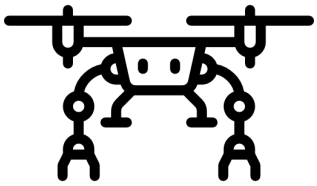

FIRA Air - Emergency Service Outdoor Competition Rules (Pro)

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Abstract

The focus of the FIRA Air - Outdoor Emergency Service competition is encouraging researchers to develop an autonomous navigation system for drones for outdoor urban environments. A suitable drone for this situation should be capable of navigating based on GPS/GNSS and vision in presence of the obstacles. Therefore, In the FIRA AIR 2019 competition, different mission elements are designed to test the performance of drones for various real-world applications: Obstacle detection and avoidance, Package delivery, Tall building, and Electrical tower inspections.

Latest Version of the Rules

The most recent official version of the rules of the FIRA Air - Emergency Service competition is always available here.

FIRA Air - Emergency Service

The goal of FIRA Air - Outdoor Emergency Service competition is encouraging research teams to develop a robust and autonomous drone for commercial and industrial applications. While drones are widely used for aerial imaging, there are still lots of challenges to create an autonomous, reliable and secure solution. Most of these difficulties are related to localization and intelligent navigation in dynamic environments.

Nowadays, drones are used for carrying packages in well-defined conditions in rural areas. But doing the same task in an urban environment is a lot more challenging. Tall buildings and communication equipment in the urban environment cause electromagnetic interference which weakens satellite signals (GPS/GNSS) and leads to a great error in localization and navigation. In such situations, additional positioning method is required. Many drones already have an onboard camera, therefore using on machine-vision for localization and visual servoing is feasible. A reliable aerial package delivery system in the urban environment should be able to detect obstacles and avoid any collision. Delivering a medicine package in emergency situations inside a high traffic area is a real-world application of aerial package delivery using drones.

Figure 1, A Picture of an “Ambulance Drone“ from https://www.springwise.com/

Another practical application of drones is regular inspection of equipment installed on hard-to-reach locations. Currently, the inspection is done manually; a professionally trained operator is needed to control the drone to take pictures of the equipment from different angles. The same procedure can be done automatically which will result in simultaneous usage of several drones, faster operation, and more accurate results.

Rules of the Game

Rules of this competition are explained in this chapter. These rules are directed to develop a new system for autonomous navigation of drones using computer vision and GPS/GNSS data.

Physical specification of the drone and operation methods 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 100 cm.
- ❏ The weight of the drone (when flying) should be less than 5 kg.
- ❏ The flight altitude should be lower than 20m.
- ❏ The drone should stay inside the competition zone at all times.
- ❏ The participant team should assign one of their members as a safety pilot to land the drone manually in emergency situations
- ❏ 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 Laws of the Game.

[FA-1]: Game Structure

This competition consists of 2 stages: the preliminary and the final. Missions get more complex as progressing to the higher stage. All teams will participate in the first stage (preliminary), and based on the scores, a selection of teams would enter the final stage. The previous scores in the preliminary will be reset and only scores in the final stage will determine the winner. In each stage, the technical committee will decide the arrangement of mission elements and difficulty level.

The competition in each stage will have a collection of 5 mission elements:

- Navigation based on GPS and vision
- Obstacle detection and avoidance
- Package delivery
- Tall building scanning
- Precision landing

Each stage consists of several mission elements which have a specific order and should be

carried out in that order. A team can take part in all mission elements or only a few of them. For example, suppose preliminary stage has 4 mission elements, a team can perform the mission elements 1-2-4 or 2-3, but if the order is 1-2-4-3, the mission element 3 will not be scored.

A team has 2 separate time slot in each stage to try the mission elements. A time slot is 20 minutes in total, consist of 5 min setup and 15 min run time. During the specified time, each team can try missions 3 times, and the highest score among three attempts would be the score for that time slot. the final score of the stage is calculated by this formula (TS1 is the time slot 1 and TS2 is the time slot 2):

$$Stage\ score\ =\ 1.5 * Max\ (TS1_{Score}\ ,\ TS2_{Score})\ +\ 0.5\ *\ Min\ (TS1_{Score}\ ,\ TS2_{Score})$$

[FA-2]: Field of Play

To focus on the development of software algorithms for real-case scenarios, this competition will be held in an outdoor area. The playing field is an urban environment That may consist of several streets, crossroads, buildings, obstacles and designated places with markers. Figure 2 shows the top view of the venue for the FIRACup Open 2019 In Tehran, Iran. The competition's environment consists of these elements:

1. Take-Off and Landing Point
2. Obstacles (eg. trees, poles and buildings)
3. Emergency Delivery Locations
4. Tall building for inspection

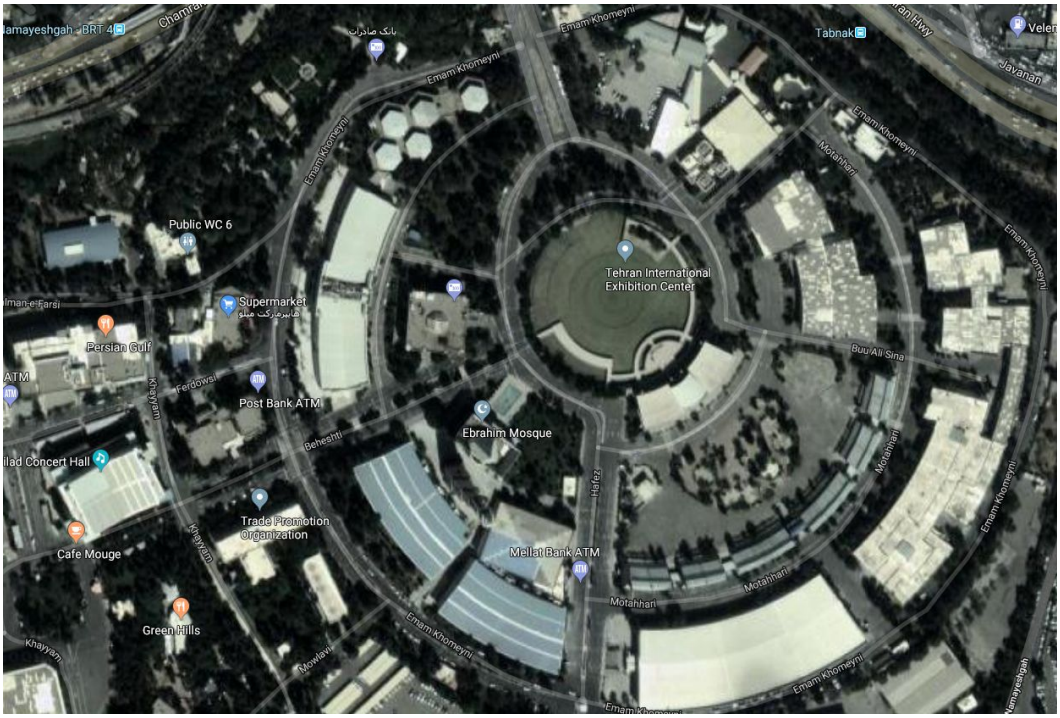

Figure 2, A top view of the venue for the FIRACup Open 2019

[FA-3]: Mission Elements

The overall scenario consists of several mission elements: The drone should deliver a number of first aid packages to specific locations while flies on a predefined path and avoids any collision with obstacles. The coordinates for the waypoints and delivery locations will be given in the competition day. After the delivery, it should go to the tall building for inspection and then return to the starting point and land.

The details of mission elements are :

1. **Navigation:** The drone should follow the path from takeoff location to a target coordinate. The path that drone should take is predefined in each stage. This mission element is scored if the drone gets from the start position to the target position correctly (following the GPS waypoints). Every time the drone gets out of the path (over 10 m deviance to the path), 1 point will be removed from this mission element score.
2. **Collision avoidance:** There are several obstacles in the environment. These are the commonly find obstacles in a city such as trees, poles, and buildings. The drone must identify and avoid them. These obstacles may exist in close proximity to some delivery locations. These delivery locations with obstacles nearby (2 m) will be determined as type D location by the referees in the competition day.

   This mission element will score only if the drone can successfully avoid the obstacles and tries to deliver the package in a type D delivery location.

3. **Delivering the first aid kits:** The delivery destination is a 1mx1m white pad marked by

a red cross. Drone should either land on the marker or gets in 0.5m altitude, release the package and fly again. The distance between the center of the marker and the place where drone releases the package (point of impact) will define the score of this section.
There are a maximum number of 4 packages for delivery but the actual number of packages and their location will be decided in the competition day. Each package and delivery location has an ID and the drone should deliver packages to the correct locations to earn scores. An only rough coordinate of these destinations will be provided to the participants and position of the pad can change in each try. For precise delivery, their exact positions can be estimated using computer vision.

The packages should be installed on the drone by team members before the flight. The drone is allowed to carry multiple packages at the same time. The weight and size of this package are roughly 200g and 8x12x18 cm with an (optional) small hook above it.

4. **Scanning a tall building:** The drone should scan different sides of the tall building by taking several pictures from different angles around the building. the drone should stay at least 10 meters away from the building. To achieve a score, the saved pictures or video of the building from all angles should be provided to the referees after the landing. Also providing a 3d model of the building will have extra marks (not later than 30 min after the flight).
5. **Return and land on the starting point:** The drone has to follow the path back to the starting point and land on the platform. The landing pad is 1x1 m and is marked by a blue H symbol.

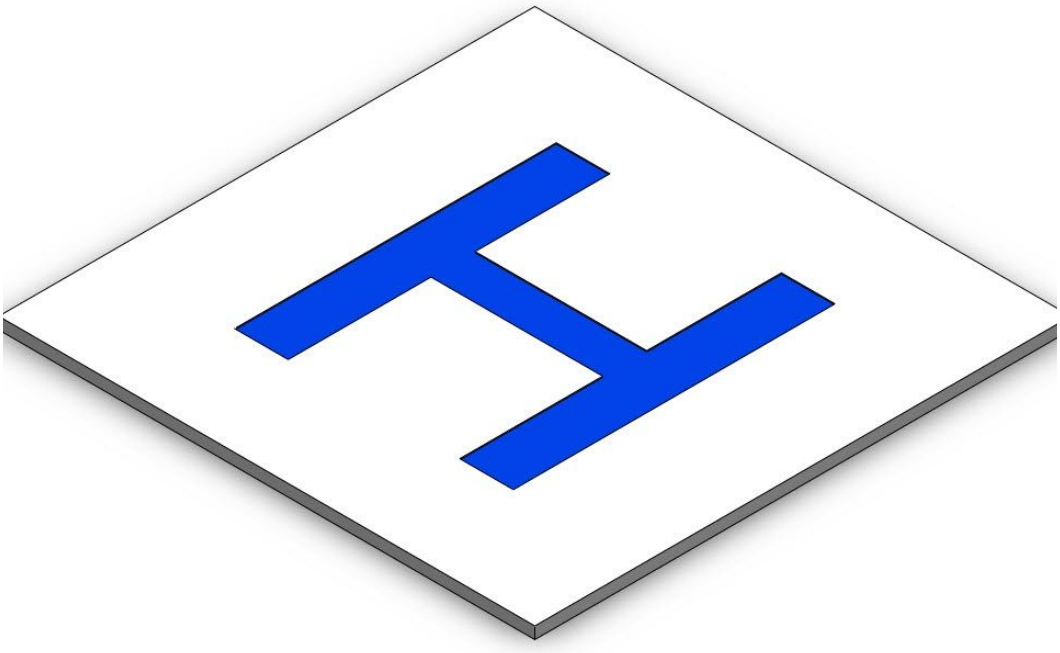

Figure 3, The landing pad

The following table shows scores of each mission element:

Number	Mission element	Score
1	Navigating to destination	2 points for reaching destination -1 point for getting out of the path boundary
2	Collision avoidance	2 point for colision avoidance in a type D delivery location
3	First aid kit delivery	3 points for placing each parcel on the 1m x 1m pad 1 points for placing each parcel in 2 meter radius
4	Scanning a tall building	1 point for clear image of each side of the building (max: 4) 2 extra point for generating 3d model of the building
5	Return and land on starting point	2 points for landing on the landing pad

		-0.5 point for landing anywhere **except** the landing pad

[FA-4]: Number of Drones

[FA-5.1]: A single drone competes in each mission attempt. Teams are allowed to use different drones for different mission attempts.

[FA-5]: Level of Autonomy

The autonomy consists of 2 levels: teleoperation control (FPV), autonomous control. Based on the level of autonomy of the drone in a mission element, a coefficient is multiplied in the achieved score of that mission element. The coefficients are defined in the following table:

Level of autonomy	**Ka (Coefficient)**	**Comments**
Teleoperation (FPV)	1	Control and navigation of the drone in that mission element is done by an operator without direct line of sight.
Autonomous	5	Control and navigation of the drone in that mission element is performed autonomously.

NOTE:

- Switching between different level of autonomy is allowed for different mission elements. For example, the drone can autonomously navigate to target position and then the operator can switch it to FPV control to deliver the package manually.

- The participant teams can use their own custom marker for mission elements but a -1 point penalty will be calculated in the score of that mission element (for each marker).

[FA-6]: Method of Scoring

The score of a mission depends on the performance of drone and the level of the autonomy. It will be calculated using the formula below:

$$Mission\ Score = \sum_i (S_i * Ka_i)$$

In this formula, "i" is the mission element number, S_i is the achieved score and Ka_i is the level of the autonomy in that mission element.

Example of scoring:

A drone autonomously navigate to target position, avoid obstacles and delivers a parcel in a type D location (1.5 m radius), and delivers another parcel correctly on a pad. Then the drone takes picture from all sides of the building by manual control (FPV) and then returns and land autonomously on the landing pad. Also, 20 minutes after their trial, the team provides a detailed 3d map of building.

$$Mission\ Score = \sum_i (S_i * Ka_i)$$
$$= 2 * 5 + 2 * 5 + 1 * 5 + 3 * 5 + (4 + 2) * 1 + 2 * 5 = 56$$

[FA-7]: Technical Challenge

Apart from the main competition, there will be an additional side competition (a technical challenge) for the participant teams. The details of this challenge will be announced on the setup day and during the competition days, the teams should develop a system to overcome this challenge. The main theme of 2019 technical challenge is "delivering a parcel on a moving platform". The team with the best performance in the technical challenge will be awarded. Scores and award of the technical challenge are completely independent of the main competition.