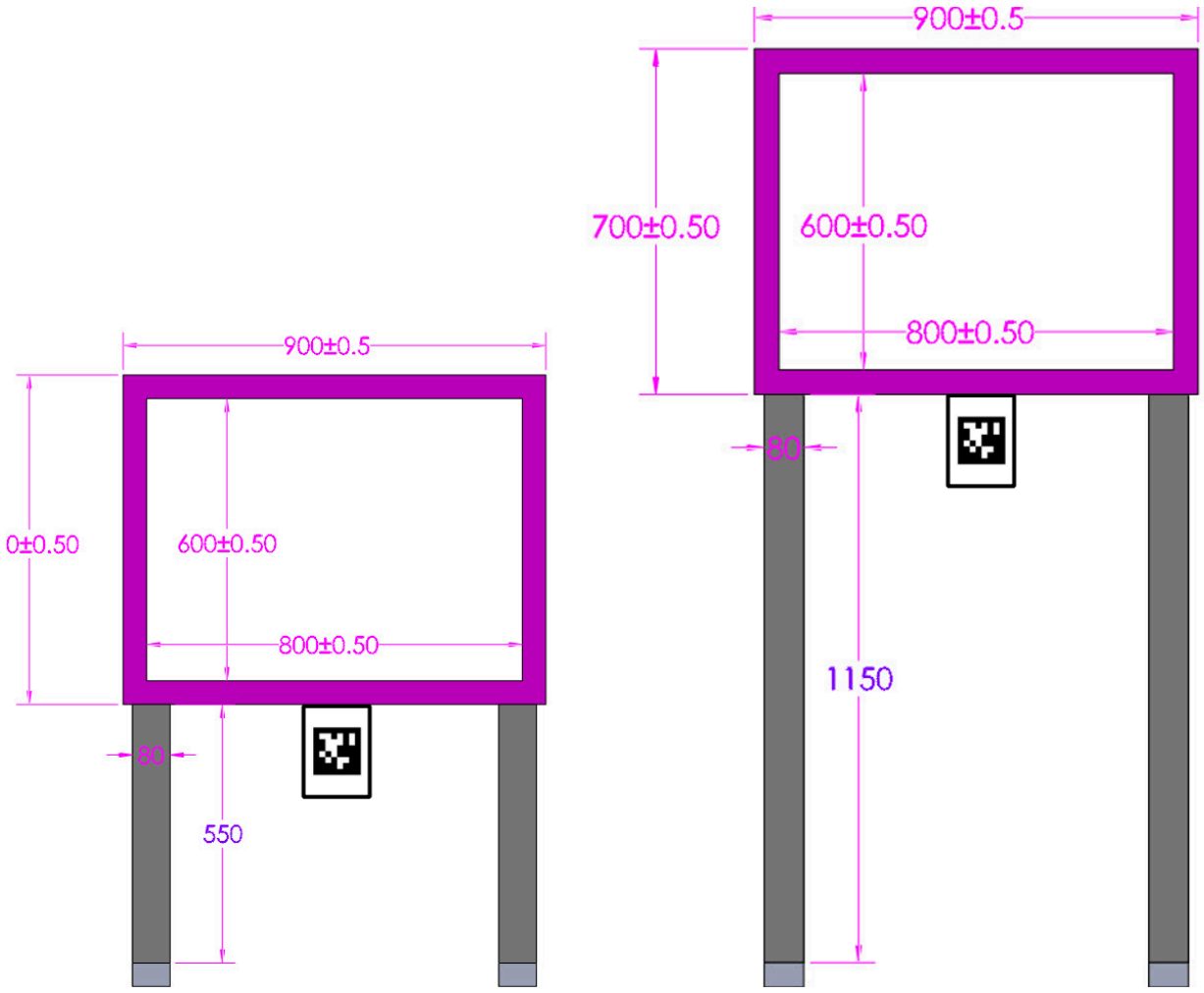


Figure 2: The gates and their tentative dimensions

The starting pad and finish pad (takeoff and landing) is a 0.5m x 0.5m square pad with a blue H mark on it. The location and number of gates, position of take-off, and landing pads will be decided by referees on the competition days. The drone should take off from the pad, follow the race track, and land on the pad to finish the race. A series of landing pads are located at the end of the course. Following the drone's takeoff, an assistant referee will randomly select one specific pad as the landing target.

The number of gates, their location, and the number of zones will be decided on the venue, but there will be a minimum 1m clearance between the gates. Also, some (random) visual features will be added on the ground which can be used for optical flow sensors. As an example, a

schema of a possible track is illustrated in Fig. 3.

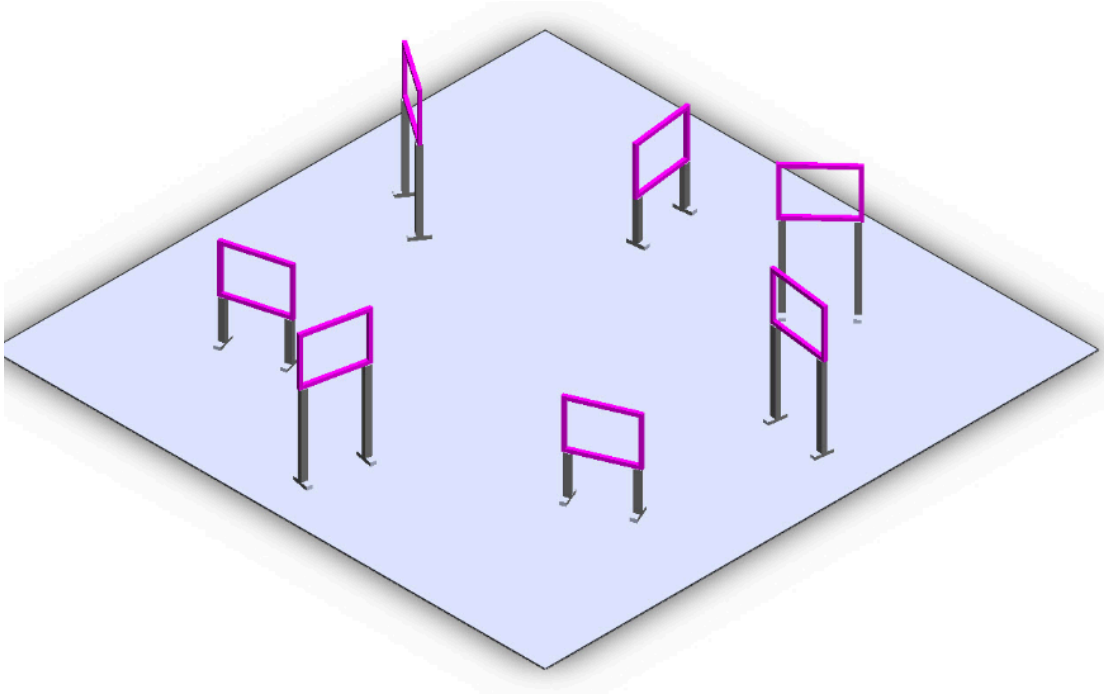


Figure 3: An example of a possible track

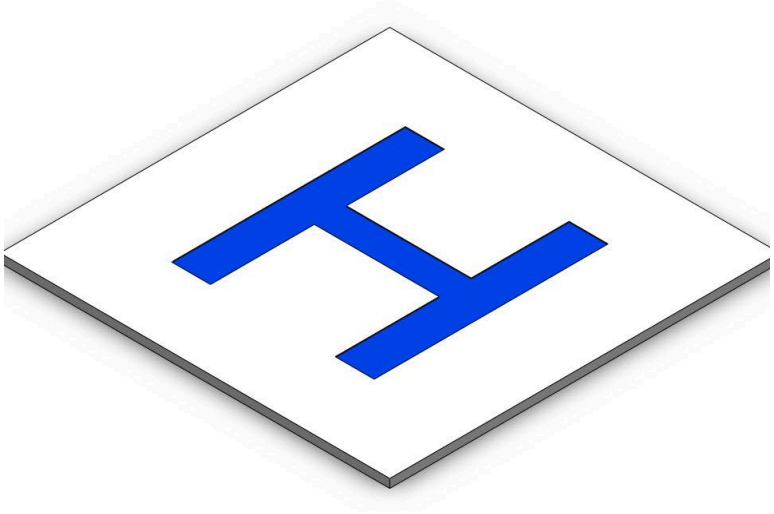
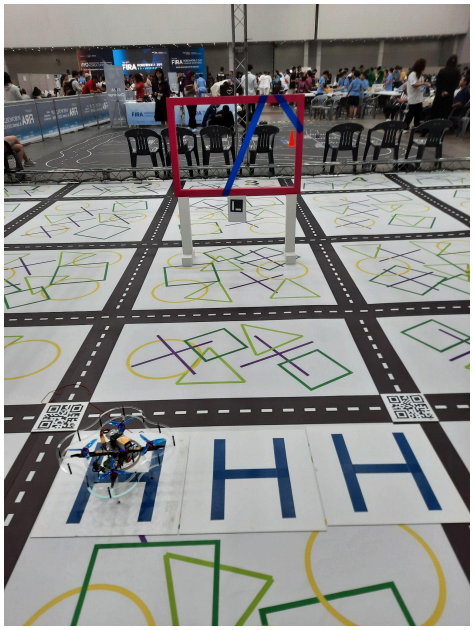


Figure 4: The landing pad

In some competition stages, the gate may be narrowed using colored tape, as illustrated below. This tape is not necessarily blue and will have a strong visual contrast against the gate's color.



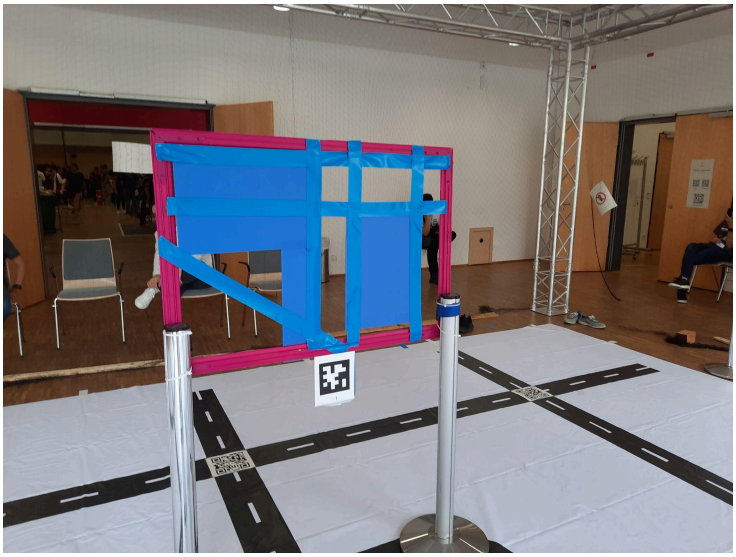


Figure 5: The narrowed gate

[FA-3]: Number of Drones

A single drone competes in each attempt. Teams are allowed to use different drones for different attempts.

[FA-4]: Level of Autonomy

In the main competition the autonomy consists of 2 levels: autonomous control with off-board processing and autonomous control with onboard processing. Based on the level of autonomy of the dr one during race, the race time will be divided by the Ka coefficient. The level of autonomy should not be changed during the race track but it can be different in different trials.

The coefficients are defined in the following table:

Level of autonomy	Ka (Autonomy Coefficient)	Comments
Autonomous (off-board Process)	1	Control and navigation of the drone is performed autonomously, and some processes are done using a computer outside of the drone itself. (e.g. Tello and Bebop drones)
Autonomous (on-board Process)	2	Control and navigation of the drone is performed autonomously, and all of the processes are done using a computer inside the drone itself.

[FA-5]: Method of Scoring

The base score is determined by the drone's progress along the track: a full completion passing all gates in the first trial awards 25 points, while partial completion grants points based on the last cleared zone (with zone values set by the Technical Committee; defaulting to 10 points if only one intermediate zone exists). Each failed attempt deducts 1 point from the base score. The final score is then adjusted by multiplier, specifically the Level of Autonomy coefficient (Ka), reflecting the drone's autonomy level. Thus, the total score = (base score − penalties) × Ka. Rankings prioritize the highest total score, with ties resolved in favor of the team that reached the last zone in the shortest time. If penalties result in a negative total score, that negative value is officially recorded. In scoring systems based on cumulative stage points, the negative score is factored into the final aggregate total. Here are some examples to illustrate how the final score is calculated:

Example 1: Full Track Completion with On-board Processing

- **Scenario:** A drone completes the entire track, passing all gates in the correct order on the first attempt, and uses autonomous control with on-board processing.
    - **Base Score:** 25 points (full completion, first trial)
    - **Penalties:** 0 (no failed attempts)
    - **Ka (Autonomy Coefficient):** 1.5 (Autonomous, on-board Process)
    - **Total Score:** (25 - 0) × 2 = 50 points

Example 2: Partial Track Completion with Off-board Processing

- **Scenario:** A drone completes two zones, and crashes three times. It uses autonomous control with off-board processing. Assume Zone 1 = 5 points, Zone 2 = 10 points.
- **Base Score:** 10points (for reaching second zone)
- **Penalties:** 3 point (one failed attempt)
- **Ka (Autonomy Coefficient):** 1 (Autonomous, off-board Process)
- **Total Score:** (10 - 3) × 1 = 7 points

Example 3: Full TrackCompletion with Off-board Processing and Multiple Attempts

- **Scenario:** A drone completes the entire track on its third attempt (first two attempts resulted in crashes), uses autonomous control with off-board processing.
- **Base Score:** 25 points (full completion)
- **Penalties:** 2 points (two failed attempts)
- **Ka (Autonomy Coefficient):** 1 (Autonomous, off-board Process)
- **Total Score:** (25 - 2) × 1 = 23 points

Important notes:

- The drones should at least enter the zone to be eligible for scoring.
- The drone passes the gate if it goes through it without ANY collision with the gate.
- The teams are not allowed to add external markers to the field.

[FA-6]: United (Co-operation) Challenge

Apart from the main competition, there will be an additional side competition (a united challenge) for the participant teams. The details of this challenge will be announced during the competition days, the teams should develop a system to overcome this challenge. Scores and awards of the united challenge are completely independent of the main competition.

In the United Challenge, all participating teams will be divided into two seeds based on their country and performance in the qualification rounds. After a draw, these teams will form united teams to jointly complete a mission. Completing the challenge typically requires a communication channel between the two drones, and teams must be aware of this requirement. Sometimes the technical committee will provide a specific communication link to the teams, which they must use; otherwise, teams are free to bring their own communication solutions. Sample challenges, based on local events or previous RoboWorld Cups, can be accessed below:

- Iran FIRA Air United Challenge Rules (2025)
- FIRA Air Robo-World Cup United Challenge Rules (2025)

[FA-7]: Age Classification

The Junior Autonomous Drone Racing league competition is limited to high school students. Junior teams may include a team official who may be an adult. With the exception of the team

official, who shall not help the students in the development of their robot, all team members must be high school, junior high school, or elementary school students or the equivalent school level in the country of origin of the team. (U19 is for students younger than 19 years old. The age of the student is determined by calendar year.)