

IMAV | 2012

International Micro Air Vehicle Conference and Flight Competition

Program Information for Flight Competition

Braunschweig, Germany 03rd to 06th July 2012





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IMAV 2012 Flight Competition Mission Description and Rules

1. General Information

From 03rd to 06th July 2012 the International Micro Air Vehicle Conference IMAV 2012 will be held in Braunschweig, Germany. In addition to the scientific conference program, the IMAV 2012 also comprises a competition for Micro Aerial Vehicles (MAV). This competition is divided into two parts: An indoor competition in Braunschweig and an outdoor competition at the glider port in Gifhorn-Wilsche, approx. 30 km north of Braunschweig. Both, the indoor and the outdoor event, consist of two different competitions. The first one is focused on flight dynamics and manoeuvrability, while the second one emphasises the autonomous flight more.

2. Frequencies

Every team has to ensure, that the used frequencies agree with the European/German regulations. A list of all frequencies is given on the following homepage: <http://www.fai.org/ciam-our-sport/frequencies>

In case of further enquiries please contact Mr. Thomas Krüger
(th.krueger@tu-braunschweig.de, +49 531 391 9971)

Allowed frequencies:

RC: 35 MHz, 40 MHz (Channel 50, 51, 52 & 53), 2.4 GHz
Data link: 433 MHz, 868 MHz, 2.4 GHz (900 MHz is not allowed!)
Video link: 2.4 GHz, 5.8 GHz

Please take note, that in the area of the competitions WLAN-networks are working on the 2.4 GHz frequency band. It is not possible to deactivate them.

3. Sizes and weight limitations

Indoor event:

	Max. lateral dimension $D_{\max}$	Max. weight
Rotary wing MAV	70 cm	5 kg
Flapping wing MAV	70 cm	5 kg
Fixed wing MAV	80 cm	2 kg
Lighter than air MAV	100 cm	-

Table 3.1: Maximum dimensions and weights for the indoor event

Outdoor event:

	Max. lateral dimension $D_{\max}$	Max. weight
All types of MAV	150 cm	5 kg

Table 3.2: Maximum dimensions and weights for the outdoor event



4. Scores (indoor and outdoor)

a. Calculation of total score

For all competitions the scores are the product of all factors regarding:

- Size factor **(S)**
- Level of autonomy **(A)**
- Design factor **(D)**
- Mission scores **(M)**

The total score T is the calculated according to:

$$T = S \cdot A \cdot D \cdot M \quad (1)$$

For all autonomy competitions each mission task can be valued with different level of autonomy, design factor and size factor (if a different aircraft is used). For example if task 1 is done with video based controls and task 2 is done automated both tasks are valued with different factors A and are added together afterwards.

b. Size factor (S)

The size factor is calculated with respect to the maximum dimension D_b between two points on the vehicle, e.g. the span width, length or rotor diameter. It is determined by:

$$S = \left(2 - \frac{D_b}{100 \text{ cm}} \right)^2 \quad (2)$$

The theoretical maximum of the size factor S is 4 (for $D_b = 0$).

c. Level of autonomy (A)

Three levels of autonomy are categorized:

	Description	A
Level 1	Video based (RC Control, no direct visual contact)	1
Level 2	Automated flight control (flight controlled automatically, operator controls the mission, e.g. control of payload, decision making)	6
Level 3	Automated mission control (no intervention by pilot/operator after take-off)	12
	Using external aids (visual markers, radio beacons, etc.)	-2

Table 4.1: Autonomy score

For the indoor and outdoor dynamics competition the autonomy level 3 will not apply.

d. Design factor (D)

The design factor is introduced to reward teams with self-made design of their aircraft system.

Description	D
commercial aircraft design	1
self-made aircraft design	4

Table 4.2: Design score



e. Mission scores (M)

During the competitions the MAVs achieve scoring points for the various mission tasks. These scores that will be explained in the mission descriptions are finally added and multiplied according to formula (1) to yield the final result. For each mission a scoring example is available.

f. Time

There is a dedicated time frame per team and mission (not including preparation time). The allowed flying time is stated in the related indoor or outdoor competition paragraphs. The preparation time is 5 minutes for all competitions (indoor and out-door).

5. Indoor competition

a. Indoor dynamics competition

The indoor flight dynamics competition is open for all categories of MAV and there will be a separate valuation for each category.

The MAV takes off close to two posts and flies around these two posts in a vertical 8-shape trajectory (fig. 5.1) as often as possible for a duration of 3 minutes time. The distance between the two posts amounts to 8 m. The height of the posts is 2 m. The horizontal trajectory is a 3 m wide path. The classification will be done by a barrier tube on each side of the path.

Each fully completed figure eight in between the barrier results in 2 points for the mission score M. An extra 2 score points will be rewarded once for showing dynamic manoeuvres such as a looping or a 360° roll. These points will only be given if at least one complete figure has been flown.

Flying time and number of flights

The allowed flying time is 3 minutes. Each team will be given the chance to fly twice. The better score will be counted. The second flight time will be in the same sequence as in the first round.

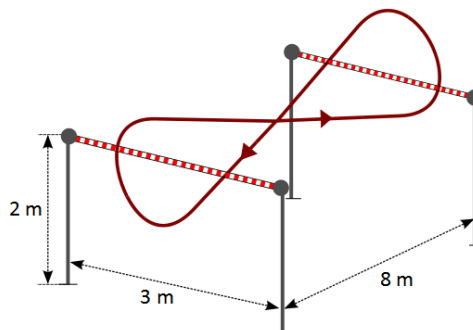


Figure 5.1: Indoor dynamics competition

b. Indoor autonomy competition

Like the indoor flight dynamics competition the indoor autonomy competition (fig. 5.3) is open to all categories of MAV and the valuation is separate for each category. The main goal of this competition is to demonstrate the MAV's capabilities of fulfilling a sophisticated mission including operation inside a small building with a covered ceiling. A video transmission from the MAV to a ground station is required for this mission.



The mission starts at point 1 behind a wall with a height of 2.5 m preventing the operator from seeing the MAV on the mission. Having overcome the wall, the MAV approaches the door (point 2). After entering the building, the MAV has to identify two targets (printed letters/numbers, font size 700, Arial, point 3), one of them is placed on one of the building's inner walls (vertical target), the other on is placed on the floor (horizontal target).

The MAV leaves the building vertically through a tilted chimney (point 4) and hovers for at least 10 seconds above the building before it lands on the top of the roof (point 5). After another 10 seconds the MAV flies to point 6 and picks up an object weighting about 20 g, which is shown in fig 5.2. With this object the MAV has to fly through the gate (point 7) and should release the object in the defined release zone (point 8).

The mission ends at the moving landing zone at point 9. The platform moves slowly in a circular shape. An alternative, stationary landing platform will be provided. Both platforms are marked with a black cross (0.2 m).

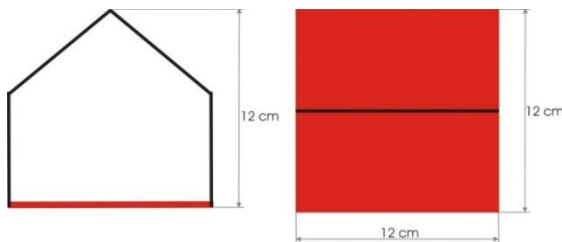


Figure 5.2: Pick-up object

Depending on the MAV's capabilities, the mission can be simplified at two critical points. Instead of starting the mission behind the wall, the operator may stand in front of the wall and start from point 1*. Furthermore, the building can be left through a window instead of the way through the tilted chimney (point 4*).

Dimensions

	dimensions
building:	4m x 3m x 3m (L x W x H), covered ceiling
wall:	2.5 (H)
gate:	2m (H)
door:	2m x 1.5m (H x W)
windows:	1.5m x 1.5m (H x W)
chimney:	1m (diameter), tilted 15° in direction to the door
landing platform:	1m (diameter)

Table 5.1: Dimensions of objects for indoor mission

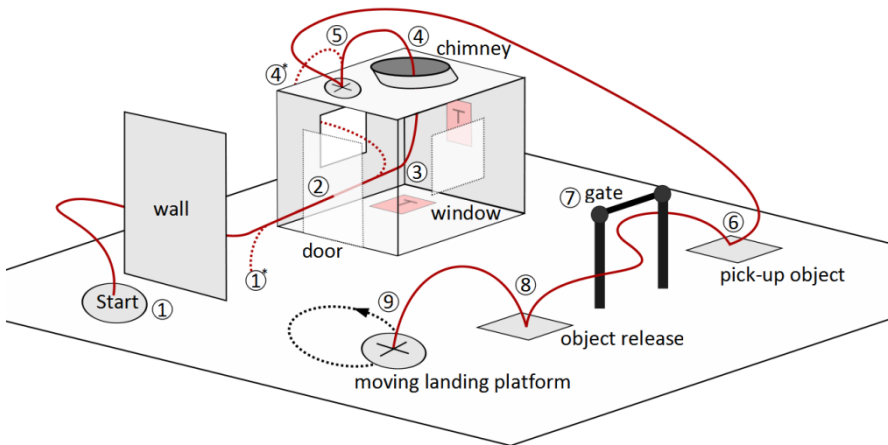


Figure 5.3: Indoor mission

Flying time

The maximum flying time is 10 minutes.

Scoring

The scores for the indoor mission competition are defined accordingly:

	Mission score points
take-off behind the wall	1
entering the building	1
identifying horizontal target	2
identifying vertical target	2
exit through the chimney	3
hovering above building (10 sec.)	1
landing on top of the building	1
pick up the object	3
passing gate	1
release object in the release zone	2
landing on (moving) platform	1, 3
Maximum score	20

Table 5.2: Mission score points (indoor)



Scoring example:

A video based rotary wing MAV with a diameter of 65 cm and self-made design takes off behind the wall, enters the building through the door, identifies only the vertical target, exits through the window instead of the chimney, hovers above the building for 10 seconds, lands on top of the building and misses the two posts.

- Size factor: **S** = 1.82
- Level of autonomy: **A** = 1
- Design factor **D** = 4
- Mission scores:
 - 1 (take-off behind the wall)
 - 1 (entering)
 - 2 (vertical target)
 - 0 (horizontal target)
 - 0 (exit through the window)
 - 1 (hovering)
 - 1 (landing)
 - 0 (pick up object)
 - 1 (passing gate)
 - 0 (release object)
 - 3 (landing on moving platform)
- Total mission score: **M** = 10 (out of 20)

→ **Final score:** $T = S \cdot A \cdot D \cdot M = 72.8$



6. Outdoor competition

a. Outdoor dynamics competition

The main idea of the outdoor flight dynamics competition is to demonstrate the progress of MAV design relating to high dynamics with precise navigation at the same time. This competition is again open for all categories of MAV with a separate valuation.

The course comprises two arches (shown in fig. 6.2) in an L-type placement with spacing of 50 m. From the starting point the MAV passes through the arches A and B, performs a 180° turn, flies back through the arches (B, A) turns and starts the course again until a flight duration of 4 minutes has been reached. Each fully completed sequence (AB or BA) results in 4 points for the mission score M. If only one arch has been passed during the sequence 1 point will be rewarded.

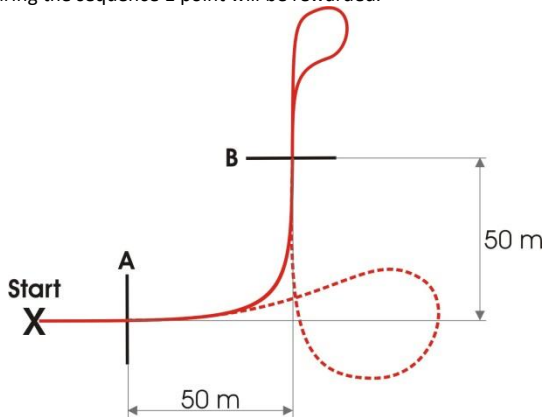


Figure 6.1: Outdoor dynamics competition

The dotted line in fig. 6.1 shows an alternative flight path, in case the MAV requires a larger turn radius. An extra 2 score points will be rewarded once for showing dynamic manoeuvres such as a looping or a 360° roll. These points will only be given if at least one complete figure has been flown.

Flying time and number of flights

The allowed flying time is 4 minutes.

Each team will be given the chance to fly twice. The better score will be counted. The second flight will be in the same sequence as in the first round.

Figure 6.2 depicts a sketch of an arch. The arches are set-up by two 6 m high posts with a spacing of 6 m. Coloured plates are used on the outsides of the arches to improve the visibility, while the upper limit is marked by a red and white barrier tape.

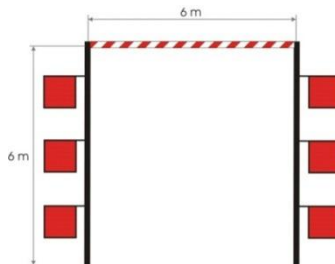


Figure 6.2: Outdoor arch (dynamic competition)

Scoring example:

A video based fixed wing MAV with a span width of 38 cm and commercial design completes 4 full sequences in the given time and shows a looping afterwards.

- Size factor: $S = 2.62$
 - Level of autonomy: $A = 1$
 - Design factor $D = 1$
 - Mission scores: $M = 18$ (for 4 full sequences + looping)
- Final score: $T = S \cdot A \cdot D \cdot M = 47.16$

b. Outdoor autonomy competition

In the following competition it is allowed to use more than one aircraft in the same flying time for different mission tasks. If only one aircraft is used for all tasks 1 extra point will be rewarded.

During the outdoor autonomy competition, which is open to all categories of MAV (separate valuation), the MAV has to identify a horizontal and vertical target, which are placed outside of the operator's range of sight, fly through one arch, drop a ball at a certain point and land in a predefined area.

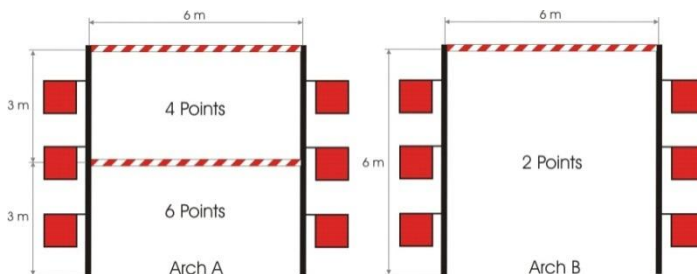


Figure 6.3: Outdoor arch (autonomy competition)

The MAV takes off from the airfield, passes the airfield buildings and heads toward the first target area. In this area two optical targets have to be identified. Once these targets have been identified, the MAV proceeds with flying through Arch A or Arch B. Figure 6.3 shows the two arches and the mission points for the different gaps. Only one passing counts. The positions of the arches are defined by WGS84 coordinates. Subsequently the MAV flies to the drop zone, where it drops a ball, which is shown in fig. 6.5. Finally the MAV lands in a pre-defined area on the airfield.



Vertical and horizontal target

The targets consist of a printed numbers or letters which are placed in the target area (black on white background, approx. 0.8m, Arial). A clear image of each target results in 2 points for the mission score M. For all teams the detected horizontal target will be important for the position of the ball drop. For teams with automated flight controls the number will stand for a missing coordinate. For teams with video based controls the letter will stand for the position where to drop the ball. This position will be visible from the air.

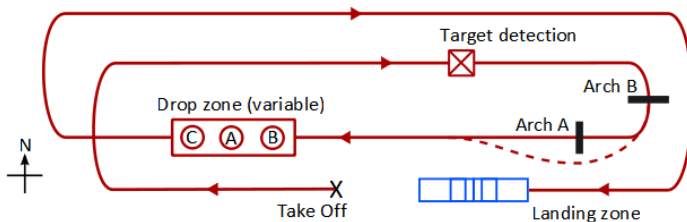


Figure 6.4: Outdoor mission

Drop zone

The drop zone is defined by WGS84 coordinates or letters on the ground. The coordinates are known except for one missing number. This number has to be detected and afterwards the mission has to be adjusted so the ball can be dropped at the right coordinates. There will be more than one drop zone. Example of the given coordinates (the final set of coordinates will be given during the competition):

N 52.52421
E 10.46X00

In case of video based controls the letter of the drop zone is the reference for the drop position. If the letter or number could not be detected in the task before an alternative reference will be given.

If the ball is dropped in the inner circle (2 m diameter), 3 points are achieved for the mission score M. A drop in the middle circle (5 m diameter) results in 2 points, inside the outer circle (15 m diameter) 1 point will be rewarded. In order to offer a better view of this part of the mission to the spectators, the ball is to be set-up by a spherical body with a diameter of 15 to 20 mm and an additional coloured flag on its tail, which should be at least 2 cm wide and 20 cm long.

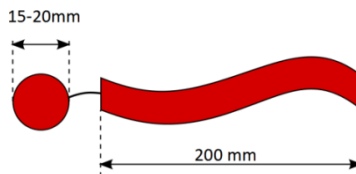


Figure 6.5: Sketch of ball for the dropping task

Precision landing

The landing zone comprises five fields with 1, 2 or 3 points and is shown with scales in fig.6.6. The corners are defined by WGS84 coordinates. The approach to this zone is made from the West or the East (see



figure 6.4). Landing outside this zone results in 0 points. The landing zones will be marked by clearly visible cones. The aircraft that is used for landing also has to be used for at least one other task.

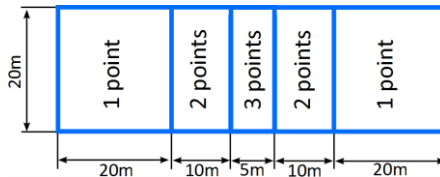


Figure 6.6: Landing field

Flying time and number of flights

The allowed flying time is 10 minutes.

Scoring

The scores for the outdoor mission competition are defined according to the following table:

	Mission score points
automatic take-off	2
identifying horizontal target	2
identifying vertical target	2
passing arch	2, 4 or 6
dropping ball	1, 2 or 3
landing in predefined zones	1, 2 or 3
Maximum score	18

Table 6.1: Mission score points (outdoor)

Scoring example:

A video based fixed wing MAV with a span width of 76 cm and self-made design, identifies both targets, passes arch A in the upper gap, drops the ball into the outer circle and lands exactly in the middle field.

- Size factor: $S = 1.54$
- Level of autonomy: $A = 1$
- Design factor: $D = 4$
- Mission scores:
 - 0 (take-off)
 - 4 (targets)
 - 4 (passing arch A)
 - 1 (ball in outer circle)
 - 3 (landing zone)
- Total mission score: $M = 12$ (out of 18)

→ Final score: $T = S \cdot A \cdot D \cdot M = 73.92$