IMAV2017

General Indoor and Outdoor

competition rules

v1.0

Changelog

December 2016 - v0.0

- Initial draft (limited access)

December 2016 - v0.1

- review
- virtual challenge

January 2017 - v1.0

- first public release

Introduction

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

- Aircraft efficient and innovative designs
- Small and light MAVs
- Autonomy and image processing
- Multi-UAV cooperation

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

In addition to this, a drone **Virtual Challenge** will be held to encourage teams using simulation tools in their airframe and algorithm conception, and to emphasize their work.

Safety and security requirements

For security and safety details see the latest version of the IMAV2017 safety regulations document which is published on the **www.imavs.org/2017** website.
All participants are required to be familiar with the contents of the document and comply with it.
Safety checks will be performed before each flight.
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 website: TODO
Failure to abide by the boundaries can lead to a penalty or disqualification.

Location

The outdoor flight competitions will take place at **Francazal airfield** (Google Maps).

Lat: 43.5419311°
Lon: 1.3686494°

The indoor flight competitions will take place at **????**.

XXXXX
Toulouse
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 land all the MAVs. *Failure to land all vehicles 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** = sum of the successful mission elements), the level of autonomy for each mission element (**A**), the size factor (**S**), the "in-a-row" factor (**I**), and a presentation made by the team during the mission (**P**).
Awards will be determined using the following formula:

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

In order to ease the jury's task, the teams flying multiple MAVs shall clearly identify (color, number) each vehicle.

A task yields points only once. If several aerial vehicles perform the same task, the scoring will be applied to only one vehicle so as to maximize the overall scoring.

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

Size factor (S)

The maximum size of the MAV is **1.5 meter,** which is determined by:

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

The maximum takeoff weight is **2 kg** for all type of MAVs.

Size factor = 1/(size of the MAV)

Level of autonomy (A)

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**
Video based control: control of the MAV is manual but out of line of sight (FPV)	1
Autonomous flight control: the navigation is completely autonomous but the operator is controlling the mission and the payload	5
Autonomous target detection: the navigation is manual but the detection and processing of the targets is automatic	5
Fully autonomous mission control: the navigation and the decision making are autonomous, without assistance of the operator	10
Using external aids such as visual markers	-2 applied to factor

The video based control (factor 1) can only count for a single mission element (per MAV). If several mission elements are performed with this level of autonomy, only the best score will be kept (and other elements not taken into account).

Technical demonstrations are going to be a separate flight session with or without autonomy. The main issue there is to illustrate a novel technique/strategy which does not fit with the tasks proposed. While they will not compete for the mission scores, **they are eligible for the special jury prizes**.

In-a-row factor (I)

The “in-a-row” factor encourages participant to complete as many mission elements as possible without stopping. The more mission elements completed in a single trial, the higher is the factor.

Number of mission elements completed in a single trial	**factor**
1	1.0
2	1.1
3	1.2
4 (Max)	1.5

Presentation factor (P)

The team is rewarded when a team member presents the tasks and actions currently performed. 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 presentation factor will be determined according to the 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)

Mission elements (M)

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 (see scoring tables further):

- a MAV can attempt to complete the mission element as many times as needed in the allotted time but only the best score will be used for the final scoring
- if several MAVs are doing the same mission element (including take-off and landing), only the best score is kept, except for the cooperative mission (in which case, all MAVs involved in the best attempt are considered in the final scoring)

Outdoor mission

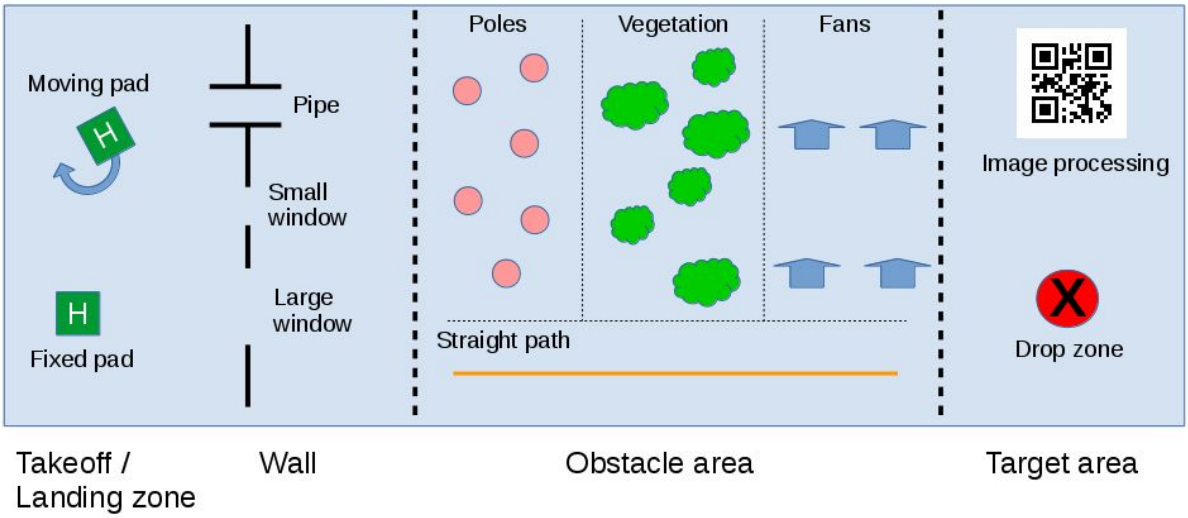
1. Automatic take-off
    a. a take-off is considered automatic as long as the safety pilot does not transmit any commands (except mission start signal)
    b. the MAV can be hand-launched.
    c. points are awarded for every MAV that performs at least one other mission element during its flight, except precision landing (taking off and landing is not enough to count as a valid mission flight)
2. 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 time to be valid
    d. flight altitude is only limited by the boundaries of the flight zone
3. Hangar scanning
    a. produce the map of a hangar (external and/or internal)
4. Target detection and recognition
    a. search and identify targets (hazardous materials or missing people) outside and inside a hangar (front doors are widely opened)
    b. targets can be located on the map produced by the team (see previous mission element) or a rough map provided by the organizers
5. Cooperative carrying
    a. at least 2 drones should carry a weight over a distance of 50 meters
    b. attaching the MAVs to the weight can be done by team members, no autonomous grasping are required
    c. TODO several weights possible ?
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**
Automatic take-off	1
Flight performance	number of laps / 8
Hangar scanning	2 for automatic processing (2D or 3D map) indoor and outdoor map are evaluated independently
Target detection	1 for clear view of the target 1 for automatic detection and classification of the target 1 for correct location on the map
Cooperative carrying	1 per MAV involved if the minimum distance is reached 1 for precision landing of the carried weight
Landing (precision/normal/field)	2, 1, 0 extra points: +1 by taking off after 10 seconds staying still without any operator assistance

Indoor mission

1. Take-off
    a. a take-off is performed from the starting zone from a fixed or a moving pad
    b. 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 one of windows or the pipe on a wall
3. Flying through the “obstacle” zone
    a. several obstacles must be crossed with different difficulties
        i. fixed poles (simple structured colored elements)
        ii. vegetation (unstructured elements)
        iii. fans (turbulent atmosphere)
    b. it is possible to use the straight line path without obstacle at any step
    c. each type of obstacle can be attempted separately or in a row (and in-a-raw factor will be applied except if straight line path is used)
4. Target detection and recognition
    a. a target is placed after the “obstacle” zone
    b. the task is to find the target and process the data on it (QRCode)
    c. the data found on this target is a reference of an object that should be dropped in the “drop” zone
5. Drop zone
    a. a “drop” zone is after the “obstacle” close to the target
    b. the object to drop depends on the data found on the target and can’t be carried a-priori on the MAV (as the possible choice is large, i.e. medicines)
    c. the two choices are
        i. go back to the beginning through the “obstacle” zone, pick the product, come back and drop
        ii. send the information to a second MAV that flies to the drop zone with the correct product
6. Cooperative carrying
    a. at least 2 drones should carry a weight over a distance of 10 meters
    b. attaching the MAVs to the weight can be done by team members, no autonomous grasping are required
    c. TODO several weights possible ?
7. Precision landing
    a. the MAV can perform a precision landing on either the fixed or moving 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	0 from fixed pad 1 from moving pad
Fly through the wall	pipe: 2 small window: 1 large window: 0.5
Fly through obstacle zone	straight path: 0.5 per MAV fixed poles: 1 per MAV vegetation: 1.5 per MAV fans: 1.5 per MAV
Target detection	1 for a clear view of the target 1 for reading the data
Drop zone	1 for dropping the correct object inside the drop zone +1 if the drop is done in one row after flying through one of the window and the obstacle area
Landing (precision)	0.5 on the fixed pad 1 on the moving pad extra points: +0.5 if taking off after 10 seconds staying still without any operator assistance

Special jury prizes and challenges

Jury prizes

The IMAV jury members, will 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

Virtual challenge

Design and implementation of complex systems usually require much preliminary work, including simulation. In order to encourage teams to follow this approach in as realistic as possible environment and to showcase this work, a virtual challenge is proposed alongside the traditional competition.
The key idea of this challenge is that a virtual environment modeling the indoor flight area will be provided to all the teams. Data from standard sensors (inertial measurement units, sonar, lidar, cameras) will allow you to develop and test algorithms and control for the real mission elements. During the IMAV event, teams willing to participate to the challenge will be able to connect their work to the same simulation tool hosted by the organizers. The evaluation of the teams will be done on:

- the number of tasks performed in the virtual world
- the time to perform the mission
- a short presentation of their work to the jury

The simulation framework will be based on Gazebo (to be confirmed) and can be addressed via several tools (ROS, MATLAB/Simulink, ...). It will be made available for the teams as soon as possible.

Treasure hunt challenge

In this challenge, the goal is to find buried objects. More precisely, metallic objects will be buried in a given area, and the UAVs will have to scan through the area so as to discover them.
The challenge will be evaluated according to the following criteria:

- duration of the hunt
- efficiency of the path planning
- location accuracy of the detected object
- percentage of false detection (detection of object where there is nothing) and no detection (no detection when flying above a buried object)

Drone team parade trophy

In this challenge, the goal is to have a patrol of UAVs (fixed-wing, rotorcraft or mixed) flying in a formation so as to demonstrate their coordination and flight accuracy skills.
This challenge will be evaluated according to the following criteria :

- accuracy of the formation shape and number of UAVs involved
- accuracy of the path followed by the UAVs
- aesthetic qualities of the formation
- elapsed time necessary to reach the formation configuration

Record breaking session

This challenge consists in lifting up a given payload 50 cm above the ground during 1 minute. The evaluation of this challenge will be simply to determine the smallest among the UAVs able to lift this payload.

Technological demonstration

The goal of this demonstration is to highlight novel disruptive MAVs architectures / technologies.

Static exhibition

A static exhibition will be planned in order to show both prototypes and commercial MAVs to the participants.

Size and shapes

All dimensions presented here are preliminary and might be updated.

Indoor flight area

TBD

Windows for indoor mission

TBD

Indoor poles

Dimensions for the indoor poles (obstacle zone):

- height: ... m
- diameter: ... cm

Indoor takeoff and landing zones

The takeoff and landing zone are 1 meter diameter circular platforms.

Indoor target

TBD

Indoor path

TBD

Indoor drop zones

TBD

Outdoor poles (performance)

Distance between the two poles: 300 m

Drop object

TDB

QRCode

QRCode are two-dimensional bar codes that can be decoded using various software libraries (for example ZBAR).

Scoring examples

TBD