

IMAV 2014 Micro Air Vehicle Competition

Competition Rules

Changelog:

Version	Changes
1.0	First published version
1.1	Updated Section 5. <i>Dimensions</i> , added dimensions for doors, windows, etc.
1.2	Reduced dimensions of the Observation panel, see Section 5. <i>Dimensions</i>
1.3	Added dimensions of garage door; Added observation panel color info

1. Introduction

This document describes the mission elements that make up the IMAV 2014 competition. This year's IMAV will be unique in that it presents for the first time a competition that integrates both outdoor and indoor mission elements into a single, coherent challenge. The presented mission elements will include tasks such as surveillance, recognition, endurance, and multi-uav operation. This document will describe in detail the competition area, mission elements and scoring rules.

2. Safety and security requirements

For security and safety details see the latest version of the *IMAV2014 safety regulations* document which is published on the website. This document will contain general flight safety rules and regulations, as well as flight safety zones and failsafe requirements. All participants are required to be familiar with the contents of the latest version of this document and comply with it.

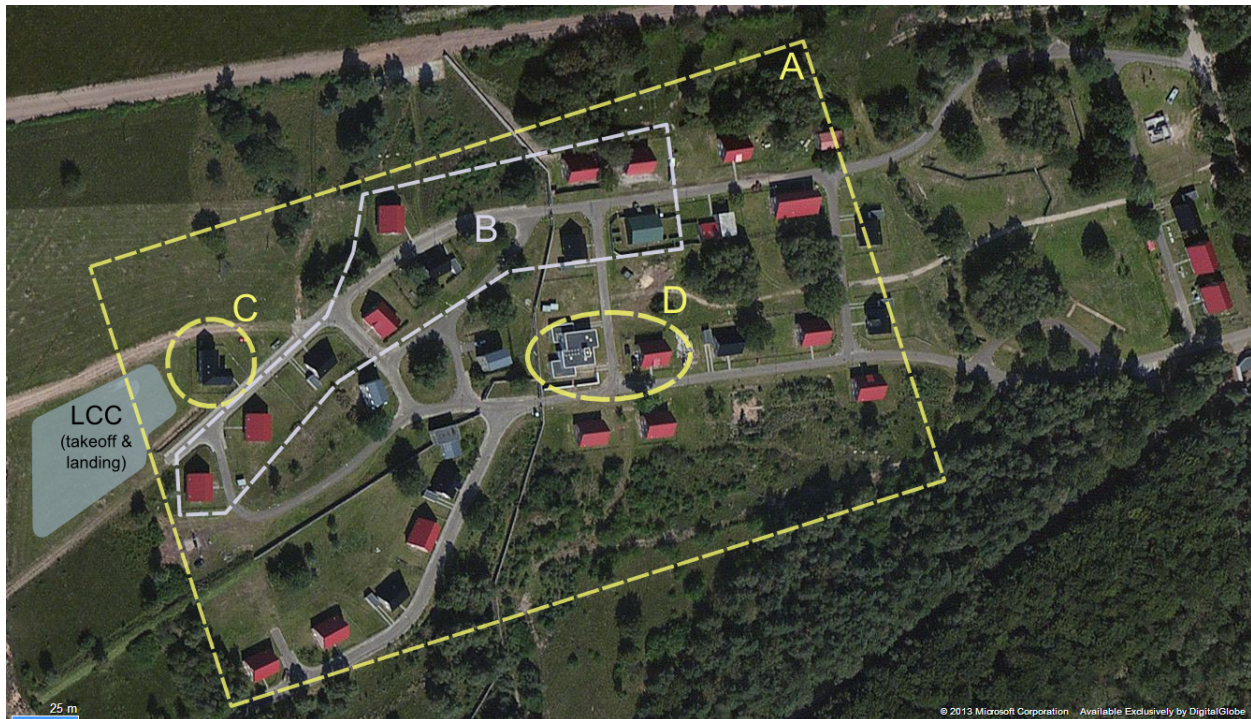
3. Overall Mission Scenario

The competition will take place in the village of Oostdorp, a training-village consisting of 30+ houses (<http://binged.it/1fSEAhI>) near the real village Harskamp. A major natural disaster has occurred in the region surrounding Oostdorp. Your team arrives at the *Local Command & Control* (LCC) center that has just been set up next to the village. The current situation in the village is largely unknown. You have been called in to perform a number of critical tasks to ensure that emergency services can be deployed effectively in the coming hours. Your mission will include the following tasks:

- A. Create a detailed map of the Oostdorp area, indicating which roads are still available and which roads are blocked;
- B. Perform an initial 'house-by-house' visual scan for any survivors;
- C. Perform a detailed visual scan of the interior of a building that is already known to contain several wounded;

- D. Observe one of the buildings that is a potential hazard to the emergency services being deployed;

The Oostdorp village and the mission areas are shown on the map below:



4. Mission elements & Scoring

This section describes the mission elements and overall scoring rules for each of the tasks introduced above.

4.1 Overall mission score

The total score for the mission is given by:

$$S_{total} = \sum_{n=1}^N \left(A_n \cdot M_n \cdot \left(2 - \frac{L_n}{L_{max}} \right)^k \right)$$

Where:

n is the mission element number for the MAV attempting that mission element,

A_n is the autonomy level of the MAV when attempting mission element n ,

M_n is the number of points scored for mission element n ,

L_n is the largest dimension of the MAV that performs mission element n ,

L_{max} is 100cm,

k is set to 2.

The maximum allowed size of the MAVs is 150 cm. However, it should be noted that MAVs over 100cm will have a very large disadvantage in the scoring system.

The level of autonomy is taken into account per mission element. Thus teams are not penalized for the entire mission if they cannot perform all mission elements at the autonomy level they were aiming for. Teams have to announce the intended MAV and autonomy level for each mission element before their flight and state the actual MAV and autonomy level during the flight. The jury will decide which level of autonomy the team actually used for each mission element, and which MAV executed the mission element. When multiple MAVs are operated the points of the mission elements are calculated using the autonomy factor (A_n) and size (L_n) belonging to the MAV that achieved the mission element. The formula is optimized for multiple MAV's participation to the challenge. Each MAV will be scored separately depending on his size, autonomy level and what mission element the MAV have performed. The total score will be the sum of all the successful missions elements.

Each mission element will be scored **once per MAV**. When a single MAV attempts a mission element multiple times, only one of the attempts will be scored. In this case, teams are required to indicate which attempt should be scored. But note that a mission element may be performed and scored **multiple times** by **different** MAVs.

Table 1 gives the values for A_n :

Autonomy Level	A_n
<i>Video based, and beyond line of sight.</i>	1
<i>Autonomous flight control:</i> Flight is controlled autonomously but the operator is still controlling mission aspects, e.g., commanding transitions between control modes, control of payload, processing perception, and decision making.	6
<i>Autonomous mission control:</i> All aspects of the flight and mission are automated, including detection and decision making. Typically, the operator does not touch the controls: hands-off control.	12
<i>Using external aids</i>	-2

Mission Time

Each team will be assigned a time slot of 30 minutes to setup their equipment, prepare flight, fly the competition, land and retrieve the MAVs, clear the flight team area, flight zones and allocated radio channels. After the 30 minute time slot, all MAVs and equipment must be switched off. Failure to comply can lead to a penalty or disqualification. Any MAVS that have been lost during the mission should be retrieved as soon as possible in cooperation with the flight safety officer.

Mission Execution

During mission time, the following rules apply:

- The main ground station screen has to be shared via a VGA output (to a beamer or flatscreen delivered by the organisation).
- Team members in the field are not allowed to talk about any elements that influence the scoring.
- Communication between team members should be in English.

4.2 Task: Takeoff

- Mission element 1: Launch MAV. Points are awarded for every MAV that takes off from the designated takeoff area and performs at least one other mission element other than landing.

The above points will be awarded to each MAV executing the mission element, depending on the autonomy level and size of the MAV.

4.3 Task: Create photomap of village (A)

The purpose of this task is to create a detailed orthomap of the village and use it to present information about the current situation to the emergency response teams.

- Mission element 2: Create a photomap. A higher ground-resolution photomap increases score.
- Mission element 3: Create map of blockages. For every blockage correctly indicated on the map (your own map or one supplied by the jury), points are awarded.

The above points will be awarded to each MAV executing the mission element, depending on the autonomy level and size of the MAV.

Teams may submit **only one complete (stitched) map/photo** of the area for scoring both mission elements 2 and 3. The final map and source images must be presented to the jury at a maximum of 10 minutes after completion of the mission time. Any detected blockages should also be indicated on this map. If a team decides not to attempt mission element 2 but only mission element 3, a map will be supplied by the organization which should be used to indicate the blockages.

The resolution of the photomap will be assessed by means of several A1 sized sheets placed randomly throughout the mission area. Each sheet will contain several squares of different sizes that can be used to determine the camera capture resolution by counting the number of pixels covering the squares. Teams are required to zoom in on the single submitted (stitched) map/photo to all the visible A1 sheets of interest and identify to the jury the smallest of the squares that is covered by approximately 25 pixels (= 5 x 5) pixels. A minimum of two A1 sheets must be visible. The teams must indicate which of the A1 sheets counts for scoring. Teams are also required to identify the MAVs that are responsible for creating the images of the sheets.

4.4 Task: Scan buildings (B)

The purpose of this task is to do a close visual inspection of the buildings and look for survivors.

- Mission element 4: Quick visual inspection: Each building is numbered. Points are awarded for correctly recognizing these numbers.
- Mission element 5: Detailed inspection. Some houses can be entered through a door or window. Points are awarded for entering a house and correctly reporting the number of survivors. The above points will be awarded to each MAV executing the mission element, depending on the autonomy level and size of the MAV.



The numbers of the buildings will be positioned near the main entrance, and will be in black, printed on white A4 paper. Not all doors and windows will be open, it is up to the team to identify the doors/windows that are suitable for entering the buildings. The survivors inside the houses will be represented by cardboard figures as shown above.

See appendix for more information on the measurements of the door and windows, and for a sample of the house numbers that will be used.

4.5 Task: Inspect building (C)

The purpose of this task is to create an overview of the rooms in a building and their contents. The building is indicated on the map as 'C'.

- Mission element 6: Points are awarded for each room visited.
- Mission element 7: Points are awarded for each correctly identified and located item in a room.



The above points will be awarded to each MAV executing the mission element, depending on the autonomy level and size of the MAV.

Takeoff and landing inside the building is allowed, but will not score points. Note that there are takeoff and landing zones outside, near the building.

Teams will be given a map of the building second floor, on which the teams will have to write the names of the items that have been identified and their positions.

See appendix for more information on the measurements of the door and windows. For more photos and videos of the layout please see the IMAV 2014 website.

4.6 Task: Observe building (D)

The purpose of this task is to observe a building for a longer period. The buildings are indicated on the map with 'D', where the left building with the flat roof can be the 'perching' location, and the right building the actual observation target location. The picture on the right shows part of the roof of the perching location, as well as the side of the house that needs to be observed.



- Mission element 8: Landing on the roof of the building with the flat roof. Points are awarded for a successful landing. The MAV must remain at this position for at least 10 seconds and has to be able to take off again.
- Mission element 9: Observe panel. A sequence of digits will appear on a large panel positioned in a window on the first floor of the west wall of the building with the red roof, during the entire competition slot.

Digits change at a rate of 30 seconds per digit, resulting in a total sequence of 60 digits in the 30 minute mission timeframe. The longer the correct sequence of digits that is reported, the more points a team scores. Mission points are multiplied by the **sequence ratio: (longest correct reported sequence / total length of sequence)**. Digits are presented in high contrast colors (non light emitting) by a mechanically driven display which is positioned vertically against the wall. Note that to score the highest autonomy points, the MAV system has to be flown fully autonomous including the camera control and the automatic recognition of the digits.

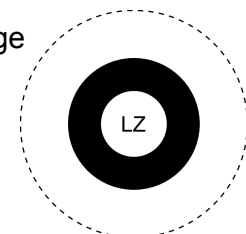


The above points will be awarded to each MAV executing the mission element, depending on the autonomy level and size of the MAV.

The digit bars will be painted in the color "Signal Orange". The background of the panel will be painted flat black. See Section 5 for more information on the panel. For more photos and videos of the layout please see the IMAV 2014 website.

4.7 Task: Precision landing (E)

- Mission element 10: Landing. The landing zone is indicated by a large circular sheet, and is for all types of MAV's. Different dimensions apply for fixed wing and VTOL MAV's, see the dimensions table below. A landing can be classified as a field landing (0 points), as a regular landing within the large circle (1 point), and as a precision landing in the small circle (2 points).



The above points will be awarded to each MAV executing the mission element, depending on the autonomy level and size of the MAV.

Points are awarded for the spot at which the MAV is fully stopped. In the case of a rough landing, the team may be asked to demonstrate airworthiness of the (remaining) vehicle, and only points are awarded for the airworthy part of the MAV, located in the landing zone. (e.g. if a fixed wing loses a small part of a wing during landing, and the wing by chance ends up in the middle of the landing zone while the airworthy part of the MAV is outside the landing zone, no points are awarded.)

The GPS coordinate of the center location of the landing spot is given. A MAV must have contributed to at least one other mission element (other than than take-off) to be able to score points for landing.

4.8 Mission points overview

Mission element	points Mn
1. Takeoff	1 per MAV that successfully completes one other mission element.
2. High resolution photo map	See appendix for sample sheet. A=1 B=1.5 C=3 D=6
3. Road blocks	1 per correctly indicated road block
4. Scan buildings: external	1 per correct house number
5. Scan buildings: internal	3 per correct number of survivors per house
6. Visit rooms	3 per room visited
7. Identify/ locate items in rooms	1 per correctly identified and located item in a room
8. Landing on flat roof	3 points
9. Observe panel	6 x sequence ratio (see Section 4.6)
10. Precision landing / regular landing / field landing	2 / 1 / 0

5. Dimensions

Entrance window 2nd floor task C (h x w)	106cm x 122cm
Entrance door task C & inner doors task C (h x w)	210cm x 90cm
Height 2nd floor task C	260cm
Large entrance window task B (h x w)	124cm x 113cm
Entrance door task B (h x w)	210cm x 90cm
Garage door task B (h x w)	approx. 2.5m x 3m
Regular landing zone fixed wing	20m
Precision landing zone fixed wing	10m
Regular landing zone VTOL	10m
Precision landing zone VTOL	5m
Observe object: digit size (h x w)	approx. 80cm x 40cm
Observe object: digit bar (h x w)	approx. 40cm x 7cm
Observe object: digit panel size	approx. 100cm x 50cm
Observation roof border (h x w)	10cm x 24cm (sloping up from roof side)

Appendix A: Mapping task scoring sheet

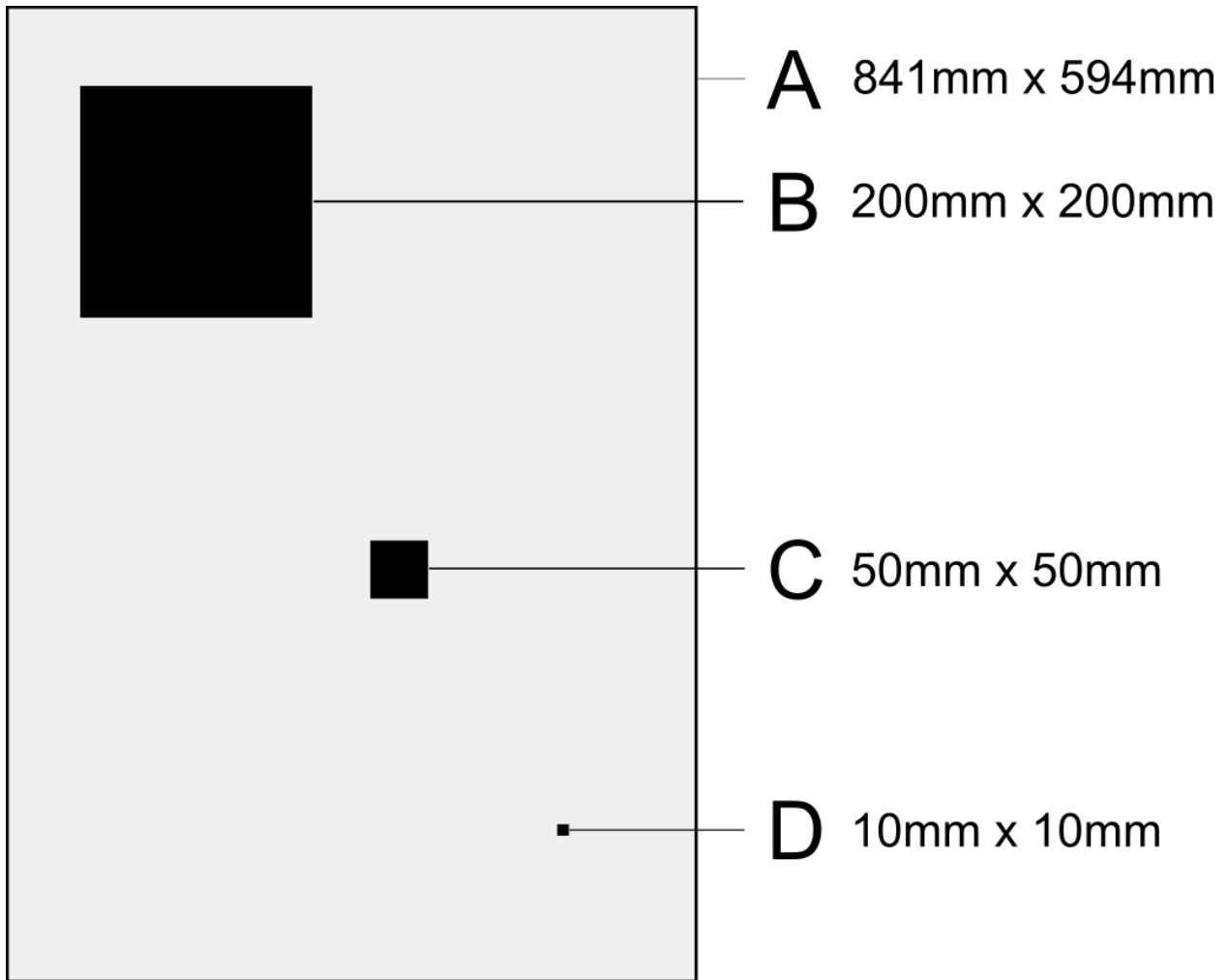
points Mn:

A=1

B=1.5

C=3

D=6



Appendix B: Example score calculations

Example A: Observe Building

This example shows the achieved score of a MAV assigned to the Observe Building task. The MAV with a diameter of 50 cm is launched into the mission fully autonomous. During the mission, landing on the roof is performed by the operator by manipulating the landing waypoint to the correct location on the roof. In this example, the team managed to correctly capture a sequence of 40 digits out of the total of 60, resulting in a sequence ratio of **0.67**. The mission ends with a fully autonomous precision landing.

(Note that the size factor in the scoring for this MAV is $:(2 - (50 / 100)) ^ 2 = 2.25$)

Version A1, scoring with manual camera

In this version the camera is manually oriented at the digit display by the operator, and digits are manually recorded by the operator:

Mission element	Result	Autonomy	Points
Take off	1 point	Autonomous MC	12
Landing on roof	3 points	Autonomous FC	18
Observe digits	seq. ratio = 0.67	Video based	4,02
Precision Landing	2 points	Autonomous MC	24
Total			58.02
Mission Score			130.55

Version A2, scoring with autonomous camera control

In this version a gimbal is automatically centered on the digit without human intervention. Digits are manually recorded by the operator. The other mission elements are performed the same as above:

Mission element	Result	Autonomy	Points
Observe digits	seq. ratio = 0.67	Autonomous FC	24,12
Total			78.12
Mission Score			175.77

Version A3, scoring with fully autonomous mission control

In this version the digits are automatically processed and displayed by the MAV/groundstation to the judges, without any human intervention. The other mission elements are performed the same as above:

Mission element	Result	Autonomy	Points
Observe digits	seq. ratio = 0.67	Autonomous MC	48,24
Total			102.24
Mission Score			230.04

Example B: Inspect Building

This example shows the achieved score of a MAV assigned to the Inspect Building task. The MAV with a diameter of 35 cm is launched into the mission fully autonomous. The MAV enters the house and navigates several rooms with only high level navigational input from the operator. Each room is visually scanned by the MAV without human intervention, and the operator manually recognizes any items encountered. The mission ends with a fully autonomous regular landing.

(Note that the size factor in the scoring for this MAV is $:(2 - (35 / 100)) ^ 2 = 2.72$)

Mission element	Result	Autonomy	Points
Take off	1 point	Autonomous MC	12
Rooms visited	3 points * 3 rooms	Autonomous FC	54
Correct items	1 point * 6 items	Autonomous FC	36
Regular Landing	1 point	Autonomous MC	12
Total			114
Mission Score			310.37