



Definition of **Air Challenge** Guidelines

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1 Introduction

1.1 Purpose

The purpose of this document is to define the Air Challenge and air competition course for the Sea, Air and Land Challenge.

1.2 Scenario

A freight train has derailed in a very sparsely populated area of the Great Plains. Cars from the middle of the train are scattered widely. Some of these train cars were carrying irradiated materials and radioactive samples headed to a western laboratory for an experiment. While emergency crews prepare to travel to the site, an Unmanned Aerial Vehicle (UAV) with radiation detection capabilities is being sent to the scene to survey the site. The UAV will be used to locate the cars which were carrying the materials and samples, and which may now have damaged packaging. With cameras, sensors and automated image processing, the UAV will fly over the wreckage and determine if any radiative matter is uncontained. A live relay of this information will be sent to the first responders, allowing them to remain protected at a safe distance until the best method of response is determined. In addition, the UAV will be able to drop markers on “hot spots” to indicate a radiation danger zone and serve as a warning to these emergency ground crews.

Using sensors that will recognize differences in radiation concentration can increase the safety for the responders and civilians. Without a fully developed UAV, equipped with radiation detection equipment, first responders would have no indication as to whether the wreckage site is safe. This Air Challenge explores building and using sensors that could one day be used on UAVs. UAVs may also be called UASs or unmanned aircraft systems. [For additional background knowledge on actual radiation sensor fundamentals, see Appendix 1.]

1.3 Definitions

Tele-Operated (or remote controlled) – References a type of robot that has an operator making decisions about the operation of the robot. Sensory data from the robot or other device (video, telemetry, etc.) is delivered in near real time to the robot operator, and the operator makes decisions about what the robot is supposed to do (e.g. turn left/right, speed up/down, deposit a payload etc.). This is the type of operation used by hobbyists and may also be called operator in the loop. This can either be accomplished by wireless or wired communications, although most (including the Air Challenge) applications dictate wireless communication.

Autonomous - The robot has a sensor package that collects data, and based on computer processing, makes decisions without an operator on how it is to operate and what it is to do. The general rules of an autonomous robot are:

- Gain information about the environment, i.e. Where am I? What is around me? What is my path?
- Work for an extended period and move either all or part of itself throughout its operating environment without human intervention
- Avoid situations that are harmful to people, property, or itself unless those are part of its design specifications

QR Code - A Quick Response code is a type of matrix (two-dimensional) barcode that can be read easily by a digital device. QR codes:

- Store information as a series of pixels in a square-shaped grid
- Are frequently used to track information about products in a supply chain, are used in marketing and advertising campaigns, and can even determine an object's position within augmented reality.

2 Challenge

For this challenge, the combination of a QR code reader system and a payload will be developed to provide QR code reading and drop capabilities for a hobby sized multirotor. The multirotor, which is controlled by an experienced pilot or a team member who passes a qualification test, will fly a pattern searching for “radiation hot spots” that have been randomly placed. As the multirotor performs its flight pattern, it must detect the QR code, which links to a situation which may be a “radiation hot spot” or “safe area”, using a camera or QR code reader. Once the operators determine that a “hot spot” has been located, the multirotor must be able to drop a marker on the “hot spot” (target) to indicate a “radiation danger zone”. Efficiency and accuracy are important aspects of this challenge.

The team is responsible for building/selecting a multirotor platform that can:

- Safely carry the sensor/payload package
- Fly for the duration necessary to complete the challenge

The team is also responsible for designing a tele-operated (or autonomous) payload package and reader that can:

- Be safely secured and carried by the multirotor
- Find potential locations (camera or pilot view)
- Identify and relay information to the operators regarding radiation hot spots. This is to be achieved using a QR code reader system
- Drop the markers onto the targets at the hot spots

Notes:

- The pilot will be required to always be in visual contact of the multirotor or have a spotter who is always in visual contact of the multirotor (pilot's choice)
- The teams that are not actively flying will be restricted in location to remain behind the flight line and the operating pilot and team. The course may be changed between team

- runs, so that knowledge of one course is no advantage to second runs or other teams.
- A proficiency test will be executed (either by video or in-person at the team's school/facility) by a member of Sea, Air, and Land staff or other qualified personnel, using the team's multirotor prior to Challenge Day.
- On Challenge Day, a brief flight worthiness test will be given to ensure the multirotor and payload are safe for flight.
- On Challenge Day, bring a copy of the team's final Bill of Materials (BOM) and Cost List to share with the judges.

2.1 Requirements

To receive maximum score on the air course the vehicle must complete the following

- Multirotor must fit within a 533 mm x 533 mm (21" x 21") box. This does not include propellers or propeller guards.
- No limits are put on height.
- Airframe must be capable of being flown indoors
- Total cost of the system must not exceed \$600
- Pilot or spotter must visually see the airframe at all times during challenge run
- Payload, including sensor or camera and drop mechanism, must be secured to Airframe
- Pilot must pass "Sea, Air and Land" qualification flight
- Airframe and payload must pass Challenge Day safety exam
- Be able to find and identify two areas of "high radiation" via QR code
- Be able to drop "radiation hazard" markers in the two "high radiation" zones (a target will be provided within the zone). Markers are of the team's choosing.
- A maximum of 10 minutes will be allowed to identify two high radiation areas and drop markers at these two zones to "warn others of high radiation".
- Prior to the run, the team will introduce themselves and their design concept in a short "elevator speech" (untimed)
- Optional Tips:
 - a. Team members should consider taking the FAA's The Recreational UAS Safety Test (or TRUST). The online test is free and take about 30 minutes to complete.
 - b. If your drone weighs more than 0.55 lbs. (250g) and you fly outdoors, register your drone with the FAA: https://www.faa.gov/uas/recreational_flyers.
 - c. The pilot may consider becoming an Academy of Model Aeronautics member. AMA youth membership is \$15 for those under age 19.

2.2 Coded Areas/Drop Zone

Outdoor courtyards or indoors areas: Coded areas/drop zones will have the following characteristics:

- Will be marked by a rectangle
- Drop zone will be at least 30 cm x 30 cm (1'x1')
- Each zone will have a QR code, with a minimum size of 15 cm x 15 cm (6" square). These QR codes will show a situation which the operators must read and determine if the location is a radiation hot spot or a safe area
- Drop zones will be scored on proximity to target within zone

Note: Teams may ask the judges to add unique marking to the drop points BUT this must be approved by the Challenge Coordinator prior to Challenge Day.

2.3 Key Design Points

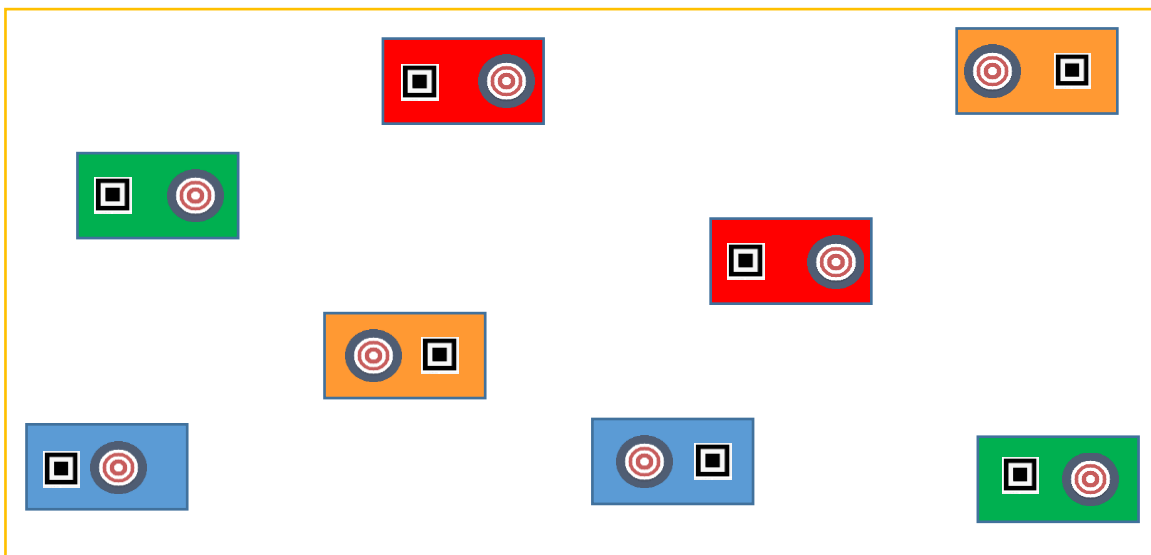
The following bullets are some key design points that will be instrumental to the success of your vehicle.

- Have a field of regard of 180 degrees
- Be able to look ahead in direction of flight
- Be able to have a system that is able to read a QR code. The complete system does not need to be attached to the multirotor.
- Be able to determine optimal height and timing to read QR code (or take a photo of the code) or drop payload

2.4 Course Layout

- The course will have up to eight coded areas/ drop zones
- The course will NOT have a specific pattern of for the flight

Figure 1 is a possible course layout derived from the above given description. This is a template for the air course and not meant to be an implementation diagram. (Optional) color is not an indicator of QR code but may be used to aid in navigation.



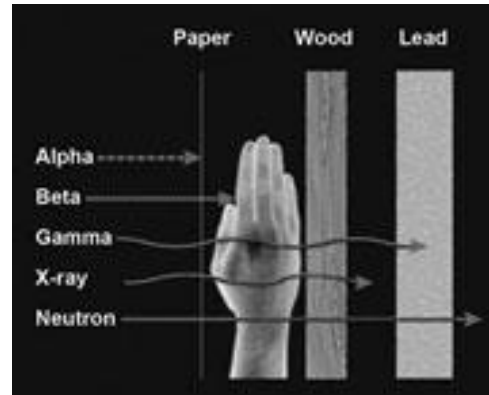
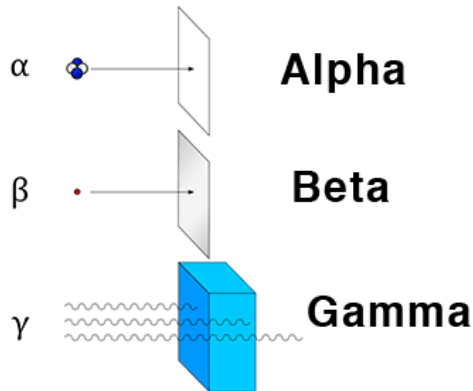
STAND BEHIND THE SAFETY LINE TO PILOT OR VIEW

Figure 1 Sample Course Layout

Appendix 1. Radiation Sensor Fundamentals

Radiation is all around us. It is important to understand radiation and how the presence of background radiation affects measurements.

- Radiation can be categorized as charged or uncharged, which primarily determines how the radiation will interact with materials.
- Alpha, beta, neutron, and gamma radiation are the most common forms of radiation (particles/waves) present in our environment. The first two of these types of radiation are examples of charged particles and the second two are examples of uncharged particles or waves.



- Radiation is all around us (called background radiation), but that is not a reason to be concerned. Different types of radiation behave differently, and some forms can be very useful.
- Many of the naturally occurring radioactive materials in the earth are radioactive and are commonly referred to as NORM. Examples include radon, which emits alpha particles, and some potassium, which emits gamma rays. Many of these materials may simultaneously emit two types of radiation, like americium, which emits both alpha particles and gamma rays.
- Carbon-14, used in carbon-dating of fossils and other artifacts, also emits beta particles. Carbon-dating simply makes use of the fact that carbon-14 is radioactive. If you measure the beta particles, it tells you how much carbon-14 is left in the fossil, which allows you to calculate how long ago the organism was alive. (U.S.NRC, 2020)
- Naturally occurring neutron emission is extremely rare and primarily limited to interaction of cosmic rays in dense/metallic materials. Neutrons have no charge and are referred to as a nucleon as they are one of two key particles that comprise the nucleus of an atom. Neutron emission from fission (splitting of nuclei) is the principle behind how nuclear reactors operate.
- The last kind of radiation is electromagnetic radiation, like X-rays and gamma rays. They are probably the most familiar type of radiation because they are used widely in medical diagnostics. These rays are like sunlight (photons), except they have more energy. Unlike alpha and beta radiation, there is no mass or charge. The amount of energy can range from very low, like in dental X-rays, to the very high levels seen in irradiators used to sterilize medical equipment or food. (U.S.NRC, 2020)

- Radioactive materials will emit radiation (particles or waves) as they decay. We can detect these particles with a specialized sensor.
 - The rate of decay can be sporadic, but will average out to be constant over time.
 - Additionally, the farther away from an object we are, the lower the amount of radiation that will be in the path of the sensor. Much like how a lightbulb looks dimmer the further away you get from it. This makes radioactive objects at a distance appear to be weaker sources, or not picked up by the sensor at all.
- Background radiation is always present and is caused by low levels of normally occurring radioactive materials in the environment, such as radioactive elements in the ground. A portion of background radiation is also due to cosmic radiation.
 - Background radiation can interfere with trying to detect a radioactive object, since the radiation sensor measures the total radiation independent of the source (background + radioactive object).
 - Since we cannot eliminate the presence of background radiation, it must be accounted for when we take measurements.
- With all the above in mind, it follows that to measure the radiation being emitted from an material of interest, we must first understand what the background radiation level is, so we can subtract it from our measurement.
 - $\text{Strength of radiation from material} = \text{Sensor Measurement} - \text{Background Measurement}$
- To accurately measure amount of radiation emitted from a material, we must measure the background radiation strength.

Background radiation = the average of radiation measurements taken at 2-3 different locations where there are no additional radiation sources.



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INTERACTION
OF IONIZING
RADIATION
WITH MATTER

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