Official Rules for the International Aerial Robotics Competition

MISSION 7

INTRODUCTION
The primary purpose of the International Aerial Robotics Competition (IARC) has been to “move the state-of-the-art in aerial robotics forward” through the creation of significant and useful mission challenges that are ‘impossible’ at the time they are proposed, with the idea that when the aerial robotic behaviors called for in the mission are eventually demonstrated, the technology will have been advanced for the benefit of the world.

As such, the International Aerial Robotics Competition has not been a “spectator sport”, but rather a “technology sport.” Since its inception, over twenty two years has passed with six successful missions having been accomplished. Each time a mission was accomplished, some aspect of the state-of-the-art in aerial robotics was advanced beyond that which had previously been demonstrated.

During Mission 1, the ability to fully autonomously fly and navigate without inertial systems was demonstrated using a triad of carrier wave GPS antennas/receivers, as was the ability to pick up objects in one location and deposit them in another.

During Mission 2, autonomous aerial mapping, millimeter target identification, and object retrieval was demonstrated using differential GPS technology for navigation.

During Mission 3, the ability to perform an autonomous search and rescue mission was demonstrated, incorporating location and discrimination between injured survivors and the dead, avoidance of real threats to the aerial robot (15 meter flames, water geysers) in a cluttered, smoke obscured environment, and mapping of a disaster scene.

During Mission 4, autonomous aerial robots demonstrated the ability to fly long distances (3 km), find a village, find a specific building in that village, identify all of the valid openings (open windows/doors) in that building, and insert an autonomous sub-robot into that opening.

During Mission 5, the Mission 4 goals were extended to assume that the autonomous sub-robot was able to fly, and that it needed to map the interior of the building and locate an object. SLAM (simultaneous localization and mapping) techniques were used to achieve this mission.

During Mission 6, the autonomous indoor flight scenario was further refined and completed by requiring a fully autonomous aerial robot to map the unknown interior of a building, avoid or defeat security measures, read and interpret printed directions on the walls (written in Arabic) to locate a specific room and remove a small object while replacing it with another like object before rapidly exiting the building as part of a simulated espionage mission. These mission goals were demonstrated during August of 2013 through the use of SLAM techniques and object recognition.
MISSION 7

It is not the intent that the IARC repeat prior technology demonstrations, but to push new areas of aerial robotic behavior. Picking up and moving objects has been amply demonstrated over the first six missions. The use of GPS and SLAM techniques to navigate has likewise been well established over the past six missions. So what new behaviors are yet to be demonstrated in a fully autonomous aerial robot?

Mission 7 will challenge teams to demonstrate three new behaviors that have never been attempted in any of the past six IARC missions. First, “interaction between aerial robots and moving objects (specifically, autonomous ground robots).” Second, navigation in a sterile environment with no external navigation aids such as GPS or large stationary points of reference such as walls. Third, interaction between competing autonomous air vehicles.

Incorporating these three behaviors and capabilities into a single mission is a challenge in and of itself, but after analysis of comments from many experts in the field of aerial robotics, machine vision, and cognitive sciences, as well as a review of the pertinent literature, a manageable and fair test of these behaviors is a reasonable expected outcome from the mission described below.

Before enumerating the details and the administration of Mission 7, consider the envisioned implementation of the mission through an example approach to each of the three behaviors required.

**Interaction between Aerial Robots and Ground Robots:** During Missions 1 through 6, IARC aerial robots have been required to interact with, and manipulate, stationary ground objects... however never before has the IARC required teams to develop the capability to track randomly moving objects and interact physically with them. Mission 7 incorporates this new behavior. This behavior has application to the use of aerial robots from moving platforms such as ships, trucks, or even other air vehicles.

Mission 7 will use off-the-shelf ground robots that are available to all teams for testing back in their laboratories. The ground robots to be used are inexpensive (under $150) iRobot Create® Programmable Robots which are available to any team for testing. The IARC will provide the robots used in the competition at both venues, and it will also make the programming source code that will be used in the IARC available to all the teams so that they can conduct tests with ground robots that exhibit the same behaviors to be encountered in the arena. Details about the iRobot Create® Programmable Robot can be found here: iRobot Create

**Navigation without External Navigation Aids:**
The use of GPS, and to a lesser extent, SLAM, has become prevalent in the world of aerial robotics. Many of the same missions that have been flown with these navigation aids over the past 22 years could have been conducted by a trained animal or human without the use of GPS or SLAM. So why should our aerial robots be dependent on these external navigation aids, especially when working in a confined space? Mission 7 eliminates these off-the-shelf nav-
igation solutions by being conducted in a GPS-free indoor environment that is devoid of obvious physical cues. Teams will be encouraged to devise other methods for stability and control, as well as navigation in the same way that a living organism might have to solve the problem.

An example of a technique that could be used to solve the navigation problem in Mission 7 would be “optical flow.” It has been demonstrated in the laboratory that honeybees and other flying creatures use optical flow to assess speed, altitude, and drift when navigating. There is no reason why our autonomous aerial robots should not similarly be able to leverage such passive navigation techniques.

**Interaction between Multiple Aerial Robots:** Reliable interaction between unmanned aerial systems and manned or unmanned aircraft is an essential capability that is necessary before civil aviation authorities will allow unmanned aerial vehicles to operate in manned airspace for civilian applications. The requirement is referred to as “sense and avoid”. Air vehicles must be able to sense the presence of fixed and moving obstacles to avoid collision. Presently, the state-of-the-art in sense and avoid technology for unmanned aerial vehicles is in its infancy, and has never been reliably demonstrated in a fully autonomous aerial robot. This aerial robotic behavior, once demonstrated, rates very high on the state-of-the-art importance scale.

Concerns by teams that their aerial robotic vehicle investment may be jeopardized by collisions of vehicles should drive their designers toward more robust designs. The IARC scoring formulas will also reward robust “crash-proof” air vehicle designs. For example, the design shown in this YouTube video ([Robust Robot](https://www.youtube.com/watch?v=Robust_Robot)) is highly robust and would survive most any collision that might occur during the IARC.

**MISSION 7 OVERVIEW**

The seventh mission of the IARC will ultimately involve a head-to-head competition between aerial robots that will incorporate the three new behaviors described in the previous section of these rules. Before teams will be invited to compete head-to-head, they will be required to demonstrate that their design can perform the required behaviors necessary for a fair and meaningful head-to-head competition. This is referred to as “Mission 7a”. Only those teams capable of demonstrating the behaviors of Mission 7a will ultimately be invited to compete head-to-head for an additional “super prize”. This head-to-head competition is referred to as “Mission 7b”. Mission 7b will involve two teams’ aerial robots competing against each other in the same arena simultaneously.

As an incentive, all Mission 7a teams demonstrating the essential behaviors required to be invited to Mission 7b, will receive a one-time $1,000 award when they attend either the American or Asia/Pacific Venue. The ultimate winner of the initial IARC Mission 7a will be based on the highest numerical score (see the section on SCORING). The winning team will receive a $30,000 prize. Soon thereafter, the IARC Judges will select the “best of the best” to be invited to go head-to-head for the even larger “super prize” in Mission 7b. The organizers reserve the right to increase the prize amount at any time. Mission 7a can be thought of as the “Qualifier” for Mission 7b. Both Missions 7a and 7b will have an independent large monetary prize awarded to the best team based on its final numerical score.
Mission 7 Aerial Robotic Behavioral Demonstration

1. A square arena is marked on the ground in an indoor GPS-free arena. This square arena will be 20 meters on each side. The boundary shall consist of wide white lines bounding the sides of the square arena, with a wide red line on one end, and a wide green line on the other end as shown in the figure.

2. Ten (10) iRobot Create® programmable ground robots will be placed at the center of the arena. The orientation of the ground robots will be such that they will initially move in all directions of the arena. The aerial robot will launch from a white side of the arena.

3. When the run begins, the ground robots begin to move toward the boundaries of the arena, but as collisions occur, they will reorient themselves to move in different directions or, after about 20 seconds of travel, they will redirect themselves. Eventually when a ground robot reaches any edge of the square arena, it is permanently removed from the arena.

4. Each robot has a magnetic influence sensor on the top. If an aerial robot comes close enough to just “touch the top” of the ground robot with a rare earth magnet, the ground robot will change its direction of movement by 45 degrees (clockwise).

5. It is the job of the autonomous aerial robot to redirect the ground robots and herd them toward the green side of the arena such that as many as possible cross over the green line. This is achieved by descending onto the top of a ground robot, the effect of which will be to cause the ground robot to change its direction by 45 degrees (clockwise). For example, descending upon the same ground robot twice will result in the robot’s direction changing 90 degrees (clockwise). Landing in front of a ground robot to induce a collision which will also cause the robot to change its direction of movement, but by 180 degrees. Ground robots that happen to collide will likewise change direction by 180 degrees.

6. In addition to the 10 ground robots that need to be herded toward the green end of the arena, there will be 4 robots with tall cylinders extending vertically from their upper surface (up to two meters maximum). These special ground robots will be preprogrammed to circle within the arena and to serve two functions. The first function is as a source to help randomize the motion of the other 10 target robots by periodically causing collisions that reorient those robots. The second function is to provide moving vertical obstacles that must be avoided by the aerial robot as it uses its sense and avoid technologies. Should impact occur between the aerial robot and one of the cylindrical obstacles, the run will be terminated.

7. The autonomous aerial robot must analyze the directions of the various ground robots and redirect them toward the green end of the arena while avoiding the four obstacle robots. Aerial robots must stay within the boundaries of the arena, but are allowed to go up to approximately
two meters outside the boundary momentarily (for up to 5 seconds). Aerial robots must not exceed an altitude of three meters above the floor, and they are allowed to land inside the arena.

8. Strategies involved would be to redirect robots that are closer to the red or white edges of the arena before contending with robots that are either still close to the center of the arena, or which are generally on track toward the green end of the arena.

9. All of the robots are autonomous (both ground and air). When the run begins, the aerial robot should do everything that it can get the ground robots to the green edge of the arena while avoiding the obstacle robots. The run will be over when all of the ground robots either reach the green edge of the arena, or go out of bounds on either of the white edges or the red edge. In any event, assuming that there are still active (non obstacle) ground robots in the arena, the run will be terminated after 10 minutes, and any robots not yet over the green line will be considered to have gone out of bounds for the purposes of scoring. Completing a run in less time is a determining factor in the selection of the final grand prize winner.

11. To diminish the effects of bad “luck,” each team will be allowed to perform a total of three times, and the one best performance out of the three attempts will be used as the final score for that team. The team with the highest score at the end of Mission 7a will be declared the winner.

12. Mission 7a design strategies and capabilities will include speed, energy endurance, object recognition, air vehicle/ground vehicle interaction, tracking moving targets, maneuvering to land (momentarily) on (or in front of) a moving target, target identification, target prioritization, knowledge of the progress of ALL targets, obstacle avoidance, and the ability to navigate without external cues such as GPS or beacons. All of these must be demonstrated during Mission 7a in order to be eligible for Mission 7b.

GENERAL RULES GOVERNING ENTRIES
1. Vehicles must be unmanned and autonomous. They must compete based on their ability to sense the unstructured environment of the competition arena. The size of any aerial robot shall be limited to 1.25 meters in any dimension. There is no weight limit.

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 boundary and uni- or bi-directional data may be transmitted to/from the vehicle in the arena, however there shall be no human intervention with any ground-based systems necessary for autonomous operation (computers, navigation equipment, links, antennas, etc.).

3. Data links will be by means of radio frequencies in any legal band for the location of the arena.

4. The air vehicle must be free-flying, autonomous, and have no entangling encumbrances such as tethers. The air vehicle can be of any type. During flight, the maximum dimension of the air vehicle can not exceed 1.25 meters. The vehicle must be powered by means of an electric motor using a battery, capacitor, or fuel cell as a source of energy. The vehicle must be equipped with a method of manually-activated remote override of the primary propulsion system.
5. Upon entering the arena under autonomous control, aerial robots must remain within the bounds of the arena or the attempt will end. The exception to this is any brief excursion of no more than 2 meters beyond any boundary line for less than 5 seconds. Vehicles leaving the arena or in the Judges’ opinion, are about to leave the arena at a high rate of speed, will have their flight terminated by a Judge. Flight termination actuation will be controlled by a Judge, not the team. Each team will supply the designated Judge with its manually-actuated safety shutdown control as they enter the arena prior to their attempt, and must demonstrate that the safety shutdown device is functional for the Judge.

6. The ground station equipment and safety shutdown device, must be portable such that it can be setup and removed from the arena quickly.

THE IARC COMMON SAFETY SWITCH
Safety has always been a primary concern of the International Aerial Robotics Competition and an effective “safety switch” has always been a part of the Competition requirements. Often teams arrive at the IARC with safety switch solutions that are not independent of the onboard computer, or are in other ways inadequate. Teams without acceptable safety switch mechanisms are NOT allowed to fly.

A simple and effective means of killing power to the motors of a small air vehicle through the use of a separate radio control receiver has been developed by a member of the IARC Judging staff so that teams can be assured that their safety switch will be acceptable to the Judges on the day of the Competition. This design can be copied and built as is, or used as a reference design for teams to implement into their own vehicle. This design is considered the standard design by which other safety switch mechanisms will be judged. Teams are not required to use this design, but are encouraged to do so. The details of the design can be downloaded as a .zip file by going to: Safety Switch.

ARENA SPECIFICS
A square arena will be marked on the ground in an indoor GPS-free area. This square arena will be 20 meters on each side. The boundary shall consist of approximately 8 cm wide white lines bounding the sides of the square arena, and an 8 cm wide red line on one end, and an 8 cm wide green line on the other end of the square arena. An approximately 8 cm wide white line will bisect the arena in a direction parallel to the red and green ends. The floor space inside the arena will be optically textured with an unknown random or regular pattern. The arena will be two-dimensional, having no vertical dimension. Lighting in the arena will be an unknown, though it will likely be what would be encountered in a gymnasium.

OPERATIONS
Teams will be given three (3) flight attempts. Each team will be given 10 minutes to setup their system and adjust parameters. If the team is unable to launch an aerial robot within the 10 minute window, one attempt is forfeited. Each team is granted one (1) pass. Once a set of attempts has been completed by a given team, the entire team will be required to leave the arena. No hardware may be left in place.
During the static inspection of the aerial robot by the Judges, the aerial robot will be measured to verify the 1.25 meter maximum dimension constraint. The aerial robot size measurement will be made with appendages, rotors, propellers, etc. in the widest orientation. The aerial robot will also be examined to assure that all safety shutdown switch functions are fully operational prior to flight.

**MAKING APPLICATION TO ENTER**

The official web pages for the competition are your source for all information concerning rules, interpretations, and information updates regarding the competition. In anticipation of the upcoming event, the official rules and application form will be obtained from the official 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: http://www.aerialroboticscompetition.org/

The application form is available electronically at:

http://www.aerialroboticscompetition.org/entryform.php

All submissions must be in English. The completed application form is not considered an official entry until a check or money order for 1000 U.S. Dollars is received by mail on or before May 1, of the current year for which a team officially enters the Competition (this is a one-time application fee). **For the American Venue**, the application fee should be sent to the attention of the Competition organizer, Robert Michelson, P.O. Box 4261, Canton, Georgia 30114, U.S.A. The application fee (in the form of a check or money order) should be made out as follows: SEPDAC Inc.† Checks or money orders made out to any name other than “SEPDAC Inc.” will be returned. **For the Asia/Pacific Venue**, Beneficiary: China (Yantai) Asia-Pacific World Trade Center Account Bank: BANK OF CHINA YANTAI BRANCH LAISHAN SUB-BRANCH Account No.: 2130 1468 7629; Bank Address: No. 139 Yingchun Street, Yantai, Shandong Province, China; SWIFT CODE: BKCHCNBJ51A

This application fee covers all of the events for Mission 7a and 7b until it is achieved. Teams entering for the first time subsequent to 2014 are still liable for the application fee. (This fee has been instituted to discourage teams from applying that are not serious competitors).

Upon receipt of the one-time application fee, your team will become “official” and will get listed on the official web site (this helps you to gain sponsorship grants), and co-sponsors offering special promotions will be notified that your team is eligible for these offers (see offer details as they become available at: http://www.aerialroboticscompetition.org/).

A brief concept outline describing the air vehicle must be submitted for safety review by the Judges (the application form provides space for this). The Judges will either confirm that the submitting team design concept is acceptable, or will suggest safety improvements that must be implemented in order to participate.

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† SEPDAC Inc. is a 501c3 tax exempt Georgia corporation established in part, to support the goals and missions of the International Aerial Robotics Competition.
A web page showing a picture of your primary aerial robot flying either autonomously or under remote human pilot control must be posted/updated by June 1 of each year to continue to be considered as a serious entry. The web page should also include sections describing the major components of your system, a description of your entry’s features, the responsibilities of each of your team members, and recognition for your sponsors. At least one picture of your vehicle flying is required, though additional photographs of the other components comprising the system are desirable. People accessing your page should be able to learn something about your system from the pages. Web pages that are deemed adequate will be listed with a link from the official Competition web site.

A research paper describing your entry will be due by the date shown at the bottom of these pages. The paper should be submitted electronically in .pdf, .docx, or .doc format via the upload feature at the Official IARC website (no hard copy is required). This paper will be presented as part of the annual Symposium to be conducted in concert with the IARC. Presentation at the Symposium is mandatory for all competing teams and is part of the static inspection process. Teams should augment their presentations with Keynote or PowerPoint presentations. Each team paper will be posted at the Official IARC web site after the event.

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

Since Mission 7 of the International Aerial Robotics Competition was announced in AD2013 and will run until the mission is completed (at least three competition cycles), anyone who is enrolled in a college or university as a full-time student (as defined by their university) any time during or after the calendar year that the team first made application for Mission 7a, is qualified to be a “student” team member.

LOGISTICS
Each team will be given three attempts during the total time allotted for performance judging. Within these three attempts the team shall demonstrate as much as it can. Due to the fact that the competition is not schedule driven, no team will be able to choose what time of day it will be making its attempt(s). The Judges will announce the starting order. After an attempt has been made, the team can choose to continue and make an additional attempt (within 10 minutes) or leave the arena and reenter the performance sequence. If a team is not ready to make an attempt when in sequence, it is allowed one “free pass” but must be prepared the next time or the lose one attempt. Each team will be allotted 10 minutes to start an attempt. The team captain will declare to the Judges the start of an attempt. If in the opinion of the Judges an attempt fails due to a situation beyond the team’s control, it will not count against the team’s remaining allotment of attempts.

A specified “Staging Area.” will be located outside of the competition arena. There will be a specified “Contestant Area.” During the performance, the vehicle operator interface and vehicle operators, with the exception of the safety pilot, will be stationed in the Contestant Area. The team that is next
in the competition sequence shall begin staging their equipment in the Staging Area. If the next team is planning to “pass” then at least one member of the team shall be present in the Staging Area. Once the currently performing team has finished and vacated the Contestant Area, the team currently occupying the Staging Area shall move its equipment into the Contestant Area. In the special case where at the end of a performance, the next team in the queue is not present or unrepresented in the Staging Area, one (1) attempt will be forfeited by that team and the Judges will call for the next team in the queue to move into the Staging Area where they will have 10 minutes to prepare prior to moving forward into the Contestant Area.

Points will be used to determine team rankings and any progress awards apart from the grand prize. Judges will score each valid attempt, with the highest score being used to determine the final ranking score.

Teams may have no more than one entry, though that entry may be comprised of any number of backup vehicles. Only one team may be affiliated with any particular university (though different universities may band together to form a single team). If several teams wish to enter from a single university, a decision must be made by the university (not the IARC) 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 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. Having a strong, involved Faculty Advisor has proven beneficial to all winners in the past.

To discourage multiple entries from a university, each team vying to represent the university must submit its individual applications in accordance with the schedule shown at the bottom of these pages, along with a nonrefundable 1000 U.S. Dollar application fee. No application will be considered valid without the accompanying fee being received. 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.

SCORING

Grand Prize Eligibility: Scoring will be based on performance of particular autonomous behaviors. Only those demonstrating the Mission 7a behaviors as defined above, are eligible to receive the grand prize cash award. In addition to the demonstrated behaviors described above, the journal quality paper describing the team’s entry (defined below) must be submitted by the designated date.

Who will be Declared the Winner of the Grand Prize: The team receiving the highest numerical score when the minimum mission is achieved, will win the AUVSI Foundation grand prize money and be declared the winner of the entire Mission 7a competition if no other teams are able to perform equally well in any given year. The minimum mission is defined as getting at least 7 ground robots that were “touched on top” by the aerial robot, go across the green boundary before the end of the run. Other factors in the scoring formula (below) will determine the final score. In the event that multiple teams execute the minimum mission with the same aggregate score, the team performing in the least amount of time (±1 minute) will be deemed the winner.
A team’s score will be based on a number of factors as follows:

**Effectiveness Measures:**
Points allotted for the following:

1. Avoiding all obstacles without collision (A) (+1000 points)
2. Points for each ground robot crossing the green line (B) (+2000 points).
3. Points for each ground robot crossing any other boundary (C) (-1000 points).
4. Per minute penalty until the end of the run (D) (-100 points/minute to compete a run).
5. Except for launch and recovery, fully autonomous operation (Z) is required (+1), else (0).
6. Mission failure due to obstacle collision (X) (+1 for success), else (0 for failure).

**Subjective Measures:**

1. **Elegance of design and craftsmanship (E)** (up to +1500 points).
   1.1 Component integration (0 to +250).
   1.2 Craftsmanship (0 to +250).
   1.3 Durability/Robustness (0 to +1000).

2. **Innovation in air vehicle design (F)** (up to +1500 points).
   2.1 Primary propulsion mechanisms (0 to +300).
   2.2 Attitude/heading adjustment schemes (0 to +300).
   2.3 Navigation techniques (0 to +300).
   2.4 Target identification techniques (0 to +300).
   2.5 Threat avoidance schemes (0 to +300).

3. **Safety of design to bystanders (G)** (up to +1750 points).
   3.1 Isolation/shielding of propulsors (0 to +1000).
   3.2 Energy source stability/safety (0 to +250).
   3.3 Crashworthiness (0 to +500).

4. **Journal Paper.** Each team is required to submit a journal-quality paper (written in English) documenting its project. This paper (H) is worth between -1000 and +1000 points depending on technical quality (0 points minimum for submitting a credible paper, and -1000 points for those not submitting a paper by the deadline). Papers are limited to 12 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 centered 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 (see: paper format). Topics to be covered are detailed in a printable document found at: paper content. A file (<50 MB in size) in .pdf format of your paper is due by June 1 of each qualifier year. Papers are to be uploaded via the website upload facility by the due date. All papers will become part of the IARC Symposium proceedings for that year and will therefore serve as a publication reference on team member résumés.

5. **Best team T-Shirt (I)** (500 points to the best, 100 points to others having team Tee Shirts, and -100 points to those not having team Tee Shirts).
The teams will be rank-ordered by the judges based on score. Scores for a given round will be totaled according to the following formula:

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    \text{SCORE} = x \ (A + B + C + D + E + F + G + H + I) \ z
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The highest score accumulated by a given entry after all runs have been completed in any event year will be considered that team’s current ranking for that year.

**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 tasks. 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 only land within the arena while fully autonomous except when overridden by the safety pilot (which terminates the attempt). Initial launch must be autonomous and without human assistance other than to issue the launch command via a switch, voice control, or other electronic interface. Vehicles crossing no-fly boundaries, or which seem to be going away from a logical path leading to the target zone, will be brought back under safety pilot control or terminated by the Judges.

3. Each air vehicle must be equipped with an independently-controlled, non-pyrotechnic termination mechanism that can render the vehicle ballistic upon command of the Judges. This termination mechanism must be demonstrated to the Judges prior to each round of each event. Air vehicles may land under manual control of a safety pilot in the event of an emergency, but credit for that run will be forfeited unless manual control is exercised AFTER the mission has been completed in full. Both autonomous and manually-assisted landings must occur within the boundaries of the Competition arena or staring area.

**SUMMARY OF ROBOT, ARENA, AND MISSION PARAMETERS**

*Target Ground Robots††*

1. Trajectory Noise Occurs = 5 second interval
2. Amplitude of Trajectory Noise = 0° ≤ noise ≤ 20°
3. Period of Trajectory Reversal = 20 seconds
4. Direction of Trajectory Reversal = 180° (“clockwise”)
5. Rotation of Trajectory for Collision = 180° (“clockwise”)
6. Rotation of Trajectory for “Top Touch” = 45° (“clockwise”)
7. Speed = 0.33 m/s
8. Initial Radius of Mission Robots (all facing outward, equally spaced) = 1 m
**Obstacle Ground Robots**
1. Trajectory Noise Occurs = Never
2. Amplitude of Trajectory Noise = 0°
3. Period of Trajectory Reversal = Never
4. Direction of Trajectory Reversal = 0°
5. Rotation of Trajectory for Collision = 0°
6. Rotation of Trajectory for “Top Touch” = 0°
7. Speed = 0.33 m/s
8. Initial Radius of Obstacle Robots = 5 m
9. Initial Direction = “clockwise”
10. Trajectory = 10 m diameter circle (centered on arena)

**Arena Dimensions**
1. 20 m x 20 m Square
2. Red boundary at one Edge
3. Green Boundary at Opposite Edge
4. White Boundaries on either Side
5. White Center Line Bisecting Square and Parallel with Green and Red Edges
6. White 1 m Circle at Geometric Center of Arena to Facilitate Initial Robot Placement
7. Four White Dots to Mark starting Location for Obstacle Robots.
8. Boundary Line Width = ~7 cm (two-dimensional tape or paint on ground)

**Mission Parameters**
Duration <= 10 minutes
Mission Robots that Leave Arena = Eliminated (Negative Score)
Mission Robots that Remain in Arena after 10 minutes = Eliminated (Negative Score)
Mission Robots that Cross Green Edge in under 10 minutes = Eliminated (Positive Score)
Mission Robots that Fail During Run = Eliminated (No Affect on Score)
Mission Robots that Fail During Run = Left in Arena as Static Obstacles
Obstacle Robots that Fail During Run = Left in Arena as Static Obstacles
Obstacle Robots that Leave Arena = Eliminated as Obstacles
Aerial Robots that Leave Arena for more than 5 seconds or more than 2 m Beyond Boundary
= Run Terminated (No Score)
Aerial Robots that Collide with Obstacles (other than Ground or Mission Robots)
= Run Terminated (No Score)
Aerial Robots that Return to Manual (Piloted) Control before the End of Run
= Run Terminated (No Score)
Aerial Robot Flight that must be Terminated by Judge for Safety Reasons
= Run Terminated (No Score)

†† These specifications are “typical”, and are provided so that teams can test realistically at home. During the IARC runs, initial conditions may vary to induce more random behavior in the ground robots. The ground robot source code will be provided to officially-registered teams, as will any modifications to the iRobot Create® Programmable Robots so that teams can work with the same equipment that will be provided in the arena.
Judging
A team of three or five judges (per venue) will determine compliance with all rules. Official times and measures will be determined by the Judges. Team papers will have been reviewed by the Judges in advance of the flight performance.

Prize Awards
The following benefits accrue to the teams participating in, and winning the International Aerial Robotics Competition:

1. As an incentive, all Mission 7a teams demonstrating the essential behaviors required to be invited to Mission 7b, will receive a one-time $1,000 award when they attend either the American or Asia/Pacific Venue. The ultimate winner of the initial IARC Mission 7a will be based on the highest numerical score (see the section on SCORING). The winning team will receive a $30,000 prize. Soon thereafter, the IARC Judges will select the “best of the best” to be invited to go head-to-head for the even larger “super prize” in Mission 7b. The organizers reserve the right to increase the prize amount at any time. Mission 7a can be thought of as the “Qualifier” for Mission 7b.
2. Any other awards prior to the completion of the full mission, shall be distributed at the discretion of the Judges.
3. International recognition for the winning students’ university.
4. International recognition through AUVSI for the winning team’s sponsors.
5. Free full-page advertisement in Unmanned Systems magazine for the winning team and its sponsors.
6. Free one year membership for all team members to the Association for Unmanned Vehicle Systems International.

2014 SCHEDULE

<table>
<thead>
<tr>
<th>Event</th>
<th>American</th>
<th>Asia/Pacific</th>
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<tbody>
<tr>
<td>2014 Application Deadline (for teams new to Mission 7a)</td>
<td>May 1</td>
<td>May 1</td>
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<tr>
<td>Current Team web page on line</td>
<td>June 1</td>
<td>June 1</td>
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<td>Journal quality paper (all teams)</td>
<td>June 1</td>
<td>June 1</td>
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<td>*Having flown the Mission 7a at home twice</td>
<td>June 1</td>
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<td>(Recommended strongly)</td>
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<tr>
<td>Final Attendee List due (via IARC website)</td>
<td>July 15</td>
<td>July 15</td>
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<tr>
<td>Teams can arrive on site (earliest x:xx AM)</td>
<td>Aug/Sep</td>
<td>Aug/Sep</td>
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<td>Team Registration (x:xx AM - y:yy)</td>
<td>Aug/Sep+1</td>
<td>Aug/Sep+1</td>
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<td>Subjective Measures Judging (by appointment)</td>
<td>Aug/Sep+1</td>
<td>Aug/Sep+1</td>
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<tr>
<td>2014 Symposium on Indoor Flight Issues</td>
<td>Aug/Sep+2</td>
<td>Aug/Sep+2</td>
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<tr>
<td>Performance Judging (visitors welcome)</td>
<td>Aug/Sep+3</td>
<td>Aug/Sep+3</td>
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<tr>
<td>Performance Judging (visitors welcome)</td>
<td>Aug/Sep+4</td>
<td>Aug/Sep+4</td>
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<td>Arena take-down</td>
<td>Aug/Sep+4</td>
<td>Aug/Sep+4</td>
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<tr>
<td>Awards Banquet</td>
<td>Aug/Sep+5</td>
<td>Aug/Sep+5</td>
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NOTE: “Practice times” for teams to align their systems near or in the Arena, will be on Aug/Sep+1
(but not during the Symposium hours, so don’t ask).