

Introduction

Radiation creates a large amount of concern both in space and on Earth. In space, the source of radiation is exploding stars and the sun. When a star explodes, the force of the explosion and the heat breaks down atoms into their sub-particles which are then released into space. The sun spots are located in solar active regions, which are the source of high energy radiation particles. The number of sun spots on the sun depends on the solar cycle. The solar cycle consists of periods called Solar Maximums and Solar Minimums. During a Solar Maximum there is a relatively large amount of sun spots so there is a relatively large amount of radiation. During Solar Minimums there is a relatively low amount of sun spots, thus there is a relatively low amount of radiation. The sub-particles are threats to any spacecraft or satellite in space. They can penetrate the electronic devices, and due to their electrical charge they can interfere with the devices ability to function.

There are trapped particles in space located in the Van Allen Belts. The Van Allen Belts consist of inner and outer belts that are located above the earth (Sherrill, 1991). Due to the eleven degree difference between the rotational and magnetic axis of the Earth, the edge of one of the inner belts is extremely close to Earth. This area is called the South Atlantic Anomaly and the electronics in this area can be disrupted by the high amounts of radiation.

The total amount of radiation that a substance is exposed to in space is called the Total Ionizing Dose (TID). An acceptable TID for any space mission is twenty-five kilorads (krad) (D. Batchelor, personal communication, December 5th, 2009). A rad is the standard measurement for radiation and 1 rad=100 erg/gram. Electronics in space can be protected by Aluminum (Al) shielding. The amount of Al shielding needed depends on the amount of radiation that will be present on a mission. The amount of radiation present depends on the trajectory path of the mission, which cycle the sun is in, and the length of the mission. The purpose of this experiment was to calculate the Radiation Doses for three different missions. It was hypothesized that 100 mils (2.5 mm) of Al shielding will be an appropriate amount of shielding for each mission.

The TID is calculated using a program called The Space Environment Information System (SPENVIS) that is based in Belgium and expedited through the internet (Kruglanski, 1997). The information in SPENVIS was collected during previous space missions by using probes that were attached to the spacecrafts.

Mission One

- Near Earth Interplanetary Orbit
- 0.8 Astronomical Units (AU) from the sun
- Duration of mission is 10 years
- 6 years in Solar Maximum, 4 years in Solar Minimum

Mission Two

- Heliosynchronous orbit
- Inclination of 101.43 degrees. The inclination changes with the altitude.
- Duration of mission is 1 year
- Solar cycle depends on the launch date

Mission Three

- Geosynchronous Orbit
- Inclination of 0 degrees
- Duration of mission is 5 years
- Assumed launch in Solar Maximum

Data

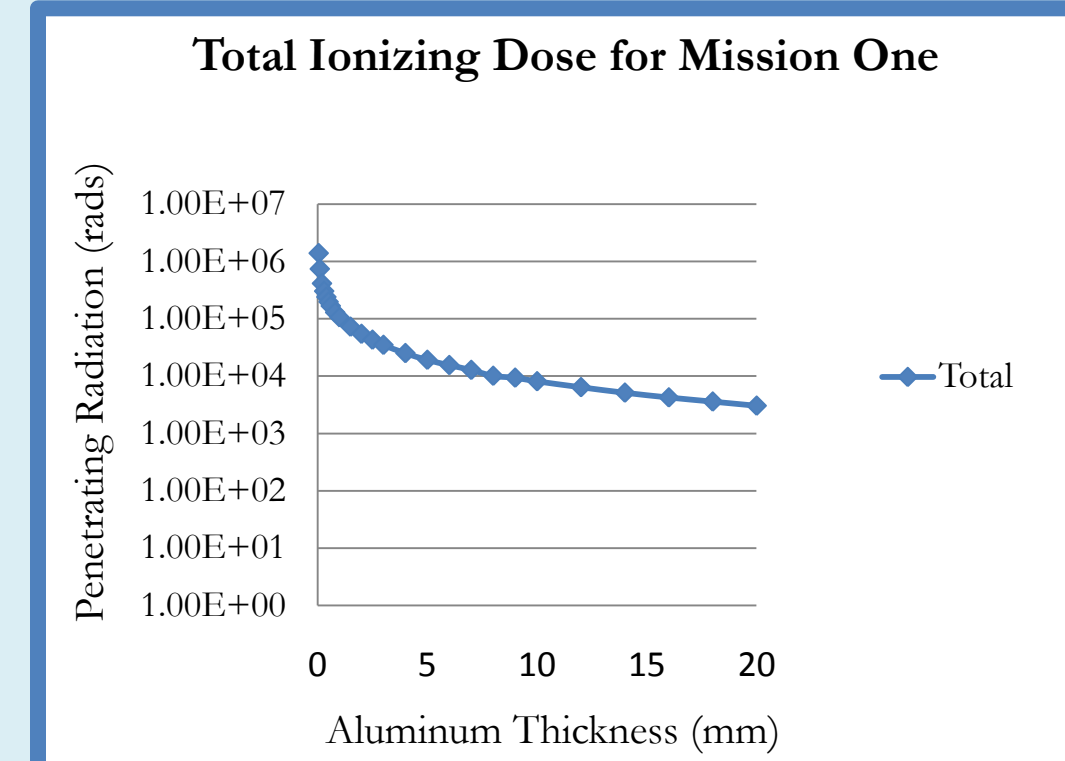


Figure 1: Shows the results for the First Mission. This is a graph of the Total Ionizing Dose separated by particles versus the Al thickness.

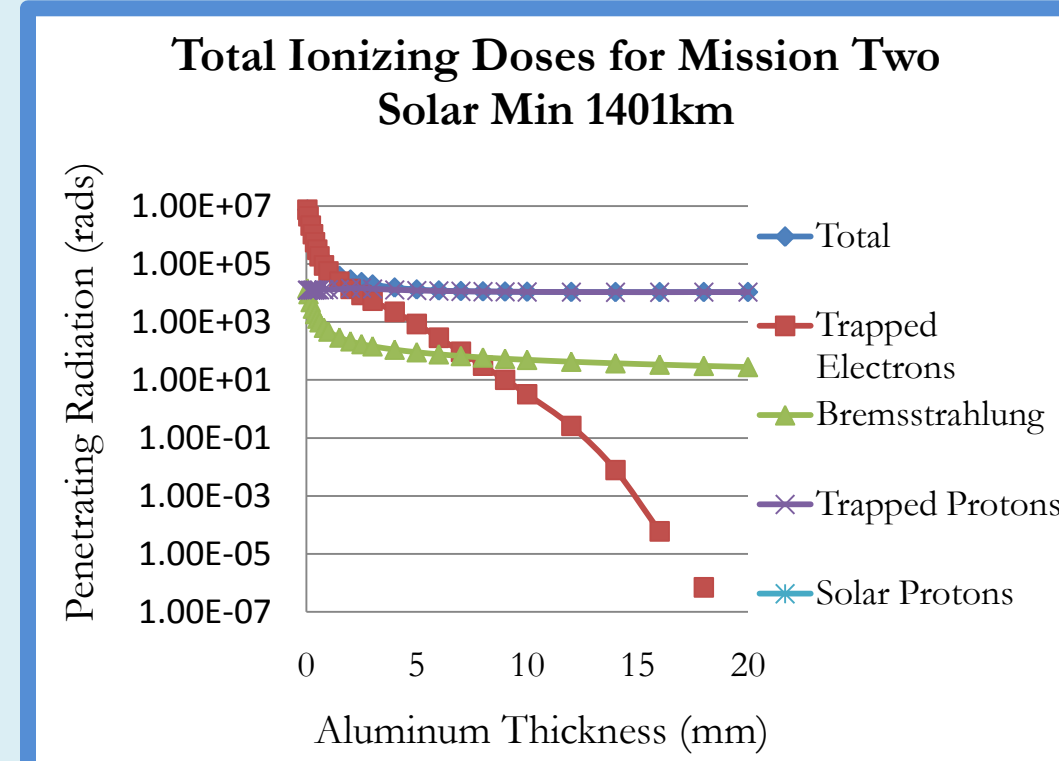


Figure 2: Shows the results for Mission Two Solar Min 1401 km mission. This is a graph of the TID separated by particles versus the Al thickness

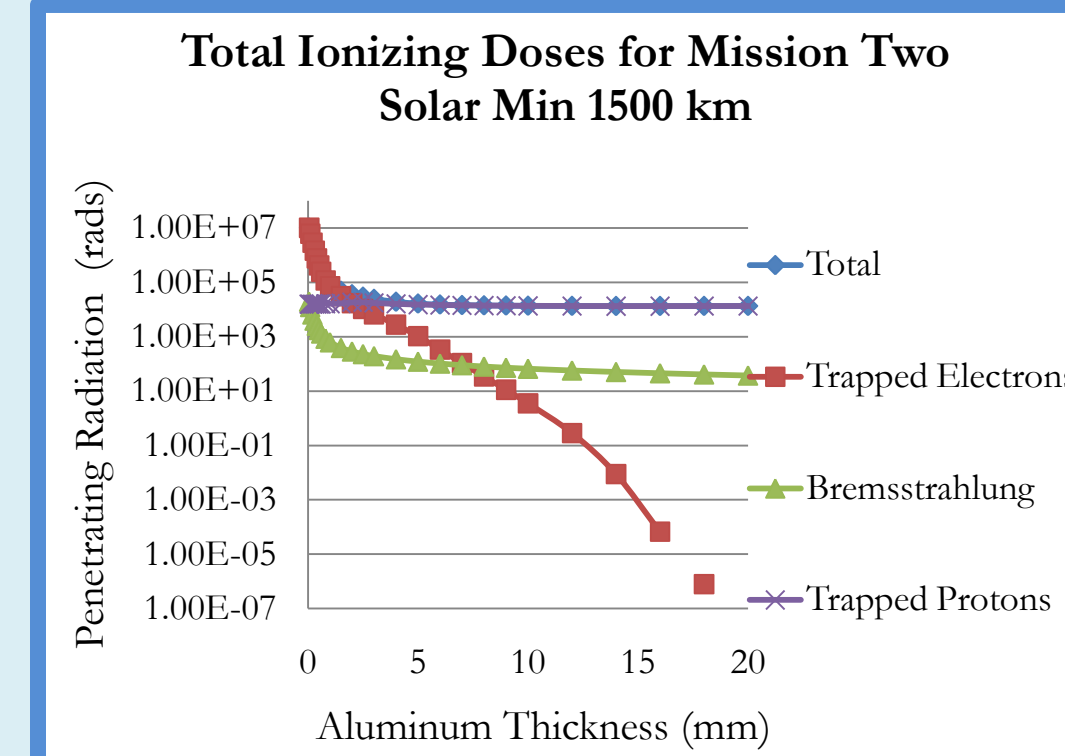


Figure 3: Shows the results for Mission Two Solar Min 1500 km mission. This is a graph of the TID separated by particles versus the Al thickness.

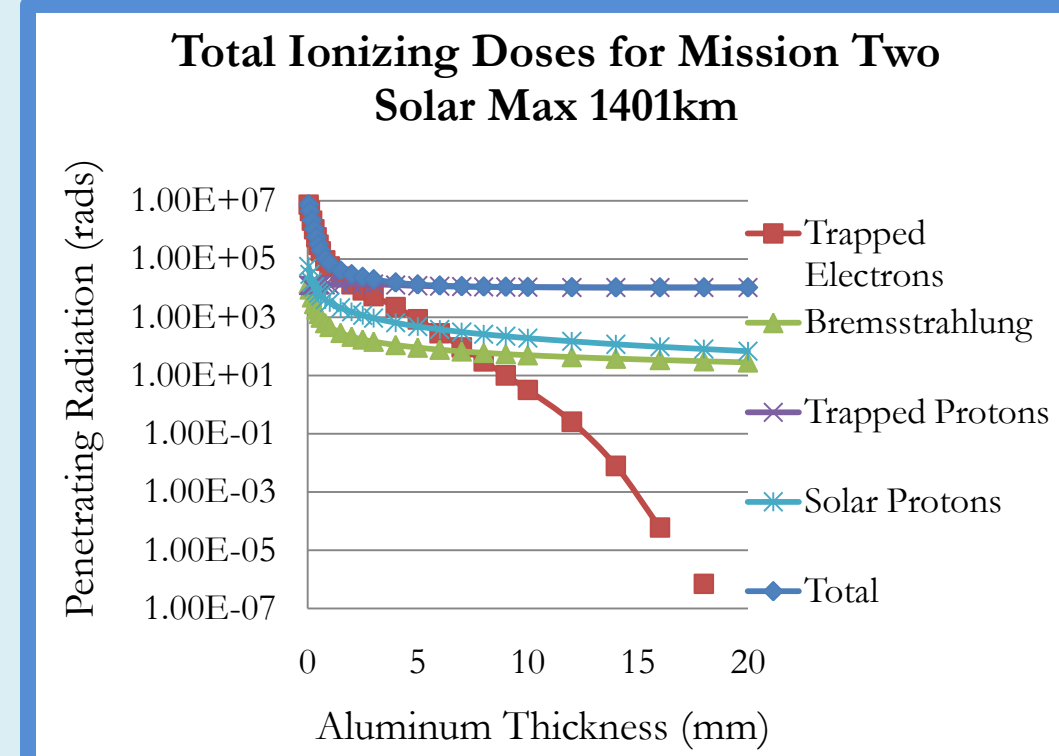


Figure 4: Shows the results for Mission Two Solar Max 1401 km mission. This is a graph of the TID separated by particles versus the Al thickness.

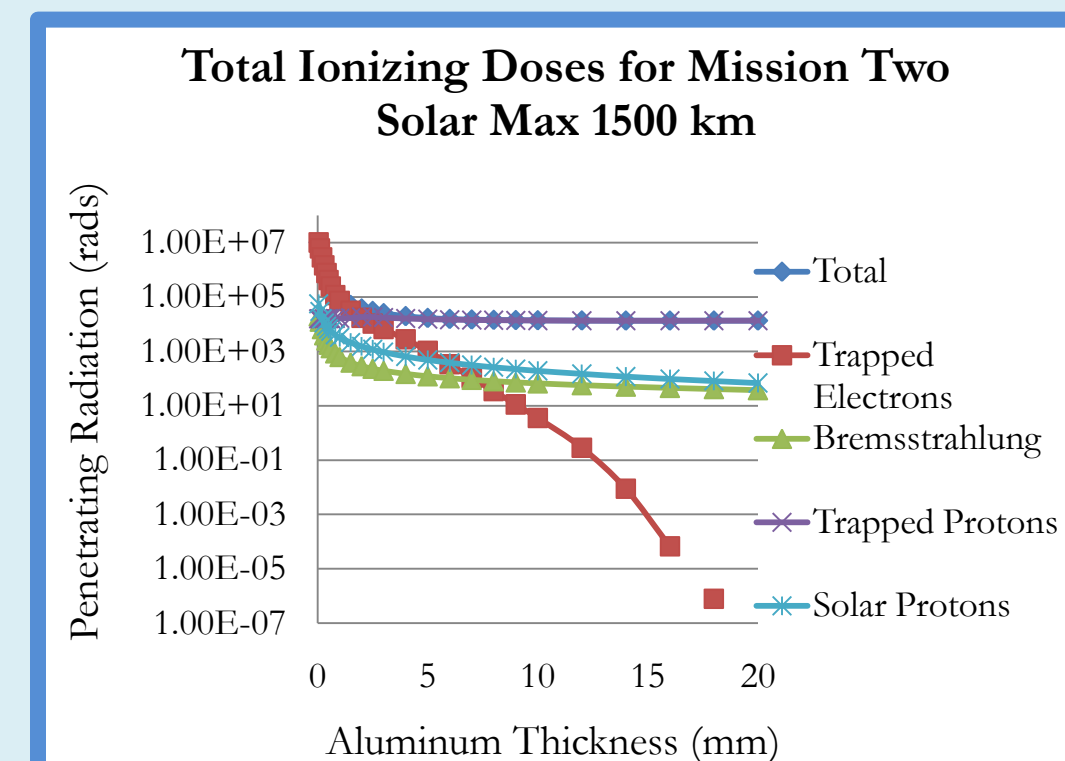


Figure 5: Shows the results for Mission Two Solar Max 1500 km mission. This is a graph of the TID separated by particles versus the Al thickness.

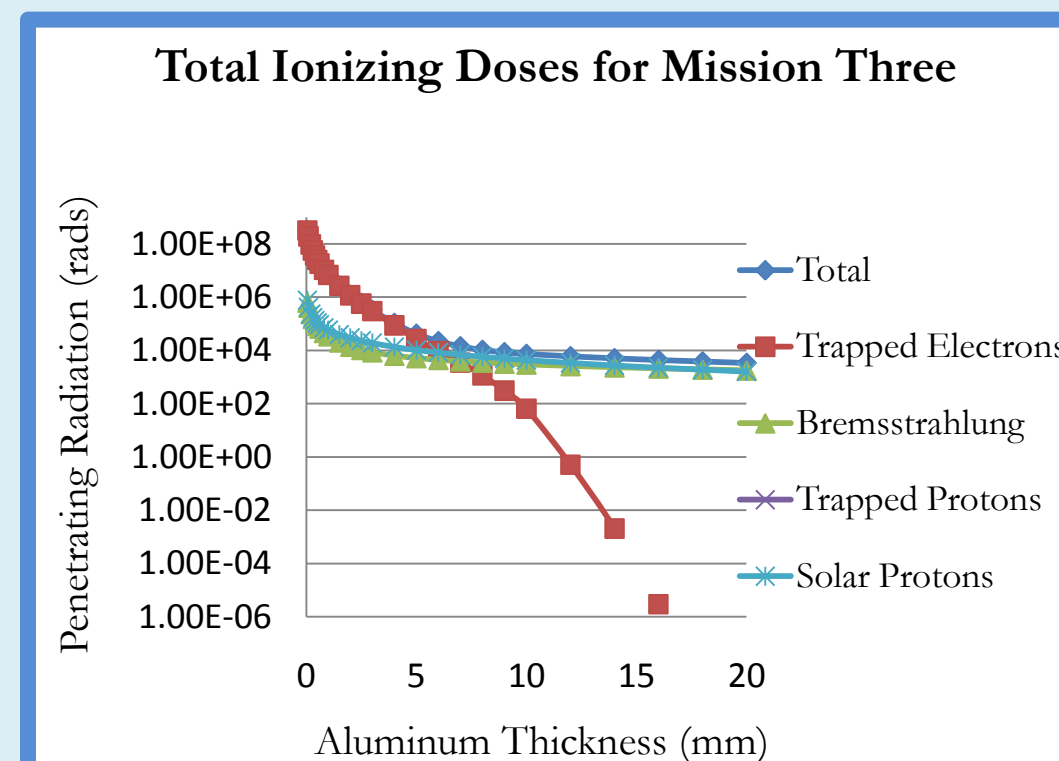


Figure 6: Shows the results for the third mission. This is a graph of the Total Ionizing Dose separated by particle type versus the Al thickness.

Methods

This project was completed using the computer program SPENVIS. For each mission, the appropriate parameter values were collected and then were inputted into SPENVIS. Some basic parameters for each mission were the type of trajectory path, mission duration, start date, and number of mission segments. Then the data was calculated by SPENVIS. Some of the data calculated was the ionizing doses, non-ionizing doses, and the solar proton fluencies. An analysis of the data was then completed by comparing the TID dose at 100 mils of Al protection to the accepted value. Then an analysis was applied to each corresponding mission.

Results

Figure 1 shows that Mission One's TID was 4.89×10^4 rads, and solar protons were the most abundant. The TID values for Mission Two varied depending on the altitude and cycle of the sunspots. Figure 2 shows that Mission Two's TID during the Solar minimum at an altitude of 1401 km was 2.32×10^4 rads, and electrons were the most abundant. Figure 3 shows that the same mission at an altitude of 1500 km had a calculated TID level of 2.92×10^4 rads, and trapped protons were the most abundant. Figure 4 shows Mission Two's TID during the Solar Maximum at an altitude of 1401 km was 3.04×10^4 rads, electrons were the most abundant. Figure 5 shows that the same mission at an altitude of 1500 km had a TID level of 2.44×10^4 rads, and trapped protons and solar protons were the most abundant. Figure 6 shows that Mission Three's TID level was 6.03×10^5 rads, and electrons are the most abundant. Every Mission's TID was determined at 100 mils of Al protection.

Discussion

After the radiation doses for three different missions was calculated, it was found that the amount and type of radiation particles present for each mission varied. Electrons are easier to stop than protons due to their lower mass. All three missions exceeded the twenty-five kilorad limitation. It was recommended that all missions should have more Al protection surrounding the microelectronic parts. Additional protection added to the overall weight of the spacecraft and therefore more fuel was needed which increased the cost of the mission. The appropriate amount of Al shielding needs to be used, because radiation can decrease the life of microelectronics. A broken microelectronic can cause a mission to fail, lead to dangerous situations and expose an astronaut to dangerous amounts of causing them to see white flashes of light in space (Clark, 2008).

Works Cited

- Clark, S. (2008). Lights fantastic. *New Scientist*, 46. Retrieved December 10, 2009 from <http://www.newscientist.com>
- Kruglanski, M. (1997). The space environment information system [computer software]. Available from <http://www.spennis.oma.be>
- Sherrill, T. J. (1991). Orbital science's "Bermuda Triangle". *Sky and Telescope*, February, 134-139.

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