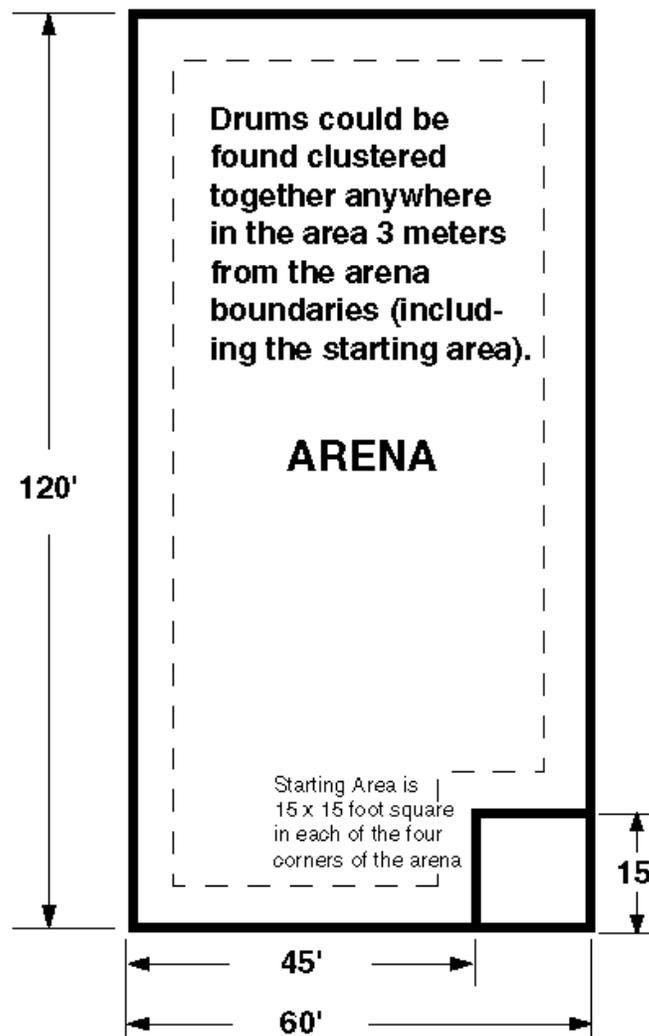


# RULES FOR THE 1997 INTERNATIONAL AERIAL ROBOTICS COMPETITION

## GENERAL RULES GOVERNING ENTRIES



**Power will be available near each of the starting areas.  
Boundary markings will be white.**

1. Vehicles must be unmanned and autonomous. They must

- compete based on their ability to sense the semi-structured environment of the Competition Arena. They may be intelligent or preprogrammed, but they must *not* be flown by a remote human operator.
2. Computational power need not be carried by the air vehicle. Computers operating from standard commercial power may be set up outside the Competition Arena foul-line boundary and uni- or bi-directional data may be transmitted to/from the air vehicle.
  3. Data links will be by radio, infrared, acoustic, or other means so long as *no* tethers are employed. The air vehicles must be free-flying with no entangling encumbrances, however, tethered subvehicles are allowed. Subvehicle(s) must be attached permanently to the autonomous air vehicle at all times. Subvehicles must themselves be autonomous. They may be deployed within the arena to search for, and/or acquire the information or objects. Subvehicles may not operate outside of the arena.
  4. Any form of propulsion is acceptable if deemed safe in preliminary review by the judges.
  5. Air vehicles may be no larger than a 10-foot (side) cube when operational.
  6. So your entry form will be anticipated, and so you can be notified that it has **not** arrived were it to get lost in the mail, an **Intention to Compete should be received no later than October 21, 1996**. To avoid unnecessary delay due to the mail (particularly for international entries), a letter of intention to compete can be transmitted by E-MAILED to Robert C. Michelson, AUVSI Technical Chairman at [robert.michelson@gtri.gatech.edu](mailto:robert.michelson@gtri.gatech.edu). Submission of a letter of intention to compete is not a requirement, however **entries received after the deadline which are not clearly postmarked may be disqualified** as late unless prior intention to compete has been expressed.
  7. **The official World Wide Web pages for the competition**

are your source for all information concerning rules, interpretations, and information updates regarding the competition. In anticipation of the 1997 International Aerial Robotics Competition, the official rules and application form will be obtained from the official World Wide Web pages and will not be mailed to potential competitors. If you have received these rules as a hard copy from some other source, be advised that the official source of information can be found at: [IARCLaunchPoint.html](#) The application form is available electronically [here](#). All submissions must be in English. The completed application form is not considered an official entry until a check or money order for 100 U.S. Dollars is received by mail on or before November 1, 1996. *(Note: the \$100 application fee is completely refundable on the day of the competition if your team's aerial robot flies autonomously for more than 30 seconds. This fee has been instituted to discourage teams from applying that are not serious competitors)*. A brief concept outline describing the air vehicle must be submitted for safety review by AUVSI (the application form provides space for this). AUVSI will either confirm that the submitting team is a qualified competitor, or will suggest safety improvements that must be made in order to qualify. **A VHS video tape of your vehicle flying either autonomously or under remote human pilot control must be supplied by March 1, 1997** to continue to be considered as a serious entry. **A research paper describing your entry will be due by June 1, 1997** (see rule No. 6-9). The competition will be conducted on July 14, 1997 at Walt Disney World's EPCOT center in Orlando, Florida. Winners will be recognized during a ceremony to follow the competition.

8. Teams may be comprised of a combination of students, faculty, industrial partners, or government partners. Students may be undergraduate and/or graduate students. Inter-

disciplinary teams are encouraged (EE, AE, ME, etc.). Members from industry, government agencies (or universities, in the case of faculty) may participate, however full-time students *must* be associated with each team. Participants must be enrolled at their schools for at least 12 credit hours or more per quarter/semester during winter and spring 1997 to be considered "students". The student members of a joint team must make significant contributions to the development of their entry. Only the student component of each team will be eligible for the *cash awards*. If your team does not qualify under the above definition, it *may* qualify for the ["High School Open Class Event."](#) which will be held concurrently with the Collegiate Class Event under different rules.

## THE MISSION

- Location and remediation of toxic waste in industrialized nations is a major problem. Even with environmental laws that prescribe the correct handling of toxic waste materials, unethical companies often secretly dispose of their waste products in unapproved and dangerous ways. In addition, large amounts of toxic waste are known to have been disposed of improperly prior to environmental legislation. In either case, the location and composition of the waste is often unknown. Investigation of toxic waste sites is a dangerous job that is well suited to unmanned systems.
- Your mission is to create an aerial robot that can map a (simulated) toxic waste dump containing both radioactive and biohazardous materials. This toxic waste dump consists of up to ten [55-gallon black plastic drums](#) containing either radioactive material, biohazardous material, or picric acid ( $C_6H_2(NO_2)_3OH$ ), a poisonous, explosive crystalline solid. The [drums](#) will appear to be either fully exposed or [partially buried](#). The [location of each drum](#) is unknown, other than it is

- within the boundaries of the arena and no closer than three meters to any arena boundary. You do not know the number of drums containing radioactive material versus biohazardous or explosive material. Your aerial robot will be able to determine this from labels on each drum (visible from above, regardless of drum orientation).
- [Radioactive Symbol-- Figure 1a](#), [Biohazard Symbol-- Figure 1b](#), and [Explosives Symbol-- Figure 1c](#) show the three types of identifying labels. The labels are *white* images on a *black* background as depicted in [Figures 1a, 1b, and 1c](#). **IMPORTANT:** the orientation will be random and the labels will conform to the upper surface of the drum in whatever position it is to be found).
  - [Figure 2](#) shows a typical drum arrangement (the actual arrangement and number of drums used on the day of the competition will be different and will be changed between runs, but in all cases the contents of each drum will be indicated on its upper surface -- viewable from directly above). Your map must identify the location of drums relative to the center of the arena. The map must be generated only by data gathered from the air vehicle and must be presented to an accuracy of one meter. The contents of each drum identified must be indicated on the map.
  - The map may be telemetered from the aerial robot to a ground station in real time or new drum locations may be stored on board as they are found, for subsequent downloading to a ground station *after* landing.
  - One of the drums containing hazardous material will also have a (simulated) contaminated disk resting on it. This contaminated disk *must* be retrieved as a sample, and returned to the starting location. The details of the construction of this disk are shown in [Figure 3](#).
  - All air vehicles must start from a designated starting area in the corner of the arena. Take-off must be autonomous. Only two members from the team may be within the boundaries of the

Competition Arena once attempts to start the vehicle begin. From lift-off until the end of the round, all team members must remain outside the Competition Arena.

- Teams will be allotted 60 minutes to complete the task. Each team will be assigned a specific 60-minute time slot in which they must set up and perform as many attempts as they wish. Judges will score each valid attempt, with the highest score being used to determine the winner.
- To accommodate the number of competing teams within a reasonable time, the arena may be occupied by up to four teams (one at each corner). The dimensions of a typical starting area are shown in [Figure 4](#). Non-flight activities such as set-up, calibration, and take-down will count against the allotted 60 minutes to complete the task. The arenas will be cleared of practicing teams 30 minutes prior to the start of the performance judging on the morning of the competition.
- Upon notice that a team is ready to fly, the clocks will be stopped for any other teams occupying the arena and the field will be cleared except for the designated officials and two members of the currently flying team. Once that run is complete, the other teams may return to their on-field activities and the clocks will be allowed to continue. After 60 minutes of arena time for any given team, a new team will be allowed to take control of the prior team's arena starting corner and the clock for the new team will begin running.
- A run will be declared a valid try if the vehicle leaves the starting area.
- Teams may have no more than one entry. Only one team may be affiliated with any particular university. If several teams wish to enter from a single university, a decision must be made by the university (not AUVSI) as to which team will represent the school. This may be done as a result of an engineering analysis of each team's design and progress, or it may be as a result of an actual demonstration of hardware. The determination should be by a panel of impartial evaluators

not directly affiliated with either team. Notification (prior to the [journal paper submission](#)) of which university entry is the "official" one must be provided in writing by someone equivalent to the "Dean of Engineering" since various departments or campus sponsors may be vying for the honor of representing the university. It is hoped that teams will join together to offer their best ideas for the benefit of a single unified team, while being willing to compromise and defer to team members with specific training and skills. The most successful teams are interdisciplinary groups of dedicated engineers and scientists with backing from their university administration and industrial partners. To discourage multiple entries from a university, all teams vying to represent the university must submit their individual applications along with the 100 U.S. Dollar application fee by mail on or before November 1, 1996. No application will be considered valid without the fee being received by the November 1 date. Further, only one \$100 application fee will be refunded on the day of the competition, and then only to the officially-designated team representing the university provided it successfully meets the [30-second autonomous flight requirement](#). It is therefore in the interest of all potential competitors from a single university to form their team without the need for arbitration *prior* to submission of an application.

- Air vehicles must stay aloft at all times except in the starting area where landing is permissible. Subvehicles, if used, must be tethered to the air vehicle at all times. Tethers may touch the ground anywhere in the arena, however subvehicles may only touch the ground in the vicinity of the drums (defined as within one meter of a drum). Subvehicles may operate on the drums themselves however the air vehicle may not latch onto or touch the drums. A run will be terminated if any part of an air vehicle touches the ground outside of the starting area.

# Scoring

The score will be based on a number of factors as follows:

1. **Effectiveness Measures:**
2. 100 points for each drum location correctly identified (**a**), plus an additional 100 points for identifying the contents of each drum located (**a'**). A drum may be correctly located (for 100 points) but identification of the drum contents will be discounted (no credit) if it is not *also* correctly located (implying that the identification was merely a guess).
3. The elapsed time (**b**) between autonomous take-off ( *leaving the starting area* ) and autonomous landing measured in "minutes-times-10" (rounded up to the nearest minute) is subtracted from the total score during a given round.
4. Successfully leaving the starting area and demonstrating intelligent autonomous navigation for *not less than* 30 seconds (**c**) is worth 100 points (and refund of the \$100 application fee).
5. Successful "sample" disk acquisition from a drum (**d**) is worth 300 points. A disk dropped within 3 meters of the drum does not count as a successful acquisition. Note from the scoring formula below, that successful retrieval of the sample is essential to you mission.
6. Successful completion of the entire mission (**e**) is worth 500 points. This includes autonomous take-off, flight, accurate mapping of all drums, identification of the contents of each drum (radioactive, biohazard, or explosive), retrieval of the contaminated sample disk, and autonomous landing back in the starting area. **Subjective Measures:**
7. Elegance of design and craftsmanship (**f**) on a scale of zero to 30 (highest).
  - Component integration (0-10).
  - Craftsmanship (0-10).

- Durability (0-10).
- 8.
  9. Innovation in air vehicle design (**g**) on a scale of zero to 70 (highest).
    - Primary propulsion mechanism {lift} (0-10).
    - Attitude adjustment scheme {yaw/pitch/roll/lateral} (0-10).
    - Navigation technique (0-30).
    - Drum identification technique (0-10).
    - Disk retrieval mechanism/scheme (0-10).
  - 10.
  11. Safety of design to bystanders (**h**) on a scale of zero to 200 (highest).
    - Isolation/shielding of propulsors (0-50).
    - Containment of fuel and exhaust by-products (0-25).
    - Crashworthiness (0-25).
    - Emergency flight termination mechanisms (0-100).
  - 12.
  13. Each team is required to submit a journal-quality paper (written in English) documenting its project. This paper (**i**) is worth between 50 and 200 points depending on technical quality (50 points minimum for submitting a credible paper, and -100 points for those *not* submitting a paper by the deadline). Papers are limited to 10 pages (including figures and references, if any). The format shall be single-sided with text occupying a space no greater than 9 inches tall by 6.5 inches wide on each page. Font size shall be 12 point (serif font) with 14 point leading. The example format is provided as an addendum to the rules. Topics to be covered include: competitive strategy, how your vehicle design achieves your strategy, propulsion, stability augmentation schemes, navigation schemes, drum identification schemes, and "sample" disk retrieval mechanism. **Five copies of your paper are due to the application submission address by June 1, 1997.**
  14. Best team Tee Shirt (**j**) (10 points to the best, 0 points to

others having team Tee Shirts, and -10 points to those not having team Tee Shirts).

In addition to the points scored during the Static Judging (*Subjective Measures*), the teams will be rank-ordered by the judges based on score. The arena starting corners and time slots will be allocated based upon the choice of the teams, with the first choice going to the highest ranked team, the next choice going to the second highest ranked team, and so on until the final time and arena starting corner remaining is assigned to the team ranking lowest based on the *Subjective Measures* during the Static Judging.

The points for a given round will be totaled according to the following formula:

$$\text{SCORE} = [(a + a' - (b * 10) + c + e) * (d / 300)] + f + g + h + i + j$$

The highest score accumulated by any entry after all rounds have been completed will be declared the winner.

## "Air Vehicle" Definition and Attributes

1. "Air Vehicles" are considered to be those capable of sustained flight *out of ground effect* while requiring the earth's atmosphere as a medium of interaction to achieve lift (as such, pogo sticks and similar momentary ground-contact vehicles are not considered to be *flying air vehicles*). The scoring formula and arena have been carefully designed to normalize advantages inherent to a given class of air vehicles such that all may compete fairly to perform the same task. Prospective teams must decide how best to allocate resources

- to maximize their potential score in light of the constraints imposed by the arena, the task, and the scoring algorithm.
2. Air vehicles may not latch onto or use anything in the arena for locomotion or stability. Vehicles crossing over the foul line will be disqualified for that run and must be returned to the starting area.
  3. Each air vehicle must be equipped with an independently-powered, independently-controlled, non-pyrotechnic termination mechanism that can render the vehicle ballistic upon command of the judges (e.g., if using R/C radio equipment, a separate battery and receiver must serve as the independent relay for the onboard flight termination signal). This termination mechanism must be demonstrated to the judges prior to the first round. Air vehicles may be landed under manual control of a safety pilot in the event of an emergency, but the points that could be awarded for that run will be forfeited. Both autonomous and manually-assisted landings must occur within the foul lines of the Competition Arena.

## Judging

1. A team of three judges will determine compliance with all rules. Official times and measures will be determined by the judges. [Subjective measures \(6-10\)](#) will be judged in accordance with a schedule to be announced a week prior to the competition. Team papers will be ranked and scores assigned to them at this time, though they will have been reviewed by the judges in advance of this static judging.

## Grounds for Disqualification

1. Vehicles crossing over the foul line will be disqualified for

- that run only.
2. Judges will disqualify any vehicle which appears to be a safety hazard.
  3. Intentional interference with a competitor's run will result in disqualification of the offending contestant's entry.
  4. Damaging the Competition Arena, disks, or navigation aids may result in disqualification.
  5. Actions designed to damage or destroy an opponent's vehicle are not in the spirit of the competition and will result in disqualification of the offending contestant's entry.

## Prize Awards

1. A cash award will be made to the single team having the highest score achieved during any fully autonomous round in which a drum is correctly located, identified, and the "sample" disk is successfully retrieved. In the event that *no* air vehicle is capable of successfully locating even a single drum during any round, the method of prize money distribution will be at the discretion of the judges -- however any partial awards resulting shall not exceed \$1,000 per award with the total allocated to such partial awards not to exceed \$5,000.
2. International recognition for the winning students' university.
3. International recognition through AUVSI for the winning industrial/government/faculty organization.
4. Free full-page advertisement for the winning company, governmental agency, or university faculty department in *Unmanned Systems* magazine. If more than one industrial/government/academic entity is supporting the team, then the student component shall designate which partner has supplied the greatest assistance (in whatever form), and *that* partner shall receive the free full-page advertisement.
5. All teams are invited to submit papers to the AUVSI-97

International Symposium and Exhibition describing their designs and strategies. These should be submitted for presentation in one of the air vehicle sessions by the regular submission deadline announced in a forthcoming call-for-papers. Also, exhibit space can be made available to all teams wishing to showcase their technology at the symposium by contacting AUVSI headquarters. (*Teams having their entries on display in the exhibit hall have found this to be a good way to make further contacts for their universities and for themselves as graduates*). Note that the AUVSI-97 International Symposium and Exhibition will be held *prior* to the competition in Baltimore, Maryland.

## Schedule

### **REMEMBER THESE IMPORTANT DATES:**

1. Notification of intention to compete   October 21, 1996
2. Application and Fee Deadline           November 1, 1996
3. VHS Video of air vehicle flying        March 1, 1997
4. Journal quality paper                   June 1, 1997
5. Static Judging                           July 12, 1997
6. Practice Day on the arena               July 13, 1997
7. Performance judging                    July 14, 1997
8. Rain-day for performance testing       July 15, 1997