# Official Rules for the International Aerial Robotics Competition
# MISSION 10

## 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.

Mission 10 will build on past missions to demonstrate both enhanced Mission 8 behaviors as well as new aerial robotic behaviors unique to Mission 10.

## TECHNOLOGIES TO BE DEMONSTRATED
Beyond those technologies and behaviors that have been demonstrated during past missions (full autonomy, obstacle avoidance, tracking, etc.) the following are emphasized:

1. Autonomous flight of a (small) swarm of miniature autonomous aerial vehicles (1 pound weight category)
2. Direction of a swarm of small autonomous aerial vehicles by a human, using only gestures or voice commands (no control station[1])
3. A swarm of small autonomous aerial vehicles capable of obstacle avoidance and simultaneous flight coordination
4. A swarm of small autonomous aerial vehicles that can sense targets and mark them physically and/or digitally (mapping in memory) with little redundancy in mine re-discovery by other members of the swarm
5. Ability to plan a safe path based on the collective target (mine) map and to communicate the safe path to the human
6. Rapid survey and decision making
7. Use ONLY onboard computing (no data links except for kill switch and safety pilot override[1]).

*1. For safety, each air vehicle will be under the ultimate control of a safety pilot using an overriding ground control station.*

## VENUES AND INTERNATIONAL TEAMS
Due to the complexity of the arena, the International Aerial Robotics Competition Mission 10 will be conducted at a single venue in the *Unites States of America*. The location of this venue will be announced at the Official IARC website. Instructions about how to enter this competition are given later in these rules. Once a venue is selected, teams will continue to compete at the selected venue unless the venue location is changed in subsequent years for logistical reasons.

It is recommended that international teams requiring visas, begin the visa acquisition process several months in advance of the IARC.

Check customs procedures and in some cases it may make more sense to ship equipment ahead by international courier than attempting to carry it as carry-on or checked baggage.

## U.S. FEDERAL AVIATION ADMINISTRATION (FAA) REQUIREMENTS
The weight class of the aerial vehicles involved in Mission 10 puts them in one of the most favorable categories insofar as the FAA is concerned. Nonetheless, teams are responsible for obtaining any certifications required based on the parameters of their vehicles.

## NARRATIVE
Anti-personnel mines are small explosive devices placed under, on or near the ground. They are "victim-activated" and designed to detonate when a person steps on, handles or comes near it, regardless of whether that person is a soldier or a civilian, or child.

During a conflict, soldiers are the obvious targets of anti-personnel mines, and they are often compelled to traverse regions contaminated by mines, however during and even after a conflict, the groups most at risk from anti-personnel mines are typically people involved in livelihood activities, such as farming, herding and the collection of firewood and water. In many affected communities, people have no choice but to enter areas that may be dangerous due to economic need. Children may also fall victim to mines during play in contaminated areas.

At least 60 countries remain contaminated by antipersonnel mines. Over the past decade, the world has seen a tragic rise in fatalities and injuries from anti personnel landmines and other explosive remnants of war. In 2021 alone, at least 2,182 people were killed and 3,355 injured from these devices.

**MISSION 10**

Goal: Create and demonstrate a personal protection swarm to allow a person to rapidly cross a minefield without triggering a mine through avoidance.

**DEFINITIONS**

*Pressure Mines*:

• These mines activate when a certain amount of pressure is applied to them, typically by a person stepping on the mine. Pressure-sensitive mechanisms inside the mine trigger the explosion.

*Tilt Rod Mines*:

• Tilt rod mines activate when the mine is tilted or disturbed from its horizontal position. The tilting action triggers the internal mechanism and initiates the detonation.

*Tripwire-Activated Mines*:

• Mines equipped with tripwires activate when the tripwire is disturbed or broken. The pulling or tension release on the tripwire triggers the explosive mechanism.

**MISSION 10 ACTION**

Goal: *Enable a person to cross 100 meter minefield in 10 minutes*. Mines encountered will be contact/influence-triggered per the definitions above. The initial focus of Mission 10 is coordination, mapping, communication, and speed rather than detection technologies (e.g., ground-penetrating radar, infrared, hyperspectral, or acoustic/seismic techniques). The miniaturization and refinement of specific sensor technologies is *not* the focus of Mission 10.

The ‘person-at-risk’ releases a swarm of 4 autonomous aerial vehicles (“drones”) each weighing no more than 1 pound.

The drones are directed by the person-at-risk through gestures indicating the direction in which he wants to travel (or voice commands). In turn, the air vehicles scout the path ahead and based on mines detected, provide visual direction to the person-at-risk as to a safe path that avoids the mines by a 1 meter radius around the mine. The air vehicles may also mark the location of mines detected as a visual aid to the person-at-risk, or alternately, mark a safe path on the ground well in advance of the person-at-risk who may stand back while the minefield is surveyed. The drones can also create a digital map that can be displayed in real time on a mobile phone. This is depicted in Figure 1. Again, the person-at-risk must cross to the other side of the minefield before 10 minutes has elapsed.

The air vehicles must track the person-at-risk, be collectively aware of surface and subsurface threats using optical infrared (IR) sensors (simulating aforementioned sensor technologies), must have an endurance of greater than 10 minutes, and must be able to see and avoid each other as well as the person-at-risk and other obstacles during the mission.

Upon completion of the mission, the air vehicles must respond to the person-at-risk's gesture or voice commands to land in a safe location ahead of the person-at-risk.

For simplicity, all mines (Tripwire/Tilt Rod/Pressure/Magnetic Influence Mines) will all be simulated by using sensitive motion/vibration detectors that will trigger the mine for purposes of this simulation. Teams will be provided with the mine specifications beforehand so they can design appropriate sensors. Some mines will have a monofilament cord attached to expand their area of influence.

Some mines may be buried, some may be on the surface, some may be camouflaged. In addition, some objects that could optically appear as an anti-personnel mine will be placed along valid pathways to cause the person-at-risk to hesitate or mistrust the direction of his air vehicles. These dummy mines will not contain the signature necessary for detection by the air vehicles and will be inert. The area will also contain inert objects to confuse the drone sensors. Since this is not a "mine clearing" exercise, but rather, a "mine avoidance" exercise, there will be at least one certified, albeit nonlinear, clear path from the starting location to the other side of the 100 meter minefield.

Activation of the mine will cause it to emit a loud audible tone. Activation of a mine will end the run. If the person-at-risk can make it to the other side of the 100 meter minefield and cause his drones to land in under 10 minutes based on the feedback from his four drones, then that will constitute a successful run. The shortest time to achieve success will determine the winning run.

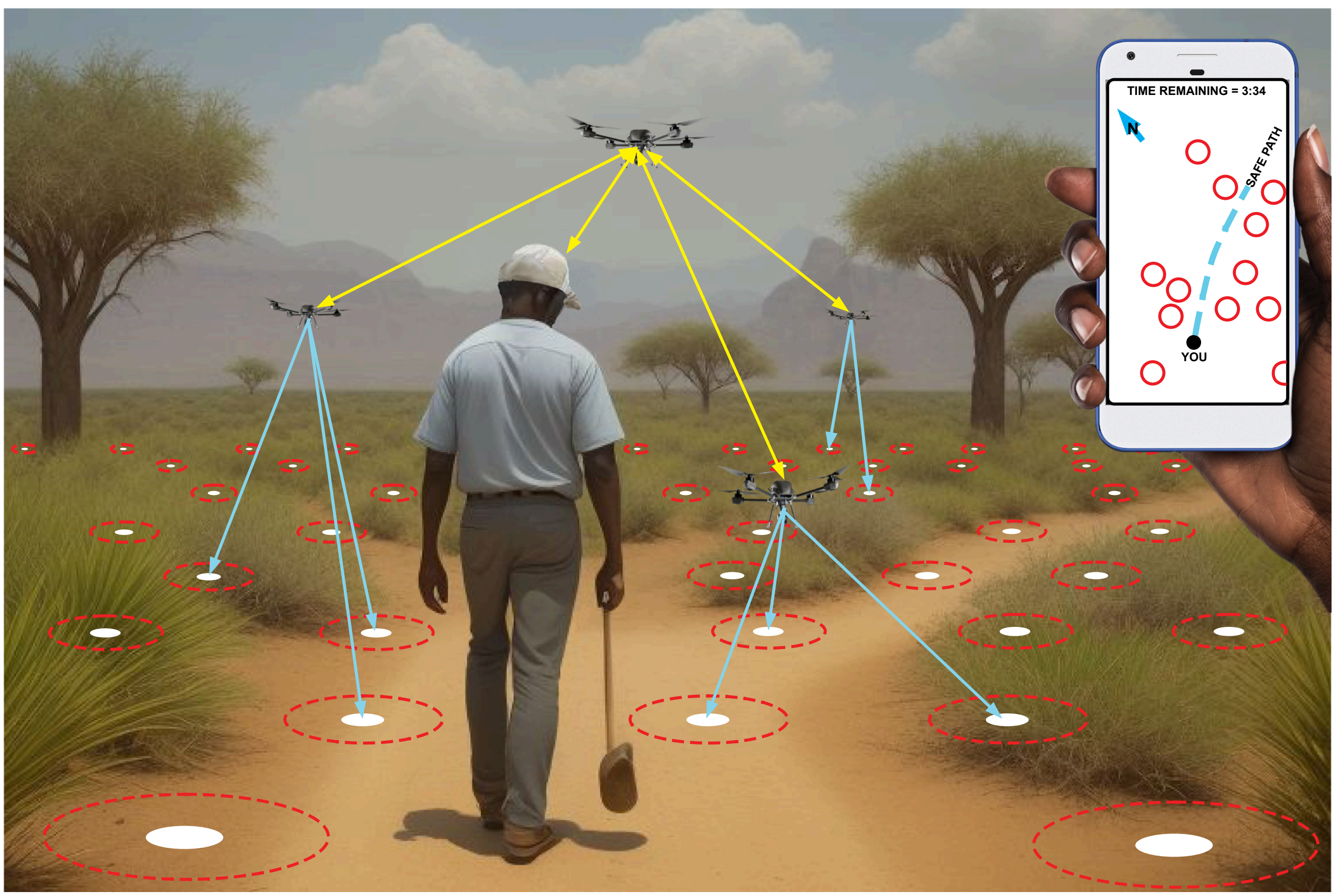


Figure 1. *Minefield mapping scenario showing user interface to a mobile phone.*

The placement of the mines will be readjusted between runs carried out by the same team. The person-at-risk crossing the minefield will be sequestered and not allowed to see previous runs where the location of mines might be disclosed (e.g., by being set off by an opposing team's person-at-risk).

The run begins with the person-at-risk at the beginning of the edge of the minefield. The person-at-risk's autonomous aerial vehicles will be in a backpack (of his choosing) and inactive. Prior to the beginning of the 10-minute run, the person-at-risk's first action will be to deploy the air vehicles outside of the arena. The run will begin when the first air vehicle has entered the arena's boundary. If the person-at-risk has not crossed into the safe zone 100 meters away and caused all 4 of the air vehicles to land outside the arena's boundary by the time 10 minutes has elapsed, the run will be considered unsuccessful.

(IMPORTANT: *Mission 10 behavior focuses on coordination, mapping, communication, and speed rather than detection technologies*)

## COMPETITION ADMINISTRATION

During any competition year, each team will be allowed 3 attempts to demonstrate that it can perform the mission. Before attempts begin, each team must have demonstrated that its vehicle can fly autonomously (including takeoff and landing), and can be controlled without use of a ground station by its operator via voice commands and/or gestures. This is "qualification". Teams unable to meet this minimum qualification requirement, will not be allowed to compete. Once a team has demonstrated these qualifying capabilities, it will then be allowed to compete. The team conducting the mission successfully in the least time will be declared the winner.

The attempt will begin upon the signal of the Judges. Teams must be ready to begin their attempt when called. Each team will have one "pass" allowing them to move to the rear of the attempt queue. Teams that are absent or not ready when their turn in the attempt queue arrives, shall forfeit that attempt.

A monetary prize will be awarded to the team successfully performing the mission in the least amount of time. It is possible that no team will successfully complete the mission in the first year, in which case, the competition will start over in the following year and the prize money will be increased. More than one team may successfully perform the mission in a given year, but the one doing so in the least amount of time will win the grand prize.

Determination of the final winner will be announced once any qualified teams have completed their best attempts during any competition year.

The grand prize will begin at $10,000 and will increase by $10,000 for each year that the mission continues. Industry-sponsored prizes may be added to this base amount as offered from time to time by industry sponsors.

## SCENARIO ASSUMPTIONS

The intent is that the person-at-risk have everything needed in his backpack. The person-at-risk is being compelled to cross the minefield quickly (in under 10 minutes), but coupled with that, it is assumed that there is some issue requiring speedy traversal of the minefield (the person-at-risk is being pursued or others are in serious need of his assistance at some location beyond the minefield). As such, it would be unrealistic for the given scenario were the person-at-risk to delay prior to crossing the minefield. Therefore, even though the 10-minute clock starts when the person-at-risk steps into the boundary of the minefield, the scenario suggests that there is no time to deploy complicated equipment outside the minefield prior to crossing (e.g., setting up a real-time kinematic positioning (RTK) system that, for the single player, would require significant time). The idea is that the player arrives at the edge of the minefield, opens up his backpack and deploys his system (rapidly) such that he can then cross the minefield in under 10 minutes. This scenario does not envision a massive equipment setup prior to traversing the minefield, or that more than a what is contained in the backpack would be required.

Teams will be allowed to measure the corners of the arena to log GPS coordinates upon arrival. There will be no physical walls, fences, or boundaries other than the marking of the arena corners.

Because the solution to MISSION 10 could have real-world application to humanitarian and military mine field traversal anywhere in the world, but especially in regions where mining has already occurred, we would not want to see solutions that are geographically denied; unlike GPS which, in its various forms is ubiquitous (for example, some systems (e.g., PointPerfect) do not have coverage outside of the Americas, Europe, Asia, and Australia. In advancing the state-of-the-art in minefield traversal using fully autonomous aerial vehicles, the team's solutions should be applicable to regions where mining has occurred (e.g., Africa, Middle East, etc.).

Beyond universal availability of GPS, we are not assuming other services to be available in the area where the minefield is found (e.g., we could be simulating some remote place in Africa where cell service is unavailable, short of satellite phones). The possession of a cell phone by the player does not imply that he has cell service (either due to no service, no valid service contract, etc.). During MISSION 10, a cell phone is essentially a hand-held computer with bluetooth or WiFi capability that can be exploited by the person-at-risk's drones. It can also be used for voice commands or GPS. We would not expect it to have access to other external blue tooth or WiFi connections or the internet. For example, the MISSION 10 scenario could be taking place in parts of Central Sahara in Algeria, Libya, and Chad, as well as regions deep within the Congo Basin rainforests in the Democratic Republic of the Congo– places devoid of cell towers and WiFi infrastructure, making these places largely free from typical digital connectivity.

Finally, note that the person-at-risk could abandon anything at the beginning, within the arena, or at the end. In a real-world scenario, someone using the winning system technology might have to traverse several minefields as they make their journey, so it would be a better design to have all of the components reusable and available.

The competition focus should not be on detection methods. Our goal is to advance the state of the art in aerial robotics, not mine detection (e.g., ground penetration radar, magnetic anomaly detectors, thermal mappers, etc.). We want to have inexpensive mine detection so the teams can focus on the aerial robotic aspects.

The person-at-risk is assumed to running from some threat and needs to cross minefields without alerting their pursuers to their presence or activity. Intentionally exploding mines is counter to the scenario goals. For example, the person-at-risk could throw rocks out ahead of themselves in an attempt to explode unseen mines, or they could have their drones explode mines in advance as they progress across the minefield. Exploding of mines for any reason, will end the run.

## AERIAL ROBOT DESIGN DETAILS

Your aerial robot must be fully autonomous and capable of performing all aspects of the mission without human intervention, other than deployment and any voice or gesture behavioral commands.

The vehicle is to be self-contained (no off-board computing). The aerial robot must have an endurance exceeding the 10-minute run time.

Obstacle avoidance must be incorporated into the design. Obstacles could be physical items on the ground, other aerial robots operating in the arena, or the person-at-risk.

The aerial robots must be able to self-navigate using GPS, visual cues, or magnetic headings.

Your aerial robot can be of any configuration (rotary wing, fixed wing, lighter than air, etc.). Propulsion can be electric or fossil fuel, but rocket propulsion or ballistic propulsion is prohibited. Each complete (individual) aerial robotic system (vehicle plus payload) must weigh less than 1 pound (0.453 kg). The person-at-risk will have four of these.

The aerial robot must be able to find mine threats based upon the signature of the simulated mines as provided prior to the Competition. The construction and physical parameters of the simulated mines are detailed in a Resource Addendum to these Official Rules. Sufficient detail is provided in that addendum to allow teams to construct their own simulated mines for testing.

Your safety pilot can override the aerial robot's autonomous flight, but doing so will terminate the run. In addition, an independent "kill switch" must be supplied to the judges. Only a judge will decide when to terminate the flight, not a team member, although in less critical circumstances, the judge may call for the team's safety pilot to bring the vehicle down safely before resorting to the use of the kill switch as a last resort. The kill switch will be able to render the aerial robot completely ballistic (dropping from the air instantly). "Independent" means that the kill switch will have its own transmitter and not use the vehicle's onboard computer to process the kill command (therefore bypassing the flight computer should it fail). The kill switch will have to be demonstrated to the judging staff before teams are allowed to fly.

## THE RUN

A run lasts 10 minutes. A run begins upon the command of a judge. The 10 minute clock begins when the first air vehicle enters the arena. A run ends when either:

(1) The person-at-risk successfully crosses the mine field (arena) and lands his air vehicles,
(2) When 10 minutes has expired,
(3) When there is a collision between the team's aerial robot and any other object,
(4) When a team's aerial robot lands inside the arena boundaries,
(5) When the judges call for the aerial robot to be manually controlled or the kill switch has been operated.

## SIMULATED MINE FIELD PARAMETERS

The arena will be 300 feet (91.44 m) by 160 feet (48.8 m). All mines will exist within this boundary. There will be one or more possible safe routes from the beginning edge to the opposite safe edge. The beginning edge may be either on the 300 foot side or the 160 foot side, but in either case, the safe route(s) across the mine field will lead to the opposite parallel side.

The arena will contain trees (obstacles) as well as open areas. Some cultural items may also exist within the arena (e.g., an abandoned vehicle, building, road signs, pavement).

The number of mines will be unknown to the person-at-risk, and the number/location may change between runs.

Mines could be set in a grid, but based on the anti-personnel type of mine envisioned for MISSION 10, those are most often scattered from the air and so they would tend to be more randomly encountered on the ground– but that is not to say that there might not have been a re-application of mines in the same area over time wherein an initial minefield was hand-laid and mapped, only to have air-scatterable mines applied by others at a later date.

ENTERING MISSION 10

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. To assure that only serious competitors enter, the completed application form will not be considered an official entry until an Application Fee (1500 U.S. Dollars) is received on or before June 1 of the current year for which a team officially enters the Competition, and each subsequent year that the team participates (this fee is NON-REFUNDABLE if a team is either unable to attend or chooses not to attend).

On the final day of the competition in any competition year, each team captain will receive a rebate (1000 U.S. Dollars). Teams failing to show up to the competition, or leaving prematurely, agree to forfeit their rebate.

Teams must be based at a university and must have an identified academic faculty advisor. While a given university may field multiple unique teams, only one team per university unit (school or department) is allowed to compete, and each team must have uniquely-developed aerial robotic hardware (no sharing of aerial robots).

TEAM QUALIFICATION

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 10 of the International Aerial Robotics Competition will run until the mission is complete, 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 originally made application for Mission 10, is qualified to be a "student" team member.

To qualify, a team must submit an acceptable Application Form and Application Fee for each competition year (for example, if Mission 10 runs for 3 years before there is a winner, teams entering each of those 3 years would submit a new application and partially-rebatable Application Fee on or before June 1 of each competition year). If upon arrival at the IARC and prior to the competition, the Judges determine that a team is NOT capable of demonstrating intelligent fully autonomous flight, the team will not be allowed to compete and the Application Fee rebate will not be refunded. The definition of "intelligent" autonomous flight will be the ability each of the four autonomous air vehicles to avoid a 6 foot (1.83m) by 3 foot (0.91 m) obstacle during an autonomous flight while being directed by verbal commands or gestures to fly directly through that obstacle to a point directly on the other side without collision. The air vehicles must be shown to intelligently avoid the obstacle and resume their commanded flight path on the other side (see next section). Further, aerial robots that do not meet safety criteria or which have no remote mechanism for disabling the aerial robot, will not be allowed to compete. Prior to the beginning of the IARC, the Judges will make these preliminary determinations. Those teams found to be in compliance will be allowed to compete in that competition year's event and will receive their rebate.

**PROOF OF "INTELLIGENT" AUTONOMOUS FLIGHT**

1. Four autonomous air vehicles will be launched by voice command or gesture and simultaneously hovering in place 20 feet (6 meters) from a set of 6 foot (1.83m) by 3 foot (0.91 m) obstacles.

2. The four autonomous air vehicles will be commanded by a team member to proceed at an altitude of 4.9 feet (1.5 meters) to a location 20 feet (6 meters) beyond an array of 6 foot (1.83m) tall by 3 foot (0.91 m) wide solid obstacles that are separated by a 1.6 feet (0.5 meters) spacing as shown in the following figure. The obstacles must be directly in the flight path of the vehicles. Vehicles must not be directed to fly above the obstacles, or around the outer obstacles.

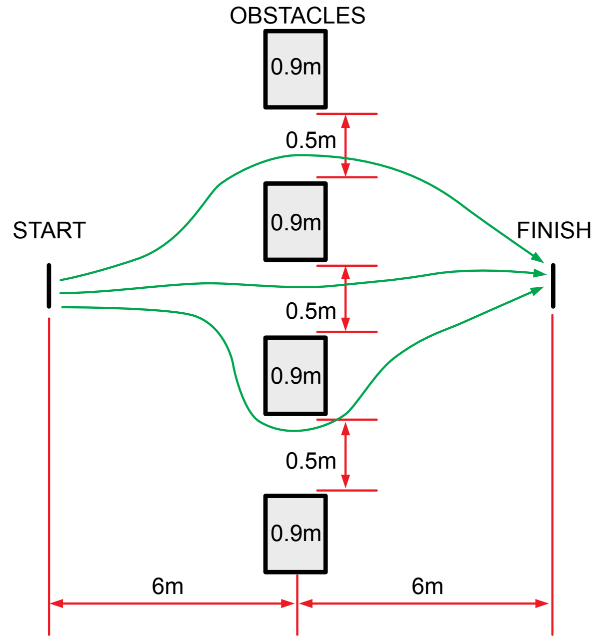


Figure 2. *Autonomous flight demonstration.*
(viewed from above)

**MAINTAINING OFFICIAL COMPETITOR STATUS**

To continue to be considered an Official IARC team, teams must submit an updated online Application, their Application Fee, and a list of expected attendees. All of these items are due by June 1 for any competition year. To advertise your team, and as an aid to gaining sponsors, we recommend that each team maintain a website about their IARC team and its entry (this is not a requirement). Teams that do not comply with these requirements will lose official IARC team status and will be delisted on the IARC competitor web page, but can be reinstated in subsequent years of Mission 10 by meeting these requirements. Unofficial or delisted teams will not be allowed to compete until their status is restored.

**COMPETITION DAYS**

Upon arrival in the city hosting the venue, teams must register their presence online (the IARC website will open a link to the registration page several days prior to the event for this purpose. This registration is a final confirmation of a team's presence and notification of the team's contact information in case last minute change information needs to be relayed to the teams by the Organizers. "Rain days" will be incorporated into the schedule to avoid inclement or hazardous weather.

Since some teams travel great distances and must disassemble their equipment for shipping, a period will be announced when aerial robotic systems can be reassembled and aligned. This is NOT a "practice time", but is a time and place where teams can verify the correct operation of their reassembled systems. The location may or may not be the same as the IARC arena. Teams are expected to come 'ready to compete' and all 'practice' should have already occurred back at their respective universities.

**LOGISTICS**

Details about the venue location, assembly times/dates, suggested lodging, etc. will be announced at the Official IARC website five months prior to each year's IARC event. Questions from teams can be submitted through the Official IARC website.

**Safety Pilots**

All teams' safety pilots must comply with 14 CFR Part 107, referred to as the Small UAS Rule, however it is important to note that the International Aerial Robotics Competition is a purely *recreational* event. *Awards are unrelated to your team's air vehicle or the skill of your safety pilot*, but rather reward the performance of your onboard computing intelligence and sensors.

The arena (simulated mine field) will be under surveillance by multiple visual observers. A safety pilot will only be able to act as a remote pilot for only a single air vehicle at any give time.

The safety pilot for each vehicle will always have line of sight to his air vehicle.

The person-at-risk who is crossing the simulated mine field will always follow the air vehicle swarm and will never proceed beneath any air vehicle. The safety pilot will be responsible to prevent his air vehicle from passing over the person-at-risk.

The safety pilots will assure that no air vehicle exceeds 43 knots (50 miles per hour) or flies higher than 100 feet above ground level.

## 2025 SCHEDULE (*to be updated*)

**REMEMBER THESE IMPORTANT 2025 DATES:**

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|---|---|
| **2025 Application Deadline (*for teams new to Mission 10*)** | **June 1, 2025** |
| **Current Team web page on line (*recommended*)** | **June 1, 2025** |
| **Submit Final Attendee List (*done online*)** | **June 1, 2025** |
| **Team Check-in/Registration (*done online*)** | **(1 to 3 days prior to event)** |
| **Proof of "Intelligent" Autonomous Flight** | **(1 day prior to event)** |
| **Performance Judging (*visitors welcome*)** | **(During Competition Days)** |
| **Awards Banquet (*time and location announced upon arrival*)** | **(the day following Competition)** |