

## 1. MISSION

- a. **Overview.** The mission objectives are for an unmanned, radio controllable aircraft to be launched and transition or continue to autonomous flight, navigate a specified course, use onboard payload sensors to locate and assess a series of man-made objects in a search area prior to returning to the launch point for landing. The scenario of the mission is that you need to operate your system as part of the overall team which supports the United States Marine Corps. It will be entering a simulated combat zone that has both hostile forces and innocent civilians. It shall fly from its operating airfield to the combat zone along a predefined route that is designed to segregate it from manned aircraft as well as enemy air defenses. However your system will need to adjust its route at the last minute just prior to or after takeoff to avoid emerging threats. Additionally, while in route to the combat zone, your system will be asked to positively identify and provide accurate locations of targets that other platforms had detected. Once in the search area, your system will be asked to search the area and detect, identify, and provide the location and orientation of targets within the combat zone. It will also be asked to identify a target at a known location and to determine the location of a specific target. Additionally, if new intelligence dictates, the search area will be modified during the mission to examine a “pop-up” target (the “no-fly” boundaries will remain unchanged). The Marines intend to call in an air strike based on your correct identification and location of hostile forces and put troops in harms way to protect innocent civilians. Therefore accurate identification and location are critical. Additionally, targets and civilians tend to move, so completing your mission objectives in a timely fashion is also important.
- b. **Mission Phases.** The following factors will be scored.
  - (1) Takeoff - Takeoff shall take place within one of two designated Takeoff/Landing areas, depending on wind direction. This area will be paved asphalt surface, roughly 100 ft wide, with no height obstacles. Systems utilizing launchers and/or not performing wheeled landing may utilize the grass immediately adjacent to the runway; however, grass area will not be prepared. Takeoff may be either manual or autonomous (extra points and a cash award will be awarded for autonomous takeoff). After a manual takeoff, the air vehicle shall successfully transition to autonomous flight mode before the next phase of the mission will proceed. For the remainder of the mission, the air vehicle shall maintain steady, controlled autonomous flight at altitudes above 100 feet and under 750 ft MSL. (Note: airfield is at approximately 10 ft MSL)
  - (2) Waypoint Navigation – Air vehicles shall be required to pass over selected waypoints and remain inside of no-fly zone boundaries. During the competition teams will demonstrate dynamic control of their air vehicle

during autonomous flight by flying a predetermined course that includes changes in altitude and in heading.

- (a) Waypoints - GPS coordinates (ddd.mm.ssss) and altitudes will be announced the day prior to the flight competition. However, because of the dynamic nature of modern warfare, it is possible that additional waypoint(s) and or search area adjustment(s) will be required.
  
- (b) In-route Search – Air vehicles will be required to fly specific altitudes and airspeeds while identifying several targets along the predefined entry/exit route. These targets will be selected from the list of targets in the table below. One of the targets will be directly along the route when the vehicle is required to be at 500 ft MSL ( $\pm 50$  ft). Another target will be up to 250 ft from the center of the flight path while the vehicle is required to be at 200 ft MSL ( $\pm 50$  ft). You will be given the position of this target. You shall not be permitted to vary from the flight paths ( $\pm 100$  ft tolerance) briefed during the mission planning in order to obtain an image of the target; flight path deviations shall not be permitted as to avoid being shot down by hostile or friendly forces.
  
- (c) Targets - Targets will be constructed of plywood of a given size, shape, and color, see figure 1. A different color alphanumeric will be painted on the plywood. Basic target information is provided from table 1. Note that there is no correlation across rows and columns.

**Table 1. List of Target Parameters**

<b>Shape</b>	<b>Size (in feet)</b>	<b>Background Color</b>	<b>Alphanumeri c Color</b>	<b>Alphanumeri c Height (in feet)</b>	<b>Alphanumeri c thickness* (in inches)</b>
Square	2 x 2	Red	Red	1	6
Equilatera l Triangle	2 x 4	Orange	Orange	2	12
Rectangle	2 x 8	Yellow	Yellow	6	18
Circle	4 x 4	Green	Green		
Cross	4 x 8	Blue	Blue		
Equilatera l Hexagon	8 x 8	Black	Black		
Equilatera l Octagon		White	White		

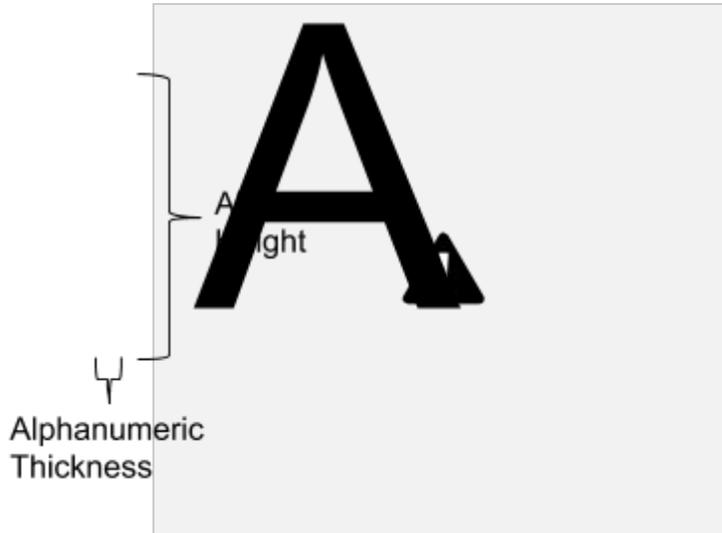


Figure 1. Alphanumeric Dimensions

- (3) Area Search - once transitioning into the predefined search area via the entry/exit route, the air vehicle shall search for specific targets on interest. Air vehicles may search the area at any altitude between 100 and 750 ft MSL. Targets conforming to the general target types and specifications in table 1 will be distributed throughout the search area. Competitors shall record the characteristics (see imagery capability in table 2) of all observed targets on a target data sheet and provide this sheet to the judges at completion of the mission. Note: extra credit will be given for providing accurate and complete target information real time, see section 5.

While executing your search mission, you will be provided with a new search area (within the existing no fly zone boundaries) allowing you to locate “pop-up” targets. There will be a minimum of 200 ft margin between the search area and the no fly zone boundary. Teams choosing to look for these targets shall display the new search area to the operator and judges.

- (4) Landing - Landing shall be performed completely within the designated takeoff/landing area. Transition to manual control is permitted for landing. Extra credit and a cash award will be provided for autonomous landing. Control in landing will be graded. Mission completion is when the air vehicle motion ceases, engine is shutdown, and the mission data sheet and imagery have been provided to the judges.
- (5) Total Mission Time - Total mission time is 40 minutes (threshold) and includes all time from application of electrical power until mission completion. Accuracy of results and time required to submit results will be measured. Points will be deducted for each minute over mission time, up

to 60 minutes total where it is mandatory to turn in results (with substantial penalty). Extra points will be awarded for completing the mission between the 20 minute objective and the 40 min threshold. Extra credit will be given for providing complete and accurate information (actionable intelligence) in real time, but once that information is provided it cannot be modified later, because the Marines will likely have destroyed any target within minutes of you providing the information. Actionable intelligence is all the target characteristics (shape, background color, alphanumeric, alphanumeric color, orientation, and location) provided at that time and recorded on the target data sheet. This will not be considered to be actionable intelligence unless you designate it as such.

## 2. REQUIREMENTS

- a. **Key Performance Parameters.** The following factors will be scored.

**Table 2. Key Performance Parameters**

Parameter	Threshold	Objective
Autonomy	During way point navigation and area search.	All phases of flight, including takeoff and landing
Imagery	Identify any two target characteristics (shape, background color, orientation, alphanumeric, and alphanumeric color)	Identify all five target characteristics
Target Location	Determine target location ddd.mm.ssss within 250 ft	Determine target location within 50 ft
Mission time <sup>(1)</sup>	Less than 40 minutes total  Imagery/location/identification provided at mission conclusion	20 minutes  Imagery/location/identification provided in real time
In-flight re-tasking	Add a fly to way point	Adjust search area

*Note 1: Time is measured from application of power to providing the judges the completed mission report sheet & associated imagery*

Key Performance Parameters are the most important requirements. KPPs make up nearly 85% of the scoring possible for the mission performance portion of the competition. Failure to meet any threshold will be heavily penalized. Performance beyond the threshold up to the objective will receive some bonus points.

Relative importance of the KPP's is approximately as follows:

<b>KPP</b>	<b>Percent of Total Score Possible</b>
Autonomy	Up to 30%
Imagery	Up to 20%
Target Location	Up to 20%
Mission time	Up to 10% <sup>(2)</sup>
In-flight re-tasking	Up to 5%

*Note 1: Penalties for taking longer than 40 minutes (up to 60 minutes total) can result in loss of 20% of the total points available.*

“Shall” indicates a requirement that is mandatory. Failure to meet this requirement will result in no points being awarded in this area.

“Should” indicates a requirement that will provide additional mission capability that is of value to the Marines, but the overall mission objectives can be achieved without meeting this requirement. Some bonus points will be awarded in achievement up to the objective.

“May” indicates a permissible implementation, but is not a requirement

“Will” indicates actions to be taken by the competition judges or other information pertaining to the conduct of the competition.

- b. **Safety.** Systems that do not meet the requirements listed below will not be permitted to fly.
  - (1) The Maximum takeoff gross weight of the air vehicle shall be less than 55 lb
  - (2) The system shall provide sufficient information to the judges to ensure that it is operating within the no-fly/altitude boundaries on a continuous basis.
  - (3) The air vehicle shall be capable of manual override by the safety pilot during any phase of flight.
  - (4) The air vehicle shall automatically return home or terminate flight after loss of transmit signal of more than 30 sec.
  - (5) The air vehicle shall automatically terminate flight after loss of signal of more than 3 minutes.
  - (6) The return home system, if installed, shall be capable of activation by the safety pilot.
  - (7) The flight termination system shall be capable of activation by the safety pilot.
  - (8) Flight termination for fixed wing aircraft without an alternate recovery system (like a parachute) shall select:
    - (a) Throttle closed
    - (b) Full up elevator
    - (c) Full right rudder
    - (d) Full right (or left) aileron

- (e) Full Flaps down (if so equipped)
- (f) For other than fixed-wing air vehicles, similar safety requirements will be assessed which result in a power off recovery in minimum energy manner at a spot on the ground no more than 500 ft radius over the ground from the point of the termination command.
- (9) The Fail-safe check will demonstrate flight termination on the ground by switching off the transmit radio for 30 seconds or 3 minutes (whichever applies) and observing activation of flight terminate commands.
- (10) The maximum airspeed of the air vehicle shall not exceed 100 KIAS.
- (11) Batteries used in the air vehicle shall contain bright colors to facilitate locating them in the event of a crash.
- (12) All vehicles will undergo a safety inspection by designated competition safety inspectors prior to being allowed to make any competition or non-competition (i.e. practice) flight. All decisions of the safety inspector(s) are final. Safety inspections will include a physical inspection, fail-safe check, and flight termination check.
- (13) Physical inspection of vehicle to insure structural integrity, including:
  - (a) Verify all components adequately secured to vehicle. Verify all fasteners tight and have either safety wire, locktite (fluid) or nylock nuts.
  - (b) Verify propeller structural and attachment integrity
  - (c) Visual inspection of all electronic wiring to assure adequate wire gauges and connectors in use. Teams shall notify inspector of expected maximum current draw for the propulsion system.
  - (d) Radio range checks, motor off and motor on.
  - (e) Verify all controls move in the proper sense.
  - (f) Check general integrity of the payload system.
  - (g) Verification of AMA Fail-safe mode operation covered by manual override and pilot commanded flight termination.
- (14) The officials will disqualify any entry that they deem to pose an unreasonable safety hazard.
- (15) The officials will confer with representatives of the host facility, and any entries that, in the opinions of the officials or of the representatives of the host facilities, pose an unreasonable risk to the integrity of the host facility will be disqualified. AUVSI and the host organization, their employees and agents, as well as the organizing committee, are in no way liable for any injury or damage caused by any entry, or by the disqualification of an entry.

**c. Imagery**

- (1) The UAS shall capture target images that can be displayed to the judges. The images may be provided to the judges during the conduct of the mission or when handing in the mission report sheet.

- (2) The system should have the capability to capture imagery for up to 60 deg in all directions from vertically below the air vehicle.

d. **Air Vehicle**

- (1) The system shall be limited to one air vehicle in the air at any one time.
- (2) The system shall not employ any ground based sensors.
- (3) The system shall be capable of commanded altitude changes.
- (4) The system shall be capable of commanded airspeed changes.
- (5) The air vehicle shall be capable of heavier than air flight.
- (6) The aircraft may be of any configuration except lighter-than-air and shall be free-flying, autonomous capable and have no entangling encumbrances such as tethers.
- (7) Aircraft shall comply with the 2007 Official Academy of Model Aeronautics (AMA) National Model Aircraft Safety Code except as noted below:
  - (a) Autonomous operation is authorized.
  - (b) Aircraft take-off gross weight with payload shall be less than 55 lb.
  - (c) GENERAL - (experimental aircraft rules do not apply)
  - (d) RADIO CONTROL - (combat does not apply and organized racing event does not apply)
  - (e) FREE FLIGHT - does not apply
  - (f) CONTROL LINE - does not apply
  - (g) GAS TURBINE restriction does not apply
  - (h) GIANT SCALE RATING - does not apply

e. **Environmental** (If conditions fall outside environmental requirements or if the judges feel environmental conditions are unsafe (such as approaching thunderstorms), the competition will be suspended. Teams are expected to be able to compete within the required environmental conditions).

- (1) The air vehicle shall be capable of takeoff and landing in crosswinds to the runway of 8 kts with gusts to 11 kts
- (2) The air vehicle shall be able to accomplish its mission objectives with surface winds of 15 kts with gusts to 20 kts .
- (3) The system shall be capable of completing mission objectives in temperatures up to 110 deg F at the surface.
- (4) The system shall be capable of operating in fog conditions of visibility of 2 miles or greater with no precipitation.

f. **Ground Control**

- (1) The system should have the capability to adjust mission search areas in flight. If the system has the capability to change mission search areas in flight, the new boundaries shall be displayed to the operator.
- (2) The system should be able to automatically detect/cue targets with a false alarm rate that does not exceed the detection rate.
- (3) The system should be able to provide imagery and actionable intelligence in real time.

- (4) The ground control system displays shall be readable in bright sunlight conditions
- (2) The system shall display “no fly zones” to the operators and judges
- (3) The system shall display search area boundaries to the operators and judges
- (4) The system shall display current air vehicle position with respect to the “no fly zones” and mission search areas to the operator and judges
- (5) The system shall display altitude (MSL) to the judges and operator

**g. Interoperability**

- (1) The system should be designed to be Joint Architecture For Unmanned Systems (JAUS) compliant as defined in the JAUS IDD (attached). – note, no overall competition points, but cash barrel of TBD.

### **3. GENERAL RULES**

- a. During the entire mission, air vehicles shall remain in controlled flight and within the no-fly boundary. The no-fly boundary is defined by Webster Field runways, taxiways and other features (diagram to be provided). Any vehicle appearing uncontrolled or moving beyond the no-fly boundary shall be subject to immediate manual override. Failure of manual override will result in flight termination. Points will be deducted for flying in no-fly zones or over flight of the crowd area.
- b. After takeoff, the air vehicles shall attain and remain in flight at an altitude between 100 and 750 ft MSL for the duration of the mission. Decent below 50 ft MSL (except in the recovery area) or above 1,000 ft MSL shall require manual override and immediate return to land. No additional points will be scored.
- c. Once in autonomous flight the vehicle shall operate with no direct pilot control to flight controls or power. The sensor payload may be manually controlled while under autonomous flight, the team will be directed to provide in-flight mission update to the vehicle.
- d. Exotic, dangerous fuels/batteries or components are discouraged. All designs and systems will undergo a rigorous safety inspection before being permitted to proceed.
- e. The mission will end as previously defined, or when any of the following occur:
  - (1) The judges order the end of the mission.
  - (2) The team captain requests the end of the mission.
- f. Advisors may operate as safety/RC pilots and may communicate to the team in the safety pilot role. Advisors shall not coach the team on non-safety/RC aspects of the conduct of the mission.

**4. FACT SHEET.** Six weeks prior to the competition (**May 5, 2008**) a one-page fact sheet providing basic descriptions of the air vehicle and systems shall be submitted. It shall include frequencies used for air vehicle control (manual or autonomous) and payload control/ imagery receipt, fuel and/or battery type and air vehicle dimensions including gross weight.

**5. PROOF OF FLIGHT.** Based on experience from the 2005 competition, we now require validation that team air vehicles have flown prior to arrival at Webster Field. A video that shows your air vehicle in flight or a statement signed by a faculty member of your university or school that verifies your system has successfully flown at least once shall be submitted with the journal paper.

## **6. SCORING CRITERIA**

- a. **Scoring Elements.** Student teams will be scored on three elements: Journal paper, oral briefing/static display, and mission performance. Approximately 50% of the total score available will be awarded for the mission performance element with 25% each going for the journal paper and oral briefing/static display. Two teams of independent judges will evaluate and score each element. Each element score will be summed for a total team score. To achieve points for any key performance parameter, the threshold must be achieved. Additional points will be awarded for performance up to objective requirements
- b. **“Stretch Objectives”.** Teams will be awarded additional points for achieving objectives associated with prize barrels described below (with the exception of JAUS compliance). The following notional prize barrels (**subject to change, based on sponsorship funding**) will be awarded:
  - (1) \$500 cash prize for any team that conducts the waypoint navigation and area search phases of the mission autonomously.
  - (2) TBD cash prize for JAUS compliance, described in the JAUS IDD (attached).
  - (3) Any team that achieves the following “stretch” objectives will either receive a \$500 cash prize or share \$2000 with the other teams that achieve that objective, whichever is less.
    - (i) Autonomous takeoff.
    - (ii) Autonomous landing.
    - (iii) Obtain an image and correctly identify 4 of 5 parameters for the “off flight path” in-route target.
    - (iv) Obtain an image, correctly identify, and provide the location within 250 ft of the “pop-up” target during the area search phase. Those teams choosing to search for “pop-up” target shall display new search area to the operator and judges.
    - (v) Successfully perform automatic target identification or cueing on at least two targets in the search area with the number of false detections being no greater than the number of correct detections.
- b. **Journal Paper**
  - (1) Each team is required to electronically submit a journal paper that describes the design of their entry and the rationale behind their design choices. The paper shall include a description of the systems engineering approach used for total systems design, descriptions of the UAS design, test and evaluation results (including payload and navigation system performance), and safety considerations/approach. **Systems engineering**

includes mission/ requirements analysis, design rationale, and any analysis of expected performance. Design descriptions are required for the air vehicle, ground control station, data link, payload, mission planning, data processing and method of autonomy and target types supported by autonomous cueing/recognition (if utilized). Specific attention shall be paid to safety criteria. The journal paper shall include a photo of the UAS air vehicle.

- (2) This paper shall be no more than 20 pages long (including all figures, references, and appendices). Additionally, each journal paper shall include an abstract of no more than 250 words. The journal paper and abstract shall be printable on standard 8.5 × 11-inch paper, with margins of at least 1 inch on all sides, and all text shall be in 12-point or larger font. Each page shall bear footer with the page number and the team name.
- (3) The journal paper shall be received in electronic format (pdf is preferred) via email to mark\_pilling@emainc.com". Papers are due May 28, 2008. Teams that do not meet the deadline may be disqualified from the competition.

c. **Oral Briefing/Static Display**

- (1) Each entry will be subject to static judging before being allowed to compete. During the static display time, the judges will visit each team. At this time, the team shall provide a 15 minute maximum presentation which highlights their mission and requirements analysis, technical approach, design, and test results. Unique or innovative features and safety approaches shall be included. The judges will evaluate each entry for technical merit, safety, craftsmanship, and effectiveness of briefing (including both the oral briefing and associated backdrops/displays). Each team is required to have at least one member attending their entry vehicle throughout the static display period (not just during the judges' scheduled visit). Advisors shall not participate in the briefing. The entire system shall be displayed, including access to the internal components of the air vehicle.

- d. **Mission Performance.** This element shall have the highest weighting factor. Judges will score mission performance according to the systems ability to meet the requirements in the specification.

## 7. OFFICIAL RULES, SUBMISSIONS, AND FEES

- a. The official source for all information concerning rules, interpretations, and information updates for the 2008 AUVSI Student UAS Competition is the World Wide Web home page at: <http://www.auvsi.org> or <http://www.auvsi-seafarer.org>.
- b. An Application form is available on the website. A completed form with entry fee is due to AUVSI Seafarer Chapter no later than January 7, 2008.
- c. The submission shall be in English and is not considered official until the entry fee of five hundred U.S. dollars (\$500) has been received by AUVSI Seafarer Chapter. As the competition format cannot handle an unlimited number of

entries, the organizers reserve the right to limit the total number of entries that are allowed to compete by declaring the competition closed to new entries before the due date above. Flight Competition/Mission phase may be further limited based upon results of journal paper, static display/oral brief and safety inspection. As with all official information, this announcement (should it be necessary) will appear on the official website.

- d. Teams shall comprise a combination of no more than 10 Inter-disciplinary undergraduate students or high school students. Members from industry, government agencies, or universities (in the case of faculty) may participate upon approval from the Competition Director; however full-time students shall compose the team with the exception of the air vehicle pilot, and no more than one graduate student. Faculty/advisors cannot do anything but be the safety pilot during the competition. Students shall present data analysis, etc. Participants shall be enrolled at their schools for at least 12 credit hours or more per quarter/semester during winter and spring 2008 to be considered "students" unless cleared by the Competition Director (for cases of 2008 graduating seniors are not considered as grad students for this competition).
- e. The student members of a joint team shall make significant contributions to the development of their entry. Only the student component of each team is eligible for the cash awards. One student member of the team shall be designated as the "team captain." Only the team captain will speak for the team during the competition run. Teams registering to compete shall indicate on their application form the name of the individual or organization to whom prize checks will be made payable.

## 8. TIMELINE

The 2008 competition will be a simplified model of the US Department of Defense system acquisition process. The competition rules will simulate a Performance Specification and Statement of Objectives. These will initially be released as a Request for Information (RFI). What this means is that this is a draft of the final specification & rules. Potential competitors are invited to provide comments or questions. This will be followed by a virtual "University Day" (modeled after industry day). This will consist of a phone conference that all competitors can dial into to hear directly from the judges and to ask questions. The competition rules will then be modified based on the feedback and put out in its final form that simulates a Request for Proposal. It is the intent of the judges to keep these requirements stable for the rest of the competition, but we reserve the right to make changes we deem necessary.

September 5, 2007	Request for Information (Competition rules simulating a performance specification and statement of objectives).
September 28, 2007	Deadline for comments or questions.
October 3, 2007	University Day (3:00 PM, EDT, phone conference with competition judges. Call 877-896-9095, (International callers dial 301 342-9906) then enter 3656# to be connected to the phone bridge.)
November 1, 2007	Request for Proposal (final competition rules).
January 7, 2008	Completed entry form and registration fee received by AUVSI Seafarer Chapter.
May 5, 2008	Fact Sheet received by AUVSI Seafarer Chapter
May 28, 2008	Journal paper received by AUVSI Seafarer Chapter (including proof of flight video or statement)
June 18-22, 2008	2008 Undergraduate Students Unmanned Aerial Systems Competition