# Over Sand Vehicle Mission Requirements

## Background

You are a member of an engineering firm that has been hired to aid the Balloon Payload Program (BPP) at the University of Maryland. As part of the program, balloons are launched and tracked as they approach space-like conditions (85,000-100,000 feet altitude) and collect data from payloads lifted by the balloon. The balloon is subject to the weather conditions of the day and has landed in a sandy patch on the edge of a remote lake. During the landing, one of the payloads, which was carrying a hazardous material, was damaged and released the hazardous material in the surrounding landing area. The area is not safe to enter for humans and there is time-sensitive data on the payloads that cannot wait until a HazMat team is able to come collect the payloads. Therefore, your firm is responsible for developing a fleet of vehicles that can be sent to the landing site in place of humans. The vehicles that your firm designs must be capable of (1) navigating the sandy/rocky terrain; (2) scouting for, collecting, and analyzing natural resources and balloon payload material; and (3) transmitting data regarding the terrain, natural resources, and balloon payload data back to your design firm for further analysis. A few things that are known about this location include:

- The terrain consists of loose sand with depths of 15 – 60 mm above the rock substrate and a narrow strip of navigable rocky terrain. Additional topographical features unseen by initial imagery may exist that could further inhibit travel (see Figure 1 on page 4).
- Because the payloads landed near a remote lake, your team would like to test whether the hazardous material spill has polluted the water of the lake. You are unsure of whether the lake is a freshwater or salt lake, but can test whether the water is freshwater, saltwater, polluted freshwater, or polluted saltwater on the shore of the lake where the water has collected into naturally-occuring pools with depths of 20 – 44 mm. The inner wall of each pool is 175 mm in diameter and 64 mm in height above the rock substrate. The outer wall of each pool is 190 mm in diameter and 75 mm in height above the rock substrate.
- There are two payloads that are spherical cells that must be identified and distinguished between one another. One of the payloads is plastic which the other is copper-coated. Each payload has a mass of 50 – 350 g and is a sphere with an approximate diameter of 100mm.
- During descent, one of the payloads was damaged and released a hazardous material. However, there is important data stored on the payload that must be extracted and analyzed within 24 hours of the payload landing. The payload's data is stored on an Arduino that has an accessible data input/output port. This port is located approximately 30 mm above the rock substrate and has two prongs that must be connected to the vehicle before data is transferred.
- An electrical component broke in the descent of the payload and started subsequent fires. A fire site with between two and five active flames is detected. The source of the flame(s) is located between 120 – 300 mm above the rock substrate. Flammable balloon debris will be located within 250 mm of the active fire site.

- Although the payload is tracked via multiple methods, oftentimes the exact location of the payload is difficult to find and must be found by eye or by near-field signaling. One of the methods for finding the balloon's payload after landing includes the emission of an infrared pulse by the "Blackbox." The blackbox payload emits an infrared 50 ms pulse, four per second, at 38.0 kHz and has a range of approximately 1 m. The blackbox also has an indicator light that changes color depending on the launch.

Each firm will be divided into five teams and all five missions (see Mission Descriptions section below) must be attempted by each firm. Your firm has assigned you to an eight-member team and tasked you with designing and building vehicles to complete one of the five missions. Your vehicles must adhere to the over sand vehicle product specifications. You must coordinate with the other design teams to ensure all aspects of the BPP's base requirements (see Mission Descriptions section) are fulfilled.

Your vehicle will be parachuted to the edge of the remote lake using the rough GPS coordinates of the payload, and will land in a random spot with a random orientation. From there you will begin communicating with the BPP command center from which your vehicle was launched and will start your mission. The command center will be able to track your vehicle and send coordinates and heading information of your vehicle through WiFi transmissions along with accurate information about most mission sites. The exact black box acquisition mission site location remains unknown. Coordinate transmissions occur at a maximum of 5 Hz and are accurate to within ± 50 mm with respect to the reference coordinate axes, and heading transmissions are accurate to within ± 0.05 radians. Each vehicle will need to complete its mission objectives within five minutes, with one exception as detailed in the product specifications.

**Mission Descriptions**

Your team is required to select one of the missions described below and to complete as many objectives for that mission as possible. **All transmissions to the command center, during product demonstration, must be single messages with final values** and not a running stream of other messages.

1. **Water Sampling**
   - Clear rocky terrain
   - Navigate to within 250 mm of the edge of the water pool
   - Measure and correctly transmit whether the pool has freshwater, saltwater, polluted freshwater, or polluted saltwater
   - Measure and transmit the depth of the water in the pool to within 4 mm
   - Collect a sample of 30 – 45 ml of water from the pool[1]

2. **Material Identification**
   - Clear rocky terrain
   - Navigate to within 250 mm of the payload debris

[1] The complete sample collected will be placed in a graduated cylinder and must have a final volume between 30 and 45 ml.

- Measure and correctly transmit the type of material present
- Acquire the debris by lifting it entirely off of the sand
- Determine the mass of the debris to within 20 g and transmit the result

3. **Payload Data Extraction**
   - Clear rocky terrain
   - Navigate to within 250 mm of the edge of the payload
   - Physically connect to at least one of the payload output ports
   - Extract and transmit the data in the form of an array to mission control
   - Physically remove all contact with the payload with the weather proof cap returned to its original position

4. **Fire Suppression**
   - Clear rocky terrain
   - Navigate to within 250 mm of the fire site
   - Measure and correctly transmit the number of active flames present
   - Contain the fire by extinguishing all flames except for the middle flame
   - Clear all wood debris within a 250 mm radius of the fire site

5. **Black Box Acquisition**
   - Clear rocky terrain
   - Navigate to within 250 mm of the black box locator beacon
   - Touch the black box locator beacon with the OSV
   - Place an Aruco marker on or within 50mm of the black box locator beacon and transmit the location
   - Measure and correctly transmit the color of LED light on the black box locator beacon

**Product Performance Considerations**

See the Product Demonstration Procedures for more details, including the randomization protocols. Additional details related to product performance evaluation can be found in the Milestone 7 document. Teams may also pursue Design Awards.

**Mission Area**

The mission area shown in Fig. 1 indicates the location of the landing zone, narrow strip of navigable rocky terrain, and a representation of the three randomly located rocky obstacles as well as the mission destination site. All dimensions and coordinates are in meters and measured relative to the vision system's x-y frame of reference. The precise coordinates of the mission destination site will be available via WiFi transmission during each mission attempt for all missions except for the black box mission. The precise coordinates of the black box is unknown.

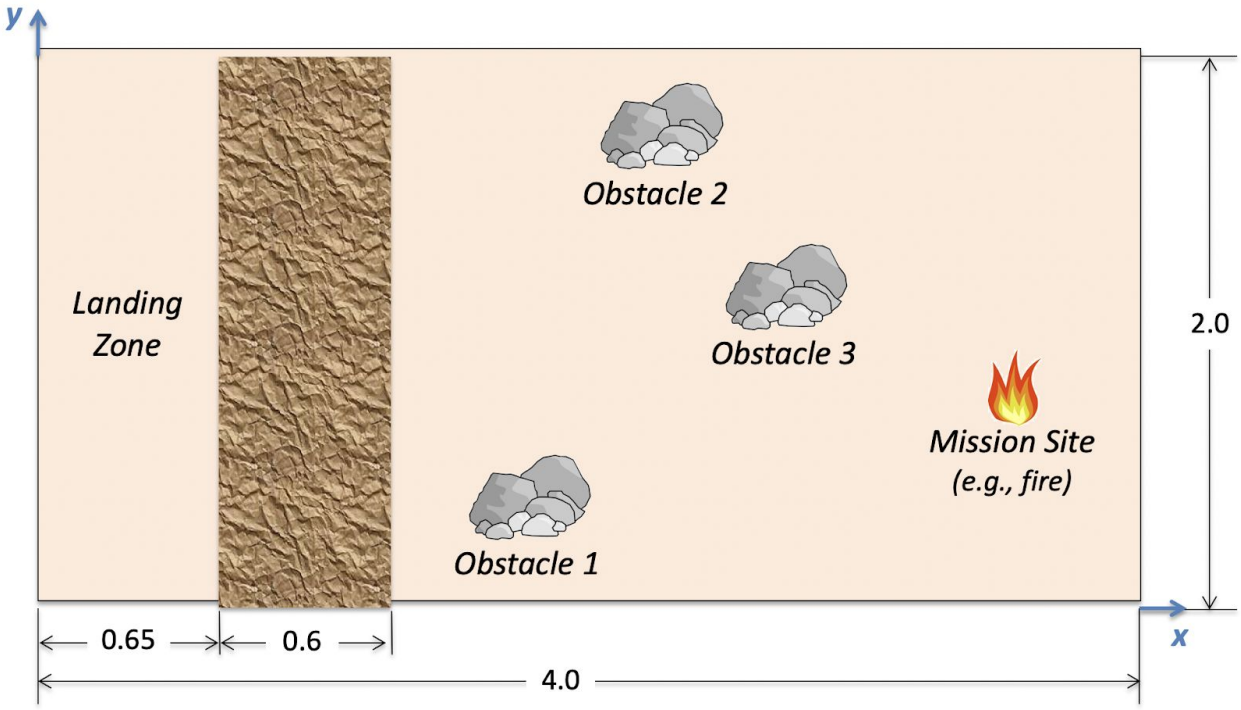


**Fig. 1:** Mission area showing a representative arrangement of obstacle locations.