Following NASA’s DAWN mission, which surveyed proto/dwarf planets in the asteroid belt to improve our understanding of planet formation, Project Elysium will further this endeavour by sending a crewed mission to Ceres allowing for full characterizing the dwarf planet.

**Mission Purpose**

- **Primary Objective 1:** Assemble the Elysium Transfer Vehicle in Low Earth Orbit
- **Primary Objective 2:** Send a crew of seven astronauts to the dwarf planet Ceres
- **Primary Objective 3:** Safely return crew and the Elysium back to Earth

- **Secondary Objective 1:** Land humans safely on the dwarf planet Ceres
- **Secondary Objective 2:** Study the effects of interplanetary space travel on humans
- **Secondary Objective 3:** Study the surface of Ceres for clues into its formation

**Requirements**

- **Primary Objective 3:** Safely return crew to and the Elysium back to Earth
- **Primary Objective 2:** Send a crew of seven astronauts to the dwarf planet Ceres
- **Primary Objective 1:** Assemble the Elysium Transfer Vehicle in Low Earth Orbit

**Power/Propulsion**

- **Propulsion Stage:** Ion engines were chosen for this mission due to their high specific impulse (5000s) and improved feasibility on long duration missions (24 + Months).
- **Power Stage:** In the diagram below, the ship’s power distribution schematic is shown. Along with the nuclear reactors, an on-board battery barry stores energy for peak loading and assured redundancy.

**Communications**

The communications for this mission involve a link between a transmitter and receiver device on the spacecraft and a grounds communication system respectively. For this project, the communications system will involve components that will be placed on a satellite that will launched to GEO along with components that will placed on the transfer vehicle with the purpose establishing reliable communications between the ground station and the crew in space and taking advantage of the Deep Space Network. The components of the system were modeled through MATLAB and the Ansys System Tool Kit (STK). These components consist of a high gain and low gain antenna and have a transmission frequency of 8.42 GHz, a gain 6.8 dBi, and a max directivity 45.6 dBi. The High gain directivity chart shown to the left.

**Orbital Trajectories**

For the construction of the orbit trajectory, the mission was split up into multiple key phases, described below and shown to the right.

- **Phase 1:** Launching from Earth to Low Earth Orbit
- **Phase 2:** Transfer Orbit from around Earth to Ceres
- **Phase 3:** Orbit around Ceres to Ceres Surface
- **Phase 4:** Ascent from Ceres Surface to Ceres Orbit
- **Phase 5:** Transfer from Ceres Orbit to Earth Orbit

To successfully model the trajectory of our mission to Ceres, we had to take into account the propulsion system, departure date and launch window, and overall A V shown in the graph below. Due to this, we calculated a trajectory from Earth to Ceres that launch in December of 2026 and includes a 13-month stay at the planet. Total mission duration is 49 months.

**Structural Analysis**

The Structural Analysis primarily consisted of hoop stress calculations in the vacuum of space and FEMAP finite element analysis.

- **FEMAP Analysis - Thrust**
  The first analysis done was on the structure of the vehicle in a fully assembled configuration when full thrust from the Ion thrusters was applied. This resulted in minimal loading to the vehicle.

- **FEMAP Analysis - Launch Configuration**
  The second analysis done was on a single module in an Earth launch configuration prior to vehicle assembly in LEO. This analysis had an applied load from the rocket as well as vibrations induced from launch. From this analysis, locations where buckling was most likely were revealed and reinforced. Both analysis sets were performed isolated from environmental factors. In a true space flight scenario gravitational and orbital loading factors need to be accounted for.

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