EMAV 2008 Flight Competition
Mission Description and Rules

1. General Information

From 8th to 10th July 2008 the European Micro Aerial Vehicle Conference EMAV 2008 will be held in Braunschweig, Germany. In addition to the scientific conference program, the EMAV 2008 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. One of them focuses on flight dynamics and manoeuvrability and the second one emphasises autonomous flight.

2. Sizes and weight

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

3. 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:

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

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:

$$S = \left(2 - \frac{D}{100\,cm} \right)^3 \quad . \tag{2}$$

The theoretical maximum of factor S is 8 (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 2.

	Factor A
Level 1	1
Level 2	2
Level 3	6

Table 2: 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 form the final result. For each mission there is a scoring example comparing MAVs with the 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.

4. 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 height of the posts is 3 m and the distance between the posts amounts to 10 m.

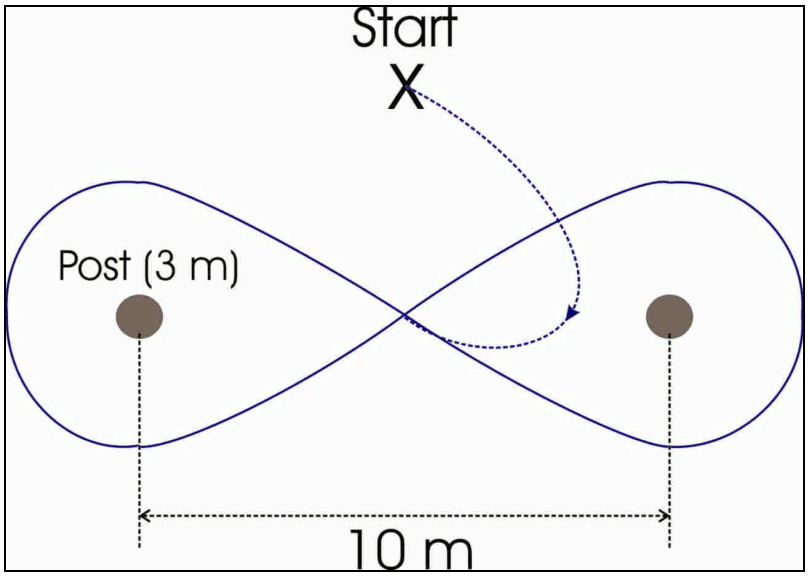

Figure 1: Indoor Flight Dynamics Competition

Each fully completed figure eight results in 1 point for the mission score M.

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.

Scoring example:

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

- Size factor: **S** = 2.35
- Level of autonomy: **A** = 2
- Mission scores: **M =** 7 (for 7 full sequences)

-> Final score: T = S * A * M = 32.9

b. Indoor Autonomy Competition

Like the indoor flight dynamics competition the indoor autonomy competition is open for all categories of MAV, but there will be no separate valuation.
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 2.5 m high wall 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 top of the roof (point no. 5). After another 10 seconds the MAV takes off and completes the mission by passing through the two posts (point no. 6) and landing at point no. 1. A fan will be placed directly at the approach of the two posts (point no. 6) simulating a cross wind of 5 m/s.

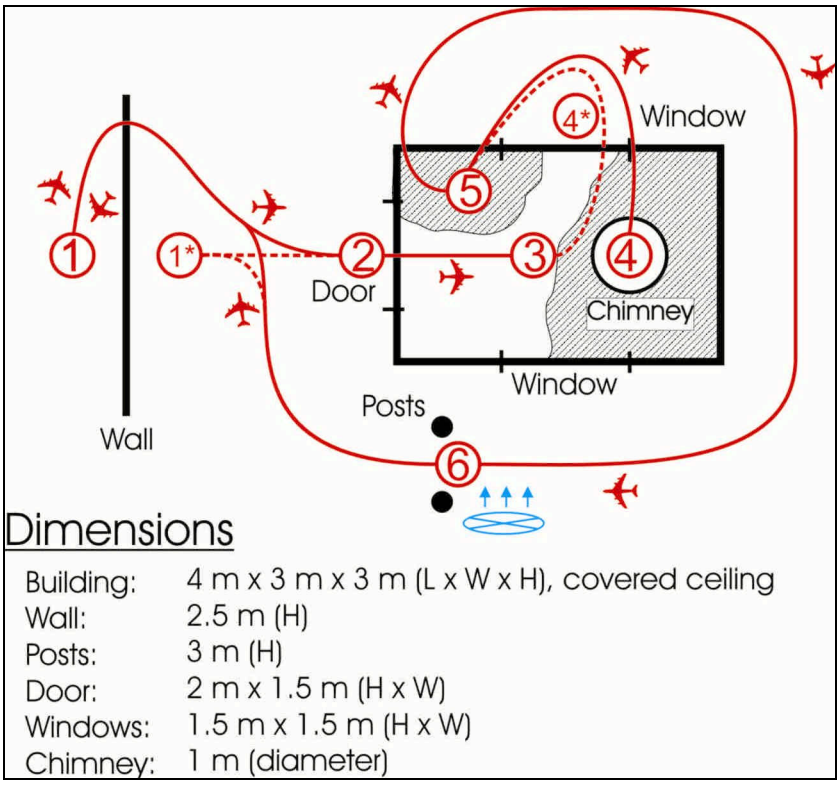

Figure 2: Indoor Mission

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*).

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
passing posts with cross wind	2
Maximum score	**10**

Table 3: 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** = 2.46
- 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 (crosswind)
  - **Total mission score** **M = 5 (out of 10)**

-> Final score: **T = S * A * M = 73.8**

5. Outdoor Competition

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 three arches in an L-type placement with a spacing of 50 m. From the starting point the MAV passes through the arches (A, B, C), performs a 180° turn, flies back through the arches (C, B, A), turns and starts the course again until a flight duration of 4 minutes has been reached. Each fully completed sequence (ABC or CBA) results in 1 point for the mission score M.

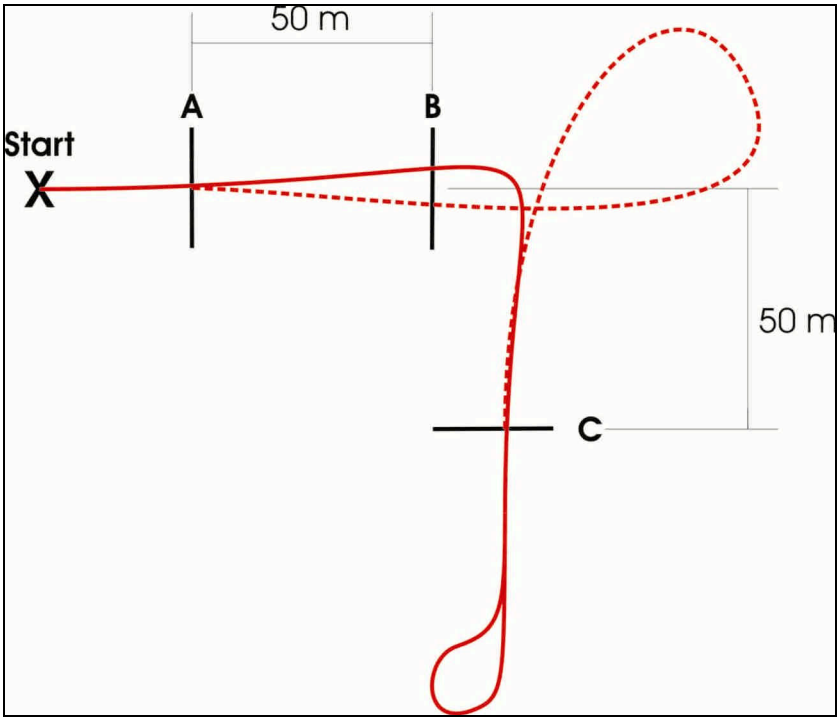

Figure 3: Outdoor Flight Dynamics Competition

The dotted line in fig. 3 shows an alternative flight path, in case the MAV requires 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 4 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 coloured balloons.

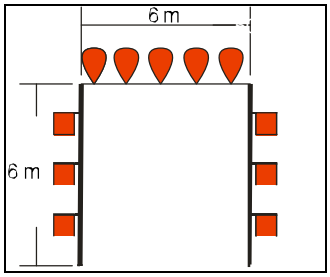

Figure 4: Outdoor Arch

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** = 4.25
- Level of autonomy: **A** = 1
- Mission scores: **M** = 4 (for 4 full sequences)

-> Final score: T = D * A * M = 17.0

b. Outdoor Autonomy Competition

During the outdoor autonomy competition, which is open for all categories of MAV (joint valuation), the MAV is to identify a horizontal target, which is placed outside of the operator's range of sight, drop a ball at a certain point and land in a predefined area.

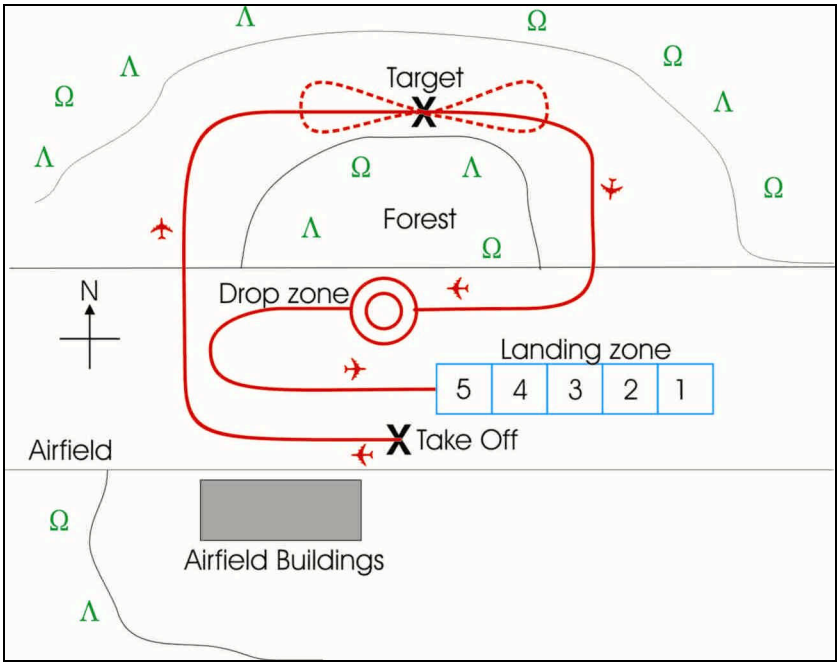

Figure 5: Outdoor mission

The MAV takes off from the airfield, passes the airfield buildings and heads toward the first target area. In this area an optical target is to be identified. Once this target has been identified, the MAV proceeds to the second target, where it drops a ball. Finally the MAV lands in a pre-defined area on the airfield.

Vertical target

The vertical target consists of a printed letter or number on top of a truck, which is placed at a position defined by WGS84 coordinates. A clear image of the target results in 1 point for the mission score M.

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 (10 m diameter), two points are achieved for the mission score M. A dropping inside the outer circle (20m 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.

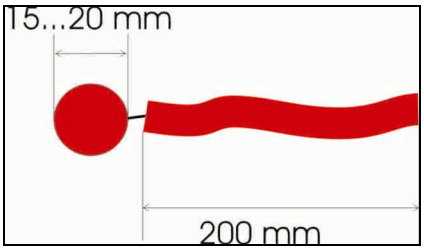

Figure 6: Sketch of ball for the dropping task

Precision landing

The landing zone comprises five quadratic fields measuring 20 m x 20 m each, whose corners are defined by WGS84 coordinates. The approach to this zone is made from the West (see figure 5). The scores that are achieved by a precision landing equal the number of the landing zone field (from 5 to 1 points). Landing outside this zone, e.g. touch-down prior to zone no. 5, results in 0 points.

The landing zones will be marked by clearly visible cones.

Scoring example:

A fully automated fixed wing MAV with a span width of 76 cm identifies the target, drops the ball into the outer circle and lands in the field no. 3.

- Size factor: **S** = 1.91
- Level of autonomy: **A** = 6
- Mission scores:
    - 1 (target)
    - 1 (ball in outer circle)
    - 3 (landing zone no. 3)
    - **Total score M = 5 (out of 8)**

-> Final score: T = D * A * M = 57.2