

IMAV 2010 Flight Competition

Mission Description and Rules

1. General Information

From 6th to 8th July 2010 the International Micro Air Vehicle Conference IMAV 2010 will be held in Braunschweig, Germany. In addition to the scientific conference program, the IMAV 2010 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 more the autonomous flight.

2. Frequencies

The 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/aeromodelling/frequencies>

In case of further enquiries please contact Mr. Andreas Scholtz (a.scholtz@tu-bs.de, +49 531 391 9981)

Recommended 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

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

Indoor event:

The limitations of the MAV size and weight amount to:

	Max. lateral dimension $D_{\max}$	Max. weight
Rotary wing MAV	70 cm	1 kg
Flapping wing MAV	70 cm	1 kg
Fixed wing MAV	80 cm	1 kg

Table 1: Maximum dimensions and weights for the indoor event

Outdoor event:

The limitation of the MAV size and weight amount to:

	Max. lateral dimension $D_{\max}$	Max. weight
All types of MAV	100 cm	5 kg

Table 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 three factors regarding:

- MAV size (Factor S)
- Level of autonomy (Factor A)
- Mission scores (Factor M)

The total score T is the calculated according to:

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

b. Size factor (S)

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

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

The theoretical maximum of factor S is 4 (for $D = 0$!).

c. Level of autonomy (A)

Three levels of autonomy are categorized:

- Level 1: Manual Control (RC Control, visual contact)
- Level 2: Video based control (RC Control, no direct visual contact)
- Level 3: Automated control (no intervention by pilot/operator after take-off)

The factor A for the calculation of the total score is depicted in table 3.

	Factor A
Level 1	1
Level 2	2
Level 3	6

Table 3: Autonomy score

As a deviation from this table there will be an interim value of the autonomy factor A for the indoor mission, which is described in the related paragraph.

d. 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 which compares MAVs with different levels of autonomy (A).

e. 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 for all competitions (indoor and outdoor) 5 minutes.

5. Indoor Competition

a. Indoor Flight Dynamics Competition

The indoor flight dynamics competition is open for all categories of MAV (fixed wing, rotary wing, flapping wing), 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 an 8-shape trajectory as often as possible for a duration of 3 minutes time. The distance between the two posts amounts to 10 m. The height of the posts is 4 m with classification in two areas. The lower area has a height of 1.5 m. The second flight area starts in 1.5 m and ends in 4 m height.. The classification will be done by barrier tape.

Each fully completed figure eight under the barrier results in 2 points for the mission score M. In the upper area each fully completed eight results in 1 point.

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.

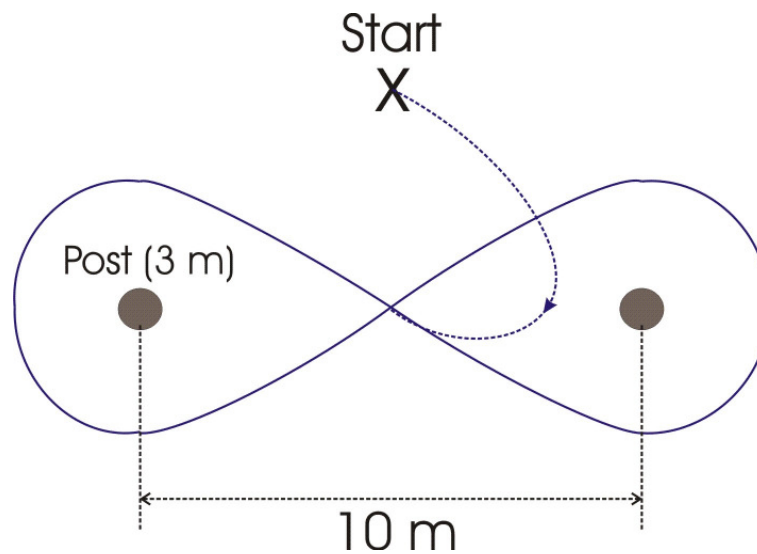


Figure 1: Indoor Flight Dynamics Competition

Scoring example:

A flapping MAV controlled by video link with a span width of 67 cm manages seven full sequences under the barrier in the given time:

- Size factor: **S** = 1.77
- Level of autonomy: **A** = 2
- Mission scores: **M** = 14 (for 7 full sequences)

-> **Final score:** **T** = **S * A * M** = 49.6

b. Indoor Autonomy Competition

Like the indoor flight dynamics competition the indoor autonomy competition is open for 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 no. 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 no. 2). After entering the building, the MAV has to identify two targets (printed

letters/numbers, point no. 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 chimney (point no. 4) and hovers for at least 10 seconds above the building before it lands on the top of the roof (point no. 5). After another 10 seconds the MAV flies to point no. 6 and picks up an object weighting about 20 g, which is shown in fig 2. With this object the MAV has to fly through the two posts (point no. 7) and should release the object in the defined release zone (point no. 8). The mission ends with the landing at point no. 1.

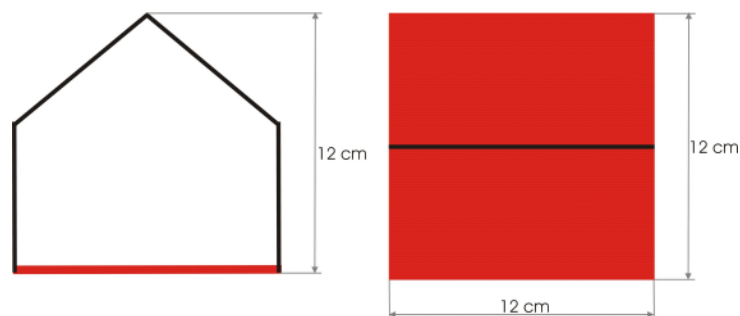


Figure 2: Pick-up object

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*. For MAVs controlled via video-link the level of autonomy factor (A) amounts to 4 when taking off behind the wall (point no. 1) and to 2 when taking of in front of the wall (point no. 1*). Furthermore, the building can be left through a window instead of the way through the chimney (point 5*).

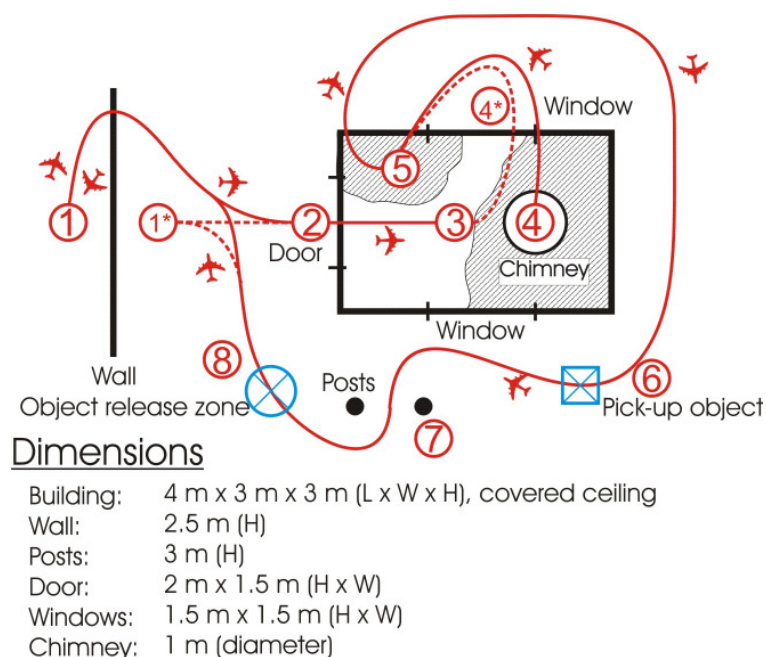


Figure 3: Indoor Mission

Flying time

The maximum flying time is 10 minutes.

Scoring

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

	Mission score points
take-off behind the wall	1
entering the building	1
identifying horizontal target	1
identifying vertical target	1
exit through the chimney	2
hovering above building (10 sec.)	1
landing on top of the building	1
pick up the object	1
passing posts	1
release object in the release zone	1
landing behind the wall	1
Maximum score	12

Table 4: Mission score points (indoor)

Scoring example:

A fully automated rotary wing MAV with a diameter of 65 cm 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 = 6**
- Mission scores:
 - 1 (take-off behind the wall)
 - 1 (entering)
 - 1 (vertical target)
 - 0 (horizontal target)
 - 0 (exit through the window)
 - 1 (hovering)
 - 1 (landing)
 - 0 (pick up object)
 - 1 (passing posts)
 - 0 (release object)
 - 1 (landing behind the wall)
 - **Total mission score M = 7 (out of 12)**

-> Final score: $T = S * A * M = 76.4$

6. Outdoor Competition

In both following competitions it is allowed to use more than one aircraft in the same flying time, but just the aircraft with the most points counts.

a. Outdoor Flight 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 in an L-type placement with a 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 1 point for the mission score M.

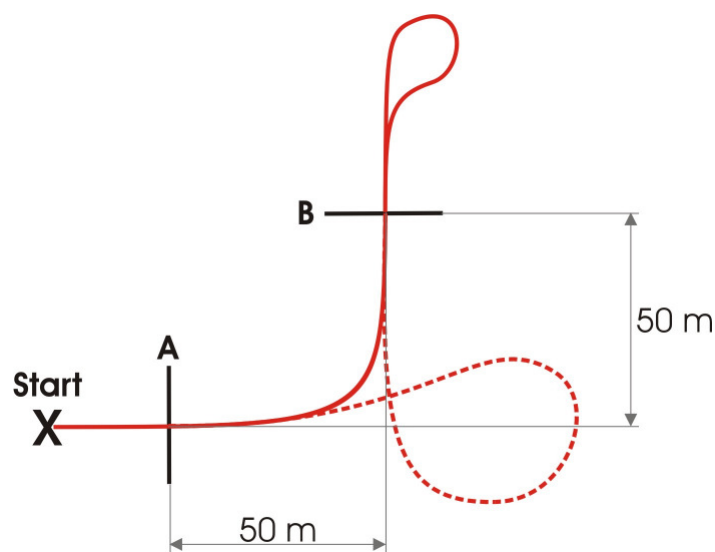


Figure 4: Outdoor Flight Dynamics Competition

The dotted line in fig. 4 shows an alternative flight path, in case the MAV requires a larger turn radius.

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 time will be in the same sequence as in the first round.

Figure 5 depicts a sketch of the arches: 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. For the outdoor flight dynamics competition both arches are represented by type B in fig. 5.

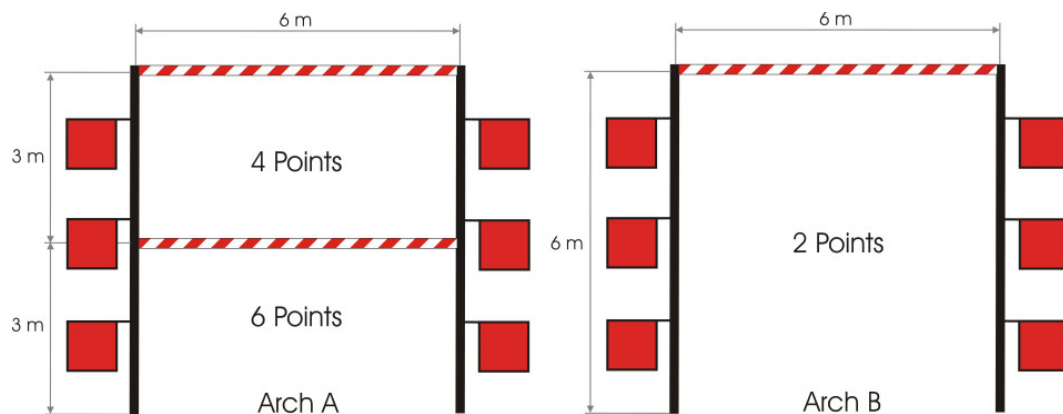


Figure 5: Outdoor Arch

Scoring example:

A manually controlled fixed wing MAV with a span width of 38 cm completes 4 full sequences in the given time.

- Size factor: **S** = 2.62
- Level of autonomy: **A** = 1
- Mission scores: **M** = 4 (for 4 full sequences)

-> **Final score:** $T = D * A * M = 10.5$

b. Outdoor Autonomy Competition

During the outdoor autonomy competition, which is open for 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.

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 5 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. 7. Finally the MAV lands in a predefined area on the airfield.

Vertical and horizontal target

The targets consist of a printed letter or number on top or on the side of trucks, which are placed in the target area in front of the forest. A clear image of each target results in 1 point for the mission score M.

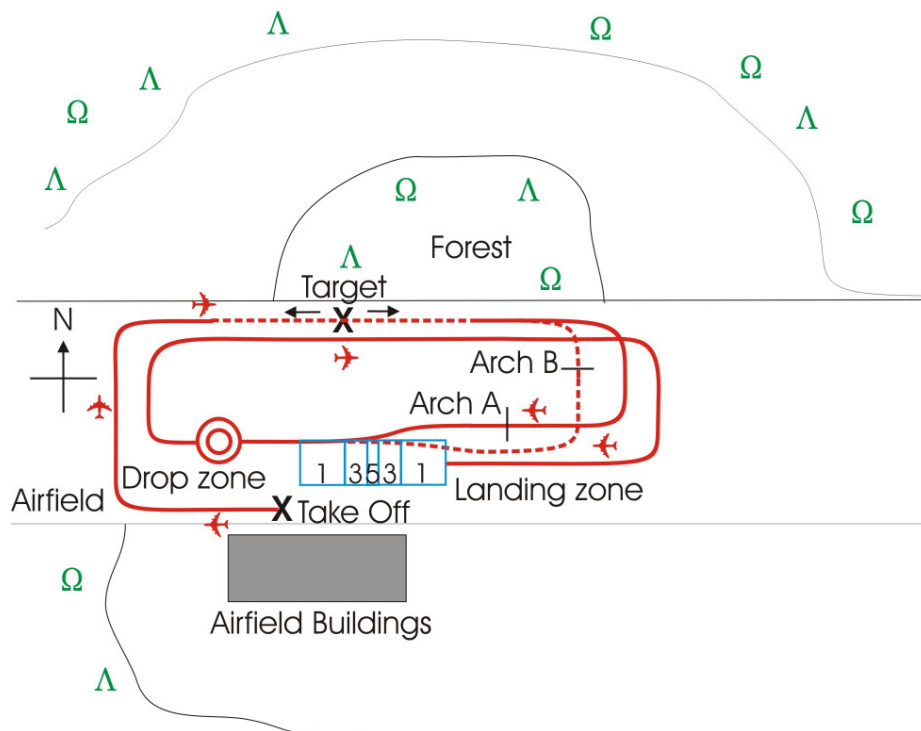


Figure 6: Outdoor mission

Drop zone

The drop zone is set up by two circles around a position defined by WGS84 coordinates. If the ball is dropped in the inner circle (5 m diameter), two points are achieved for the mission score M. A dropping inside the outer circle (15 m diameter) results in 1 point.

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.

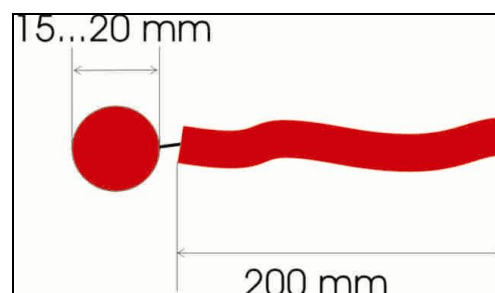


Figure 7: Sketch of ball for the dropping task

Precision landing

The landing zone comprises five fields with 1, 3 or 5 points and is shown with scales in fig. 8. The corners are defined by WGS84 coordinates. The approach to this zone is made from the West or the East (see figure 6). Landing outside this zone results in 0 point. The landing zones will be marked by clearly visible cones.

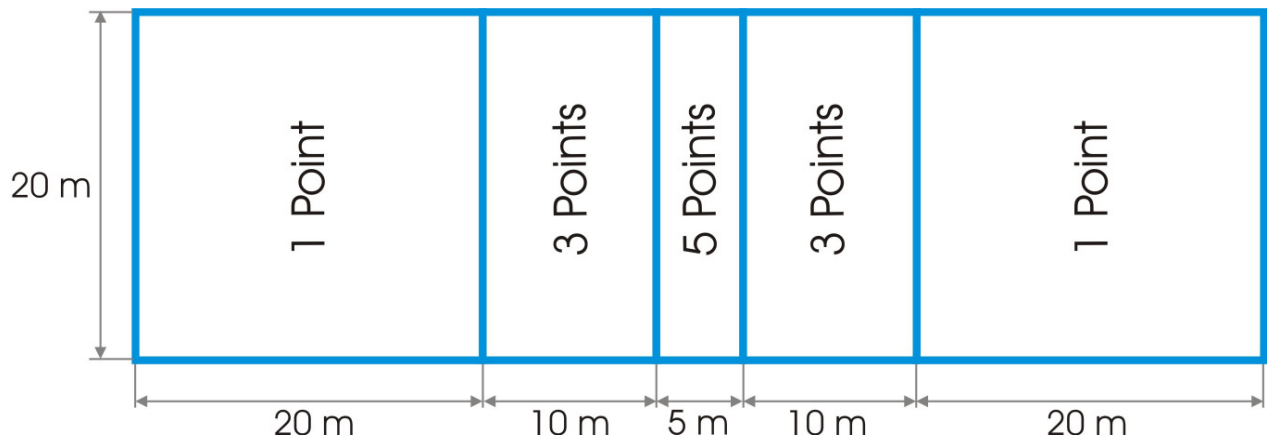


Figure 8: Landing field

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	1
identifying vertical target	1
passing arch	2, 4 or 6
dropping ball	1 or 2
landing in predefined zones	1, 3 or 5
Maximum score	17

Table 5: Mission score points (outdoor)

Scoring example:

A fully automated fixed wing MAV with a span width of 76 cm takes off automatically, identifies both targets, passes arch A in the upper gap, drops the ball into the outer circle and lands in the field no. 3.

- Size factor: **S** = 1.54
- Level of autonomy: **A** = 6
- Mission scores:
 - 2 (take-off)
 - 2 (target)
 - 4 (passing arch A)
 - 1 (ball in outer circle)
 - 3 (landing zone)
 - **Total score M = 12 (out of 17)**

-> **Final score: T = D * A * M = 110.9**

IMAV 2010 Flight Competition

MAV and team information

(If you plan to employ more than one MAV, please return one sheet per MAV)

MAV name/team name		
Institution/Company		
Team leader		
Type of aircraft (fixed/rotary/flapping wing)		
MAV size (mm)		
MAV weight (gr.)		
Level of autonomy (remote/video-based/automatic control)		
Short description of the MAV's special features (e.g. structure, control and propulsion system) If possible, please send a picture of the MAV via mail!		
Mission (please mark with an "x")	Indoor Flight Dynamics	
	Indoor Autonomy	
	Outdoor Flight Dynamics	
	Outdoo Autonomy	
RC frequency* (If possible, also specify the channel)		
Video link frequency*		
Data link frequency*		
(Safety) Pilot's name and personal address** (required for insurance purposes)		

*The team has to ensure, that the used frequencies agree with the European/German regulations.
In case of further enquiries please contact Mr. Andreas Scholtz (a.scholtz@tu-bs.de, +49 531 391 9981)

Recommended 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

**There will be a free general insurance for all (safety) pilots.