

7th Korea Robot Aircraft Competition
1st International Open

**General Regulations, Mission Descriptions, and
Scoring Guidelines**

February 2008

Regulation Committee

1. General Regulations

- A. Participating teams should be comprised of members attending college or higher institution, or general public with related backgrounds. Teams from colleges should enter the competition under the guidance of a supervising faculty(s).
- B. The aerial platform (called “vehicle” hereinafter) should be uninhabited and capable of autonomous flight. The required missions described below must be performed by the vehicle using its onboard “intelligence” or preprogrammed logics, NOT by human control.
- C. Any type of aerial platform (e.g. fixed-wing, variable-wing, or rotary-wings) can be used for the competition insofar as judged safe during the static judging session prior to the competition. Each team should enter the competition with only one type of platform.
- D. The computing unit for automatic flight must be installed onboard the vehicle.
- E. The data communication can be implemented in any manner as long as no tether is employed.
- F. Any type of propulsion system can be used provided that judged safe during the static judging session.
- G. The maximum take-off weight is limited by 80 kg.
- H. The aerial vehicle and its flight control system must demonstrate its safety features described in a separate article.
- I. The main event will be held with at most six domestic teams who passed the preliminary event and the foreign teams who passed the technology report review. The preliminary competition rules for domestic teams are explained in a separate article. The foreign team should submit application form accompanied by a journal-quality technical report explaining their vehicle and employed technologies. The judging committee will review the submitted reports and make decisions for acceptance or rejection of foreign teams.
- J. At least the onboard computer(s), flight/mission software, and ground control systems should be developed by the team members. If a team enters with a robot aircraft that was purchased as a whole, or that does not meet the requirement specified above may be disqualified by the judging committee.
- K. Multiple teams from one institution are allowed insofar as the entry vehicle and the team members (and the supervising faculty in case of a college team) are not shared by other teams in the same institution.
- L. If the vehicle qualified in the static judging session is damaged beyond repair, the replacement vehicle should be in the “same class”, and it should obtain a separate approval before the competition by the judging committee.

M. Time Table

Mar. 22, 2008	: Introduction session for missions and regulations
Apr. 30, 2008	: Deadline for foreign team application and technology report submission
May 16, 2008	: Notification of review result of foreign team reports
Sep. 6, 2008	: Preliminary competition for domestic teams (Sep. 7, '08 if weather is not permitting on Sep. 6, 08)
Sep. 25, 2008	: Registration of foreign teams
Sep. 26, 2008	: Ground judging and practice flight session
Sep. 27, 2008	: Main event (Sep. 28, '08 if weather is not permitting)

2. Mission Descriptions

- A. The flight modes of robot aerial vehicles are herein categorized as following:
- Manual flight:** The control surfaces are commanded directly by a human operator on the ground (e.g. radio control flight)
 - Remotely controlled automatic flight :** The control surfaces are actuated by the onboard computer system based on the flight commands and the current states of the vehicle. (Example: the attitude of the vehicle is commanded by the ground station. The commands from the ground station are of high-level such as attitude reference command or waypoint navigation, NOT the actuation amount of control surfaces)
 - Programmed automatic flight:** When a trigger from the ground station such as a key on the keyboard or a switch on the radio transmitter is sent, the aircraft goes into an autonomous mode (e.g., the robot aircraft starts a mission when a key is pressed or a switch is flicked on the ground station)
- B. Before takeoff, each team should demonstrate to the judges 1) their safety feature such that the transition between manual and automatic mode can be made smoothly and 2) the operators are fully familiar with activating this feature. If the system or the team is deemed unable to meet the safety standard demanded by the judging committee, the team can be immediately disqualified for the competition.
- C. Mission Time
- In the main event, each team is allocated forty minutes. they can make as many attempts as they need within the allocated time. If the team runs over the given time, five points are deducted for each extra minute. After the first forty minutes have passed from the start, the vehicle is not allowed to take off at all.
 - If the team announces halt of their mission within the first twenty minutes, they can make another attempts after all other teams' first attempts are made.

- D. Each team should report to the judges which missions they are planning to attempt during the technology report presentation session.
- E. The competition arena is around the runway of Hanseo University Airfield as shown below. The flight zone is the area within the black solid line and up to 300 m above ground level (AGL).
~ denote the waypoints. A-F denote the vertices of the flight zone. The exact coordinates of the waypoints and vertices are given in the appendix.



Figure 1. An aerial view of the competition area (Airfield of Hanseo University, South Korea)

- F. Each team must submit a data file for the trajectory recorded during the attempts to the judges within twenty minutes immediately after all of the team's attempts are over. The submitted trajectory file should be in one of the format (1) or (2). If a team fails to submit the data file as specified, the team may not be credited at all for their attempt. The data file should include clear indications if the vehicle was in manual or automatic mode at the corresponding moment. If multiple attempts were made for single mission, only one data file should be chosen and submitted.

Format 1. XYZ coordinates in ECEF¹ system

Data	Manual/Auto flag	Waypoint Flag	GPS time	Position	Satellite
Unit	0 or 1	Waypoint number	second	meter	PRN number
Remarks	Manual:0 Auto: 1	Put 2 If the vehicle is flying to waypoint 2	GPS time	ECEF (WGS-84). Truncate after 0.1m	All PRN numbers used by GPS at the moment

(The data should be recorded onboard or transmitted at every 1 second in ASCII format)

Example 1. trajectory.asc

```

GPStime      x              y              z              PRN No.
0 2 8.6817e+04 -3.0478881e+06 4.0516322e+06 3.8573362e+06 5 8 12 17 23 25 28
0 2 8.6818e+04 -3.0478886e+06 4.0516333e+06 3.8573366e+06 5 8 12 17 23 25 28
0 2 8.6819e+04 -3.0478883e+06 4.0516334e+06 3.8573365e+06 5 8 12 17 23 25 28
0 2 8.6820e+04 -3.0478884e+06 4.0516334e+06 3.8573372e+06 5 8 12 17 23 25 28
1 2 8.6821e+04 -3.0478873e+06 4.0516323e+06 3.8573365e+06 5 8 12 17 25 28
1 2 8.6822e+04 -3.0478874e+06 4.0516329e+06 3.8573360e+06 5 8 12 17 25 28
1 2 8.6823e+04 -3.0478878e+06 4.0516334e+06 3.8573366e+06 5 8 12 17 25 28
1 2 8.6824e+04 -3.0478869e+06 4.0516321e+06 3.8573361e+06 5 8 12 17 23 25 28
1 2 8.6825e+04 -3.0478870e+06 4.0516329e+06 3.8573364e+06 5 8 12 17 23 25 28

```

Format (2) : LLA coordinates

Data	Manual/Auto flag	Waypoint Flag	GPS time	Position	Satellite
Unit	0 or 1	Waypoint number	second	degree and meter	PRN number
Remarks	Manual:0 Auto: 1	2 If the vehicle is flying to waypoint 2	GPS time	Latitude, longitude, height (WGS-84). For degrees, up to six points below decimal points. For altitude, truncate after 0.1m	All PRN numbers used by GPS at the moment

(The data should be recorded onboard or transmitted at every 1 second in ASCII format. The altitude is AGL, but altitudes measured by GPS or barometric pressure sensors are also acceptable)

Example 2. trajectory.asc

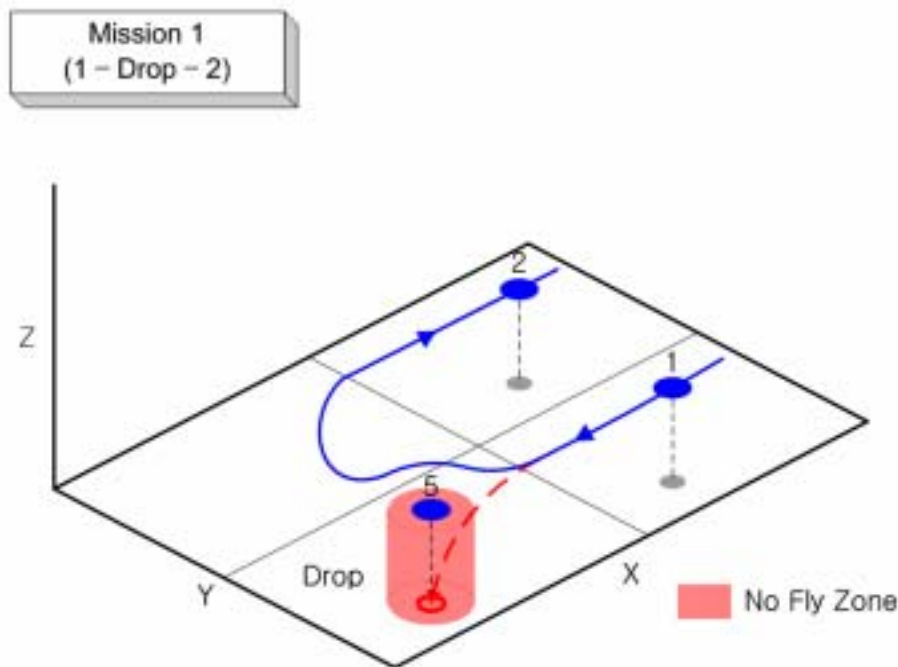
```
0 2 8.6822e+004 37.604256 126.860377 180.0 5 8 12 17 25 28
0 2 8.6823e+004 37.599905 126.856694 180.0 5 8 12 17 25 28
1 2 8.6824e+004 37.598360 126.859049 180.0 5 8 12 17 23 25 28
1 2 8.6825e+004 37.602660 126.863120 180.0 5 8 12 17 23 25 28
```

B. Main Event Missions

Mission 1. Precision drop

- i. As shown below, after passing waypoint 1, two objects should be dropped from the vehicle on the point on the ground right below waypoint 5 before passing waypoint 2.
- ii. During this mission, the vehicle should be flying above 70m AGL in programmed automatic flight mode (refer the definition above) at all time. The dropping of the objects can be triggered manually or automatically.
- iii. The space within 50 meters radius around the target point in all altitude is no-fly zone. If this zone is violated during an attempt, it is immediately called void.
- iv. Two objects can be dropped simultaneously or separately during multiple attempts.

Two objects to drop are made identical and provided by the organizing party. Each object weighs less than 200g and the longest side is less than 7.5 cm. Insofar as deemed safe, the objects can be augmented with extra structures (e.g., fins, feathers, or ribbons for stability or whatsoever). The dropping action can be done in any manner as long as deemed safe.



Mission 2. Fixed-Target Recognition and Geolocation

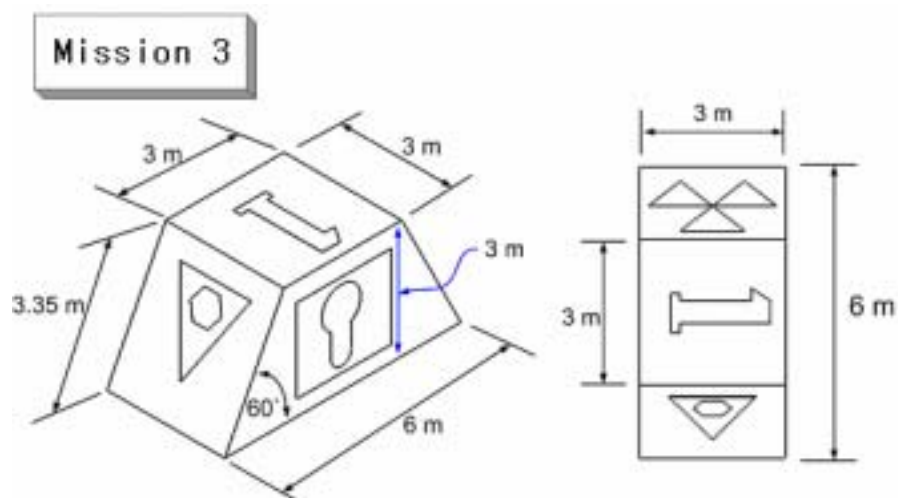
- i. A fire engine will be parked at somewhere within the red box in Figure 1. The team is required to compute the coordinates of the fire engine by image processing only. The coordinates of the four vertices of the red box are given in the appendix.
- ii. The vehicle should not enter the red zone at all altitude. The mission must be performed outside of this zone and, in the event of entering this zone, the attempt is called void.
- iii. During this mission, the vehicle should be flying above 70m AGL in the programmed automatic flight mode (refer to the definition above). The coordinates must be computed by automatic image processing and the process should be clearly shown on the computer screen.
- iv. The fire engine for this mission is as shown below. It is 7.95m long, 2.49 wide, and 3.25m high.





Mission 3. High-quality Image Acquisition

- i. This mission is to acquire high quality images to read or recognize drawings or numbers on the five faces of a structure shown below. The drawings or numbers are not disclosed prior to the mission.
- ii. The area within 50 meters radius from the target point in all altitude is no-fly zone during this mission. If this zone is violated during the attempt, it is immediately called void.
- iii. During this mission, the vehicle should be flying above 70m AGL in programmed automatic flight mode (refer to the definition above). The onboard camera can be operated manually or automatically
- iv. In order to acquire high quality images, any image enhancing techniques such as camera zoom or others can be employed.



Mission 4. Sea Search

- i. The objective is to find three distressed “people”(simulated by mannequins) at undisclosed locations within the search area over the shore marked as blue box in Figure 1. Images and the estimated coordinates of the people should be acquired, and computed, respectively. The coordinates of the four vertices of the search area are given in the appendix.
 - ii. During this mission, the vehicle should be flying above 70m AGL in programmed automatic flight mode (refer the definition above). The onboard camera can be operated manually or automatically.
 - iii. In order to acquire high quality images, any image enhancing techniques such as camera zoom or others can be employed.
- C. During any mission, If the vehicle is switched from automatic flight to manual, only the results obtained during the interval within which the vehicle was continually operated automatically are accepted for scoring. In the main event, each mission can be attempted separately.

3. Scoring Guidelines

A. Technology Judging (Technical report presentation and static judging)

The main scoring criteria are autopilot design, technical originality, and the capability of the team to implement the designed system. The technical report should include:

- a. Overview of the developed robotic aircraft
- b. Descriptions on the autopilot system and other implemented technologies
 - Guidance, navigation, and control system design
 - Detailed approaches to missions
 - Adequacy of the components
 - Results from ground and in-flight tests
- c. Uniqueness of the system design and development
 - Creativity of the system implementation
- d. Descriptions on the implemented safety features
 - Safety system design and performance evaluation
 - Technical adequacy of safety features
 - Simulation or live demonstration of the safety feature

* Each team should submit a technical report within 20 pages following the guidelines given

above. The contents of the report should match with the vehicle that is actually implemented.

* In the technical report, it is recommended to include supporting evidences such as video clips or flight data to show that the entry vehicle is capable of automatic flight.

* Only the teams qualified in the static judging can compete in the Main Event

B. Main Event

Mission	Score	Evaluation points	Scoring formula
Mission 1 (Precision Dropping)	26	<ul style="list-style-type: none"> Distance d between the target point and the actual hit point on the ground Number of waypoints passed 	<ul style="list-style-type: none"> Distance point= $(50-d)/5$ (zero if $d>50$) 3 points per waypoint
Mission 2 (Fixed-Target Recognition and Geolocation)	30	<ul style="list-style-type: none"> Distance d between the target and the estimated coordinates (latitude and longitude) 	<ul style="list-style-type: none"> Distance point= $(50-d)*3/5$ (zero if $d>50$)
Mission 3 (Precision Image Acquisition)	30	<ul style="list-style-type: none"> Quality of acquired still and live images to recognize the numbers/drawings on each face 	<ul style="list-style-type: none"> Max 2 points per still image Max 4 points per live images
Mission 4 (Sea Search)	45	<ul style="list-style-type: none"> Acquired images of the distressed people Distance d between the actual location and the estimated coordinates (should submit latitude and longitude) 	<ul style="list-style-type: none"> 5 pts per recognizable image Distance point= $(100-d)/10$ (zero if $d>100$)

- In mission 1, when passing waypoints, 3 points are given if the vehicle passes a waypoint within 15 meters horizontal radius and 30 meters vertical, 2 points within 30 meters horizontal radius and 45 meters vertical, 1 points in 45 meters horizontal and 60 meters vertical, zero points otherwise.

C. Extra points and penalties

- Additional 5~8 points are given if the vehicle can send live images (depending on the quality, i.e., duration, quality, etc).
- Additional 5~8 points are given if the ground control system can display the flight data such as latitude, longitude, height, speed, and heading in real time on the screen.
- If the vehicle flies outside of the designated fly zone, five points are deducted for each incident.

D. For tie-breaker, the team that finished the mission in a shorter time (time spent from the start to the final landing) wins.

E. The grand prize is given to the team who scored the highest points above 60 points in the Main Event.

F. Each prize is awarded to only one team. Table below shows the amount of each prize and guidelines for other special awards.

Prize	Award (US \$)	Remarks
Grand Prize	10,000	
Gold Prize	5,000	
Silver Prize	3,000	
Bronze Prize	2,000	
Best image system design award	2,000	Voted by the judges for those who designed the best hardware and software for image processing.
Best dropping system design award	2,000	Voted by the judges for those who designed the best hardware and software for the dropping mission
Best ground control system design award	2,000	Voted by judges for those who designed the best ground system and operated it most effectively.