IMAV2013 General Indoor and Outdoor competition rules v0.5

August-2013

Introduction

The indoor and outdoor competitions are set up to highlight the following points :

- high level of autonomy.
- multiple Micro Air Vehicles (MAV).
- operable MAV systems.
- custom autopilot design.
- high performance platforms.

To promote autonomous operation, RC-only control is no longer part of the competitions. Teams with an innovative RC-only platform can request a demo slot.

Safety and security requirements

For security and safety details see the latest version of the IMAV2013 safety regulations document which is published on the **www.imav2013.org** website.
All participants are required to be familiar with the contents of the document and comply with it.
Due to regulation and safety, the maximum weight for all types of MAV is **2 kg** and the maximum flight altitude is **50 m** above ground level.
Safety areas are described in a kml file available on imav web site:
http://www.imav2013.org/images/IMAV2013.zip

Location

The outdoor flight competitions will take place at **Muret-Lherm airfield** (Google Maps).

Lat: 43.449546°
Lon: 1.263383°

The indoor flight competitions will take place at **ENAC** (Google Maps).

7 Avenue Édouard Belin
31055 Toulouse Cedex 04
France

Competition slot: preparation time & flight time

Teams are not assigned a specific preparation time and a flight time but rather a competition slot. In this slot, they will set up their equipment, prepare the flights, fly the mission, and clear the flight area. *Failure to clear the flight area within the slot can lead to a penalty or disqualification*.
The order of the teams' slots will be randomly decided on the morning of the day of the competition. At any time, before or during the mission, a team can decide once, and only once, to postpone the rest of its mission. In this case, the flight slot of the team is shifted to the end. Therefore, all teams must be ready to fly at any time.
Time slots are 15 minutes for the Indoor mission and 25 minutes for the Outdoor mission.

Scoring

The final score will depend on the success of the mission elements (**M** = successful mission elements), the level of autonomy for each mission element (**A**), the size of the MAV (**S**), a presentation made by the team during the mission (**P**), and a system operation factor (**O**).
For IMAV2013, emphasis is placed on autonomy and operation of the MAVs. For this purpose, two scores will be computed based on the same mission elements. Awards will be determined by both rankings given by the following formulas:

- Autonomy: Total score = $\text{Sum}_{\text{each MAV}}(M \times A \times S) \times P$
- Operation: Total score = $O \times \text{Sum}_{\text{each MAV}}(M \times S) \times P$

In order to facilitate the work of the judges, it is ask to the teams flying multiple MAVs to clearly identify (color, number) each vehicle.

In addition, two **special jury prizes** will be awarded (see at the end of this document).

Size factor

The maximum size of the MAV is 1 meter, which is determined by:

- the wing span of the aircraft
- or the maximum horizontal distance of a rotary wing (including blades).

The maximum take-off weight is **2 kg** for all type of MAVs.

Size factor **S** = 1 / (size of the MAV in meters)

Level of autonomy

The level of autonomy describes how a MAV is operated in order to fulfil the mission elements. The factor associated to each autonomy level is then used to compute the final score.

Level of autonomy	**factor A**
Video based control: control of the MAV is manual (from complete manua control to attitude-stabilized control)	1
Assisted flight control: the navigation is not completely autonomous but th low-level control is augmented by additional controls (such as collision avoidance or hovering based on laser scanner or optical-flow)	4
Autonomous flight control: the navigation is completely autonomous but th operator is controlling the mission and the payload	6
Autonomous target detection: the navigation and is not autonomous but th detection and processing of the targets is automatic	6
Fully autonomous mission control: the navigation and the decision making ar autonomous, without assistance of the operator	12
Using external aids such as visual markers	-2 applied to factor

During the mission, the team will have to demonstrate that all MAVs can sustain flight safely (MAV(s) cannot leave the flight area nor crashing) without any commands input (RC, joystick, ground station, …) for 30s (outdoor) or 15s (indoor).
The team can decide at which time and place this demonstration is performed. During this test, the MAVs can continue their mission if their level of autonomy allows. The goal is to show that all the MAVs entering the competition can at least achieve a level of autonomy higher than 1.
Failing this test will disqualify the MAV for the final score.

Teams with **innovative design** that are not able to perform this minimum autonomy demonstration will have an opportunity to present a technical demonstration of their MAVs.
While they will not compete for the mission scores, **they are eligible for the special jury prizes**.

Presentation factor

The team is rewarded when a team member presents the activity currently performed by its team. The goal is to make the demonstration of each team more lively and accessible for the public. A video feedback of the ground station is also possible and is strongly recommended (standard VGA cable or analog video).

The main points for judging the presentation factor based on a description of:

- the MAV system and its design
- the initial plan to perform the mission elements
- the tasks actually performed
- the level of autonomy of each task / MAV

Presentation factor = 0 to 10 % of the total score (**P** from 1 to 1.1)

System operation factor

The system operation factor reflects the ease to operate a MAV system. It takes into account the number of MAV operated during the mission (the one that actually scored mission elements) and the number of people needed to operate them. All team members entering the flight area to take part in the mission (ground station operators, video operators, antennas holders, MAV launchers and retrievers) are counted as mission operators. Only the safety pilots (one for each MAV) and the “presentation” members are not counted as long as they do not take part of the mission (it is therefore not possible to have a number of mission operators less than 1).

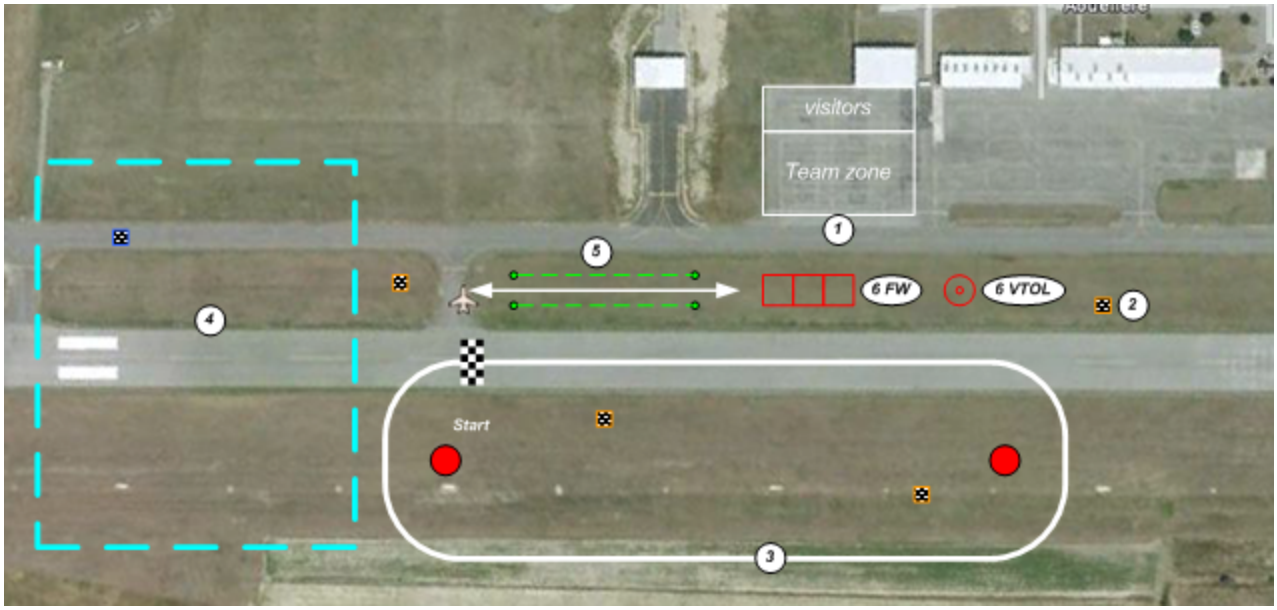
Operation factor **O** = number of MAV / number of mission operators

Mission elements

A mission consists of multiple elements that can be performed in any order by one or more MAV. For each mission element, a score is awarded to the MAV that accomplishes the assigned task. A MAV can attempt to complete the mission element as many times as needed in the allotted time. Only the best score will be used for the final scoring.

Outdoor mission

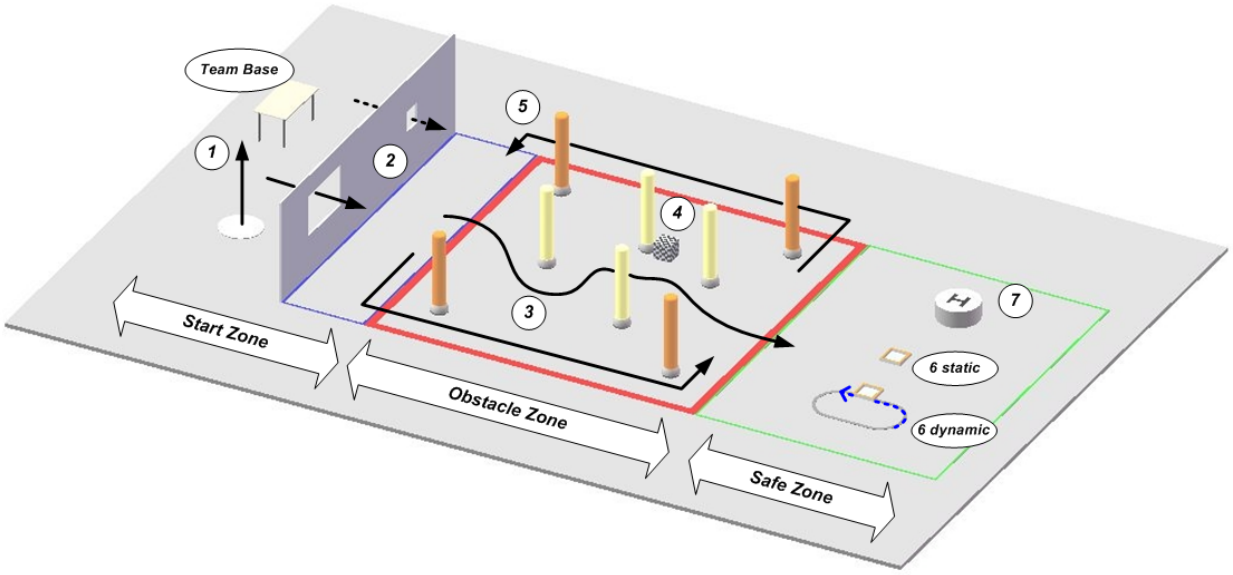
1. Automatic take-off
    a. a take-off is considered automatic as long as the safety pilot does not transmit any commands (except mission start signal)
    b. the MAV can be hand-launched.
    c. points are awarded for every MAV that performs at least one other mission element during its flight, except precision landing (taking off and landing is not enough to count as a valid mission flight)
2. Drop zones
    a. four drop zones are scattered around the flight area
    b. the center of a drop zone is marked with a QRCode
    c. the score is awarded based on the distance of the dropped ball to the center of the drop zone (Points will be awarded for distances less than 5 meters and less than 10 meters)
    d. the GPS coordinates of the centers will be given before the flight
    e. all coordinates are exact except for one for which the real position can be up to 20 meters again from the gps coordinates (vision is thus needed for accurate drop)
    f. when all drop zones are filled during the mission, extra points are awarded
3. Flight performance
    a. fly as many laps as possible in the competition slot around 2 poles
    b. begins when crossing the “start” line; only laps that have been completed count in the final score
    c. the MAV must land before the end of the allotted mission to be valid
    d. flight altitude is only limited by the boundaries of the flight zone
4. Target detection and recognition
    a. search and read a landmark within the flight area
    b. Two signs will be shown: a human readable number and a QRCode (only online decoding is considered as fully autonomous detection, extraction from a recorded picture is not considered)
5. Urban corridor
    a. fly between 2 aligned arches without going out of the corridor
6. Precision landing
    a. a landing will be classified as one of the following: a field landing, a normal landing, or a precision landing
    b. the size and place of each landing zone (normal/precision) depends of the type of MAV (fixed-wing, VTOL)
    c. in case of rough landing, the team will be asked to demonstrate the airworthiness of the vehicle
    d. extra points are awarded if the MAV is able to take-off again (fly higher than 5m) after staying still 10 seconds on the ground and without any operator intervention
    e. all MAVs must land within the time slot, otherwise all mission elements since last take-off will be discarded for this MAV



Mission elements	**Mission score M**
Automatic take-off (1)	1 per MAV
Drop (close/far/outside) (2)	2, 1, 0 per zone and per MAV extra points: +2 if at least one point is scored within each zone
Flight performance (3)	number of laps / 8 (per MAV)
Target detection (4)	1 for clear view of the target 1 for human readable sign 2 for QRCode decoding
Arch (5)	low altitude: 2, higher: 1 (per arch and per MAV) extra points: +1 for crossing the 2 arches without going out of the corridor
Landing (precision/normal/field) (6)	2, 1, 0 per MAV extra points: +1 by taking off after 10 seconds staying still without any operator assistance

Indoor mission

1. Take-off and hover
    a. a take-off is performed from the starting zone
    b. after taking-off, the MAV must hover for at least 5 seconds within the take-off area
    c. points are awarded for every MAV that performs at least one other mission element during its flight, except precision landing (taking off and landing is not enough to count as a valid mission flight)
2. Flying through the window
    a. the MAV must pass through on of the two different size windows on a wall; higher scores will be awarded for flying through the smallest window
3. Flying through the “obstacle” zone
    a. several poles are placed in the flying area and the MAV must cross the area to reach a “safe” zone at the other side
    b. four fixed poles mark the corner of the “obstacle” zone, four others have unknown positions
    c. if the MAV flies over the poles, it has to start over from the entrance of the “obstacle” zone
4. Target detection and recognition
    a. a target is placed in the “obstacle” zone near a pole
    b. the task is to find the target and read the sign on the pole close to it
    c. Two signs are placed on each pole: a human readable number and a QRCode (only online decoding is considered as fully autonomous detection, extraction from a recorded picture is not considered)
5. Follow a path
    a. the designated path is laid out around the four fixed poles which mark the obstacle zone
    b. the score depends on the number of laps completed flying over the path
6. Drop zones
    a. a static drop zone and a moving drop zone are placed in the “safe” zone
    b. each zone are marked with a QRCode
    c. the static zone can be scored only once, but the moving zone can be scored as much as possible (only one ball can be dropped at a time, the next drop can start after the previous ball touches the ground)
7. Precision landing
    a. the MAV must perform a precision landing on a small platform
    b. in case of rough landing, the team will be asked to demonstrate the airworthiness of the vehicle
    c. extra points are awarded if the MAV is able to take-off again after staying still 10 seconds on the ground and without any operator intervention



Mission elements	**Mission score**
Take-off (1)	1 per MAV
Fly through window (small, big, none) (2)	2, 1, 0 per MAV
Fly through obstacle zone (3)	1 per MAV
Target detection (4)	1 for a clear view of the target 1 for reading the human readable sign 2 for QRCode decoding
Path following (5)	number of laps (per MAV)
Drop zone (6)	1 for the static drop zone (per MAV) 2 for each drop in the moving zone
Landing (precision) (7)	1 per MAV extra points: +1 if taking off after 10 seconds staying still without any operator assistance

Special jury prizes

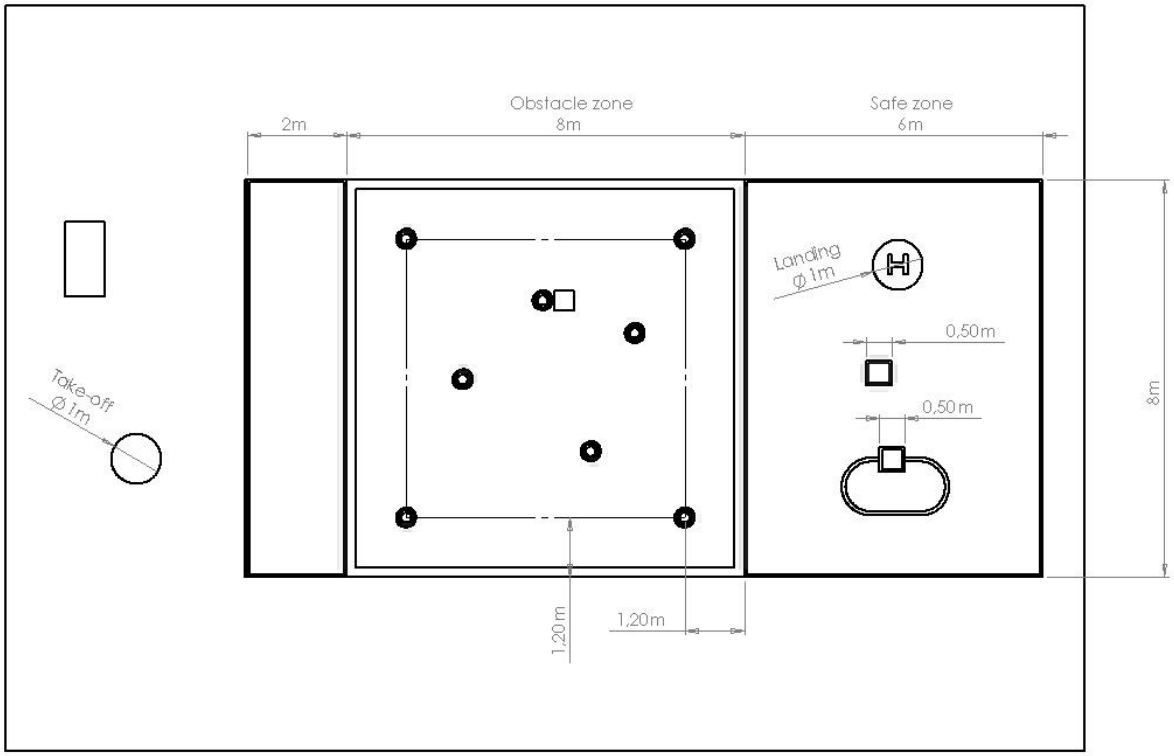
The IMAV jury members, will also award two special prizes:

- System prize: this prize is awarding the team that presents the highest level of innovation of MAV system elements such as autopilot hardware or software design, Human-Machine Interface, payload control, computer vision, code analysis, simulation.
- MAV Design prize: this prize is awarding the highest level of innovation of aerodynamics or mechanical solutions

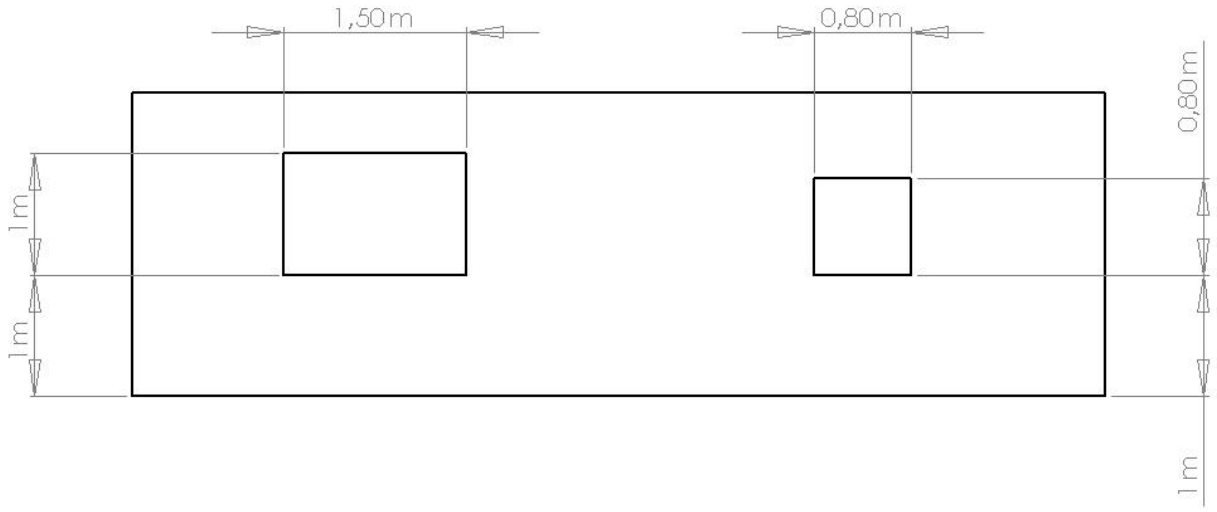
Size and shapes

All dimensions presented here are preliminary and might be updated.

Indoor flight area



Windows for indoor mission



Indoor poles

Dimensions for the indoor poles (obstacle zone):

- height: 3 m
- diameter: 40 cm

Indoor take-off and landing zones

The take-off and landing zone are 1 meter diameter circular platforms.
The landing platform is around **55** cm above ground.

Indoor target

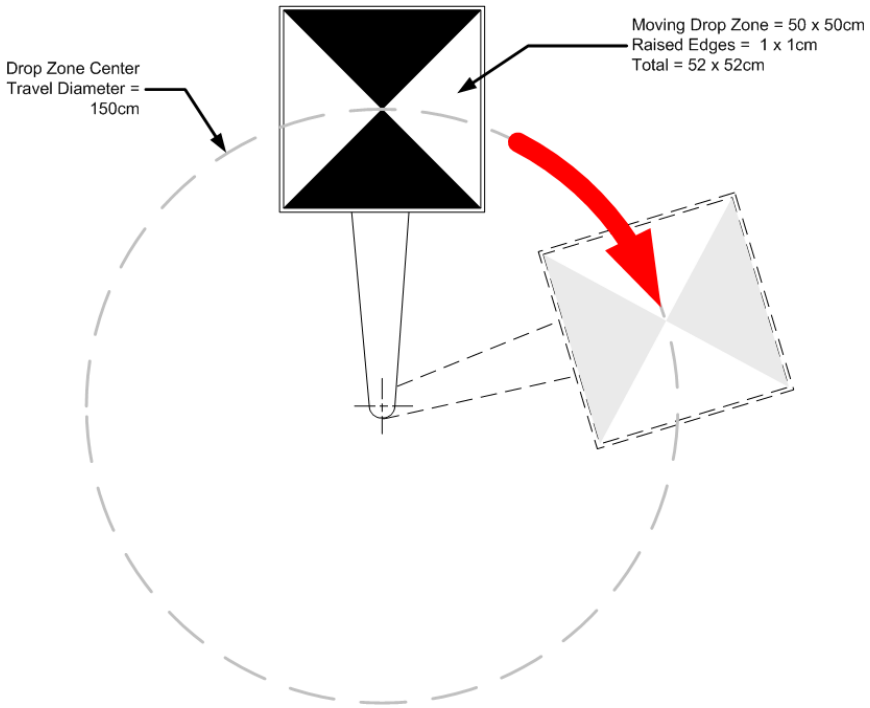
The indoor target is black and white cube with dimension: 20x20x20 cm
See imav web site for pictures.

Indoor path

The path to follow is made of a 50 cm width carpet (dark blue) with an orange tape in the middle.
See imav web site for pictures.

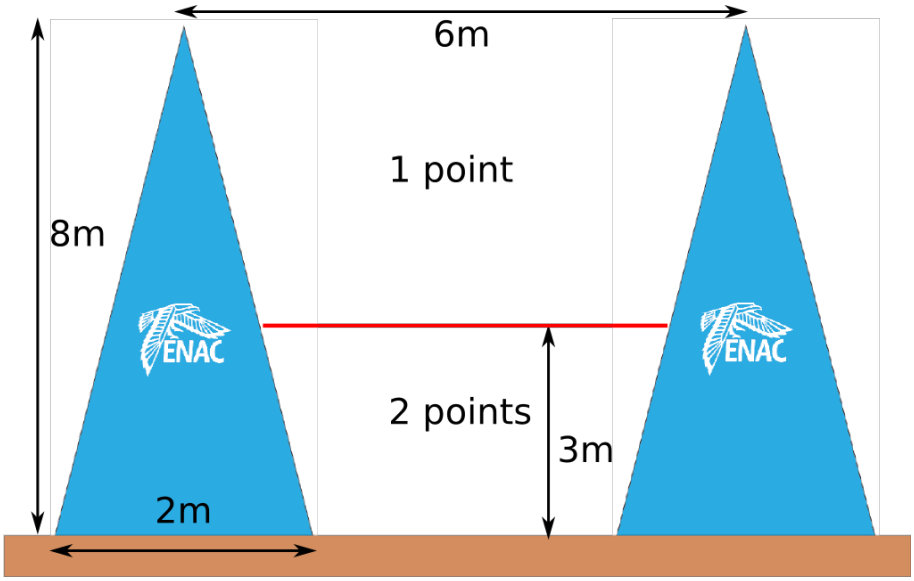
Indoor drop zones

Drop zones: 50x50 cm
The center of the moving zone follows a 75cm radius circle.

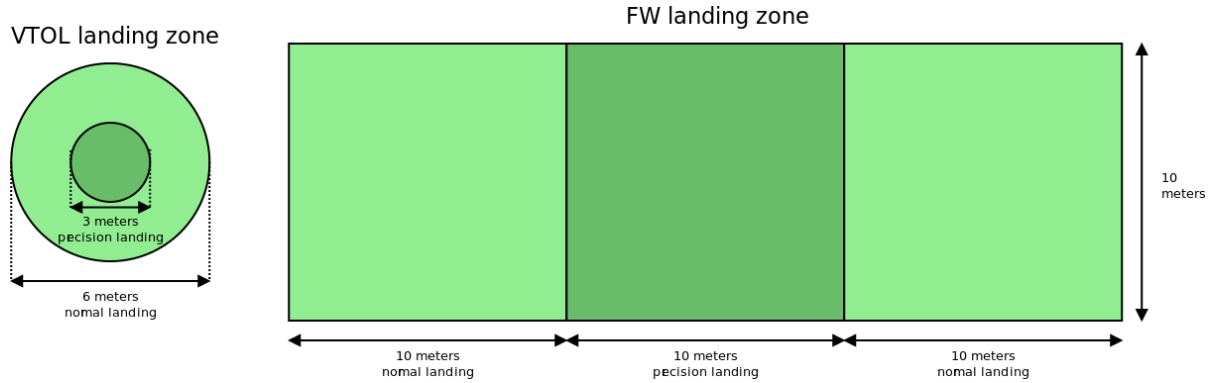


Outdoor archs (corridor)

Distance between the two archs: 100 m

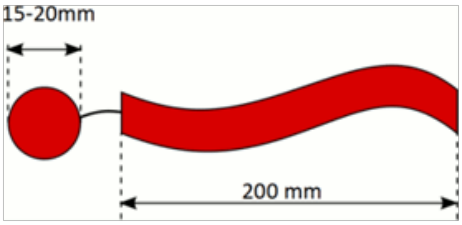


Outdoor landing zones



Ball (indoor and outdoor drop)

The ball must be spherical body with a diameter of 15 to 20 mm. An additional coloured flag, which must be at least 1cm wide and 20 cm long, is required for the outdoor competition. This flag is optional for the indoor competition.



QRCode

QRCode are two-dimensional bar codes that can be decoded using various software libraries (for example ZBAR).
The size of the QRCode for the outdoor mission zone will be 60x60 cm, and 15x15 cm for the indoor mission (printed black over a white background).
See imav web site for pictures.

Scoring examples

Outdoor

A team with 5 members, 1 presentation and 2 MAVs for the outdoor mission:

- a 50 cm fixed wing aircraft performs an automatic take-off, 20 fully autonomous laps and a normal automatic landing (no action from the operator between the mission elements)
- a 40 cm VTOL MAV performing an autonomous take-off, 2 drops within 5 meter and 1 within 10 meter (autonomous navigation with visual validation), finds and reads the human-readable target (assisted navigation), flies the corridor (video-based, below 3 meters) and makes an autonomous precision landing

The scores are:

- operation: (2/5)*((1/0.5)*(1+(20/8)+1)+(1/0.4)*(1+5+2+5+2))*1.1 = 20.46
- autonomy: ((1/0.5)*(1+(20/8)+1)*12+(1/0.4)*(1*6+5*6+2*4+5*1+2*6))*1.1 = 286.55

Indoor

A team with 3 members, 1 presentation and 1 MAV for the indoor mission:

- a 60 cm MAV performs an autonomous take-off, flies through the big window in assisted mode, crosses the obstacle zone with autonomous navigation, finds the target in assisted mode, reads automatically the QRCode, drops 1 ball in the static zone (assisted mode) and performs a precision landing (assisted mode)

The two scores are:

- operation: (1/3)*(1/0.6)*(1+1+1+1+2+1+1)*1.1 = 4.88
- autonomy: (1/0.6)*(1*6+1*4+1*6+1*4+2*6+1*4+1*4)*1.1 = 73.3333