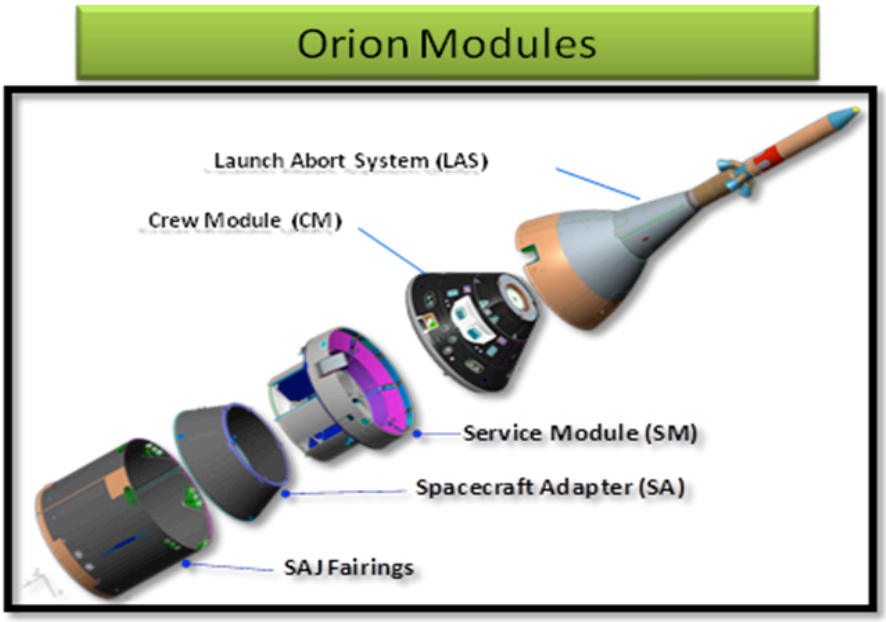
Exploration Design Challenge

Radiation Shielding Experiment Design Criteria and Constraints



During the test, which is currently referred to as Exploration Flight Test-1 (EFT-1), Orion will launch from Cape Canaveral, Florida, and orbit Earth twice in a highly elliptical orbit, taking Orion to an altitude higher than any achieved by a spacecraft intended for human use since 1972. The spacecraft will then re-enter Earth's atmosphere at higher speeds and energy than a low altitude orbital mission and land in the Pacific Ocean off the west coast of the United States. A narrated animation of the flight may be viewed at: http://www.nasa.gov/multimedia/videogallery/index.html?media_id=135794971

This flight test will evaluate several of the most significant events of a deep space mission to reduce the overall risk for Orion's first human-rated flight. The data provided by an early orbital flight test will influence design decisions and validate innovative new approaches to space systems development, as well as reduce overall mission risks and costs.

Learning how to protect Orion's crew from adverse effects of space radiation will be a critical need for long-duration missions into deep space. The Van Allen Belt is a dense radiation field that surrounds Earth in a protective shell of electrically charged ions. These particles protect Earth from harmful solar radiation, but when traveling through the Van Allen Belt, the same radiation field that protects Earth from the sun can harm humans as they pass through it. The Van Allen Belt, like all radiation fields, consists of small particles that penetrate living tissue leaving small changes as they pass. Over time, these small changes alter and mutate tissue.

The NASA Exploration Design Challenge (EDC) Radiation Shielding Experiment (referred to hereafter as the Payload) will be flown onboard the Orion Crew Module on Exploration Flight Test-1 (EFT-1), at the discretion of Lockheed Martin.

All components of the payload must meet in-flight certification requirements and must be submitted by the project deadline to ensure adequate time for certification to occur.

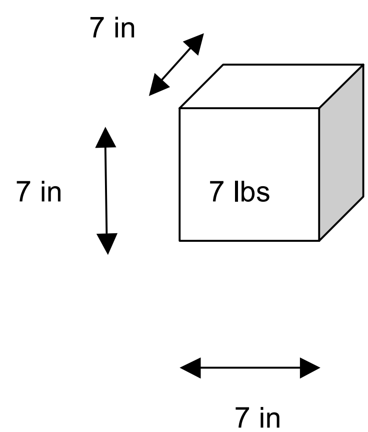
All designs must adhere to the Payload Criteria and Payload Constraints outlined in this document.

The payload will be inserted into a cargo container that will be attached to the interior of the Crew Module. The cargo container will be a soft-sided, canvas style bag. A cargo container will be provided to the team chosen to build their prototype.

Payload Criteria

The contents of the experiment must meet the following criteria:

Maximum Payload Size



1. Height: 7 inches
   Width: 7 inches
   Depth: 7 inches

2. **Maximum Payload Mass**

   7 lbs

3. **Payload Contents:**

   - Up to 10 Passive radiation dosimeters will be provided to the winning team for inclusion into the payload volume. Each dosimeter is approximately the size and mass of an aspirin tablet (325 mg). Passive dosimeters are used to measure radiation exposure over time. Results are not provided in real-time, but are retrieved from the instrument after the conclusion of the experiment. Some passive dosimeters are light-sensitive. Within this challenge, you will most likely be using Optically Stimulated Luminescence Dosimeters (TLD-500), which ARE sensitive to light.
   - The dosimeters will be embedded or covered by shielding material according to the winning team's design. This is referred to as a sensor package.
   - The sensor package(s) must be secured within the cargo bag to prevent shifting during flight. The payload must be balanced and must be able to withstand the pressure of lift-off and orbital flight.
   - If multiple sensor packages are incorporated into the design, volume voids (spaces) between the sensor packages should be filled with packaging material approved for human rated spacecraft (see constraints below) to prevent the sensor packages from shifting in the cargo bag, potentially damaging the payload contents or disrupting other payloads.
   - Shielding materials must be approved for use on human rated spacecraft (see both Payload Materials and Environmental Constraints sections).

Payload Materials Constraints

The contents of the experiment must adhere to the safety regulations established by NASA for human spaceflight. All components of the payload must meet in-flight certification requirements.

- No materials may be used in the design that could result in catastrophic hazard. NASA defines catastrophic hazard as any hazard that can result in the potential for a disabling or fatal personal injury, or cause major system destruction or malfunction.
- Solids, liquids or gases that might be used in the design may not be reactive within the environment of space.
- Soldering may not be used for any structural applications.
- Adhesive bondings (glue) are limited and must be controlled to prevent contamination of the spacecraft, other experiments on board, cargo, or crew.
- Flammable materials are prohibited to avoid fire and/or combustion events.
- Materials that deteriorate, creating toxic gases, or outgassing, are prohibited.
- No batteries or electric, magnetic, or other power sources, either internal or external, may be used.
- All metals, wires, cable, and exposed surfaces of connectors must be insulated to prevent spark and/or interference with onboard systems.
- Materials should be fungal-resistant.
- Sandwich assemblies designed to hold the sensors in place inside the flight bag must be able to withstand stress while maintaining their structural integrity and performing the task of stabilizing the sensors.
- Materials used may not create a foreign-object-debris (FOD) contamination or danger issue.
- Materials, used in both the shielding and cargo packaging, must be able to withstand the pressure of lift-off, orbital flight and high speed/high energy return.

For detailed information on materials, refer to the NASA Technical Standard, NASA-STD-6016, *Standard Materials and Processes Requirements for Spacecraft*, which can be accessed at: https://standards.nasa.gov/documents/viewdoc/3315591/3315591

Environmental Constraints

Rigorous acoustic, shock, and vibration tests that simulate launch and spaceflight environment should be designed to ensure the payload and internal contents are able to withstand the external forces and environmental conditions of launch, flight, and landing. Payloads should also be able to withstand the thermal ranges and relative humidity inherent in a space environment for the duration of the mission. Details of tests and results should be documented in team design notebooks.

Orion's Testing and Verification program continues to validate hardware and software integration, test subsystems and refine production operations. The criteria for EFT-1 will be modified as new designs for the spacecraft are tested, trajectories are adjusted, and environmental parameters are established. As in any engineering project, designs must be revised as new constraints arise. For the most current information about EFT-1, including Orion status updates, refer to this NASA web site: http://www.nasa.gov/exploration/systems/mpcv/index.html

Final Testing

Submitted shielding designs will be evaluated by a team of experts. Five designs will be chosen to be tested in an online virtual simulator. Students may need to redesign one or more components of their sensor packages based on specific criteria within the simulator and/or recommendations made by their NASA/Lockheed Martin mentor(s).