The Influence of Cosmic Factors on Spacecraft

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Introduction

To build spacecraft that will survive in harsh space environment, scientists must understand with which hazards they may face. Earth, the Sun, and the Cosmos combined offer unique challenges to spacecraft designers, as shown in Figure 1 [1, 3].

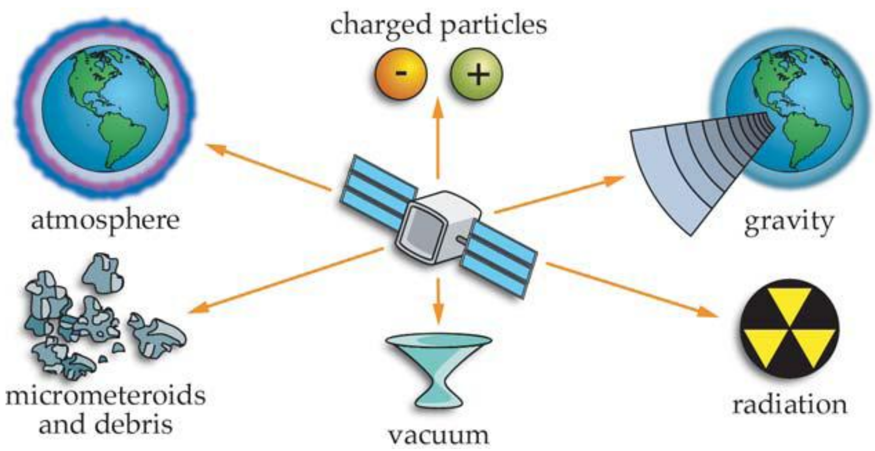

Figure 1 – Factors affecting spacecraft in the Space Environment

There are six challenges unique to the space environment spacecraft deals with – gravity, the atmosphere, vacuum, micrometeroids and debris, radiation, and charged particles [2, 4].

Vacuum

The vacuum environment creates three potential problems for spacecraft: out-gassing, cold welding and heat transfer [1, 2].

Out gassing occurs when materials, such as plastics or composites, release trapped gasses (volatiles) upon exposure to vacuum - particularly problematic if the released molecules coat delicate sensors, such as lenses, or cause electronic components to arc, damaging them. Prior to launch, spacecraft are usually tested in a thermal-vacuum chamber to reduce or eliminate potential out-gassing sources.

Cold welding occurs between mechanical parts that have very little separation between them. After launch, with the small cushion of air molecules between components eliminated, parts may effectively "weld" together. The potential for cold welding can be mitigated by avoiding the use of moving parts or by using lubricants carefully selected to avoid evaporation or out-gassing.

Heat transfer via conduction, convection, and especially radiation may also complicate spacecraft operation. Conduction is heat flow directly from one point to another through a medium. Convection takes place when gravity, wind, or some other force move a liquid or gas over a hot surface. Both of these methods can be used to move heat around inside a spacecraft but not to remove heat from a spacecraft in the free fall, vacuum environment of space. So here the third method – radiation is used. Radiation is a way to transfer energy from one point to another. Because radiation doesn't need a solid or fluid medium, it's the primary method of moving heat into and out of a spacecraft.

Micrometeoroids and space junk

The space around Earth is not empty. It contains lots of debris or space junk. For spacecraft or astronauts in orbit, the risk of getting hit by a meteoroid or micrometeoroid is remote [2]. However, since the beginning of the space age, debris has begun to accumulate from another source - human beings. With nearly every space mission, broken spacecraft, pieces of old booster segments or spacecraft, so that the environment near Earth is getting full of these space debris (about 2200 tons of it). This problem is posing an increasing risk to spacecraft and astronauts in orbit [3]. In low Earth’s orbit, this tiny chunk is moving at speeds - 7000m/s or greater when it hits. This gives spacecraft a great amount of energy - much more than a rifle bullet [2].

One frightening debris hazard is the collision of two spacecraft at orbital velocity. A collision between two medium-sized spacecraft would result in an enormous amount of high velocity debris. The resulting cloud would expand as it orbited and greatly increase the likelihood of impacting another spacecraft. The domino effect could ruin a band of space for decades.

The radiation Environment

Electromagnetic (EM) radiation from the Sun, while primarily in the visible and near-infrared parts of the EM spectrum, also contains significant higher energy radiation, such as X-rays, and gamma rays [1]. Spacecraft and astronauts are well above the atmosphere, so they bear the full brunt of the Sun’s output. The effect on a spacecraft depends on the wavelength of the radiation. The Sun's radiation heats, degrades or damages surfaces and electronic components, and the resulting solar pressure can perturb orbits.

Prolonged exposure to ultraviolet radiation can begin spacecraft coatings degrading [2]. This radiation is especially harmful to solar cells, but it can also harm electronic components, requiring them to be shielded or hardened, to handle the environment. In addition, during intense solar flares, bursts of radiation in the radio region of the spectrum can interfere with communications equipment onboard.

EM radiation could be thought of as waves, like ripples on a pond. Another way to look at it is as tiny bundles of energy called photons. Photons are massless bundles of energy that move at the speed of light. These photons strike object, exerting pressure similar in effect to atmospheric drag. But this solar pressure is much, much smaller than drag. It is only 5N of force for a square kilometer of surface [1]. While that may not sound like much, over time this solar pressure can disturb the orientation of spacecraft, causing them to point in the wrong direction.

Charged particles

Perhaps the most dangerous aspect of the space environment is the pervasive influence of charged particles caused by solar activity and galactic cosmic ray (GCRs) [2].

The Sun puts out a stream of charged particles (protons and electrons) as part of the solar wind - at a rate of 10^9 kg/s. During intense solar flares, the number of particles ejected can increase dramatically. Galactic cosmic rays (GCRs) are particles similar to those found in the solar wind or in solar flares, but they originate outside of the solar system. GCRs represent the solar wind from distant stars, the remnants of exploded stars, or, perhaps, shrapnel from the "Big Bang" explosion that created the universe. In many cases, however, GCRs are much more massive an energetic than particles of solar origin. Ironically, the very thing that protects us on Earth from these charged particles creates a third hazard, potentially harmful to orbiting spacecraft and astronauts - the Van Allen radiation belts.

Whether charged particles come directly from solar wind, indirectly from the Van Allen belts, or from the other side of the galaxy, they can harm spacecraft in four ways: charging, sputtering, single-event phenomenon, and total dose effects [1].

Spacecraft charging results when charges build up on different part of a spacecraft as it moves through concentrated areas of charged particles. Once this charge builds up, discharge can occur with disastrous effects - damage to surface coatings, degrading of solar panels, loss of power, or switching off or permanently damaging electronics. These particles can also damage a spacecraft’s surface because of their high speed. It's referred as sputtering. Over a long time, sputtering can damage a spacecraft's thermal coating and sensors [2, 5].

Single charged particles penetrating deeply into spacecraft electronics systems may cause a single event phenomenon. One type of is a single event upset or "bitflip" [1]. This occurs when the impact of a high-energy particle resets one part of a computer' memory from 1 to 0, or vice versa. This can cause subtle but significant changes to spacecraft functions. For example, setting a bit from 1 to 0 may cause the spacecraft to turn off or forget which direction to point its antenna [2].

Total dose effects are long-term damage to the crystal structure of semiconductors within a spacecraft's computer caused by electrons and protons in the solar wind and the Van Allen belts. Over time, the cumulative damage lowers the efficiency of the material, causing computer problems.

Conclusion

In this paper the influence of cosmic factors on spacecraft was considered. It can be noted that, for optimum efficiency and effectiveness, definition of the flight environment is of great importance at the beginning of spacecraft design cycle.

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Brushless Direct Current Motor and its Control

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Introduction

BLDC motors have a wide variety of applications. The BLDC motor loads a commutator, so it is more reliable than the direct current (DC) motor. The BLDC motor also has advantages in comparison with an alternating current (AC) induction motor. With the ability to generate rotor achieve magnetic flux with rotor magnets, BLDC motors are more efficient and therefore are used in high-end goods (refrigerators, washing machines, dishwashers, etc.), high-end pumps, fans and other appliances which require high reliability and efficiency (satellite, aerospace equipment, etc.). There are some more advantages of BLDC motor, such as [1]: long service life due to a lack of electrical and friction losses; reduced noise because of the elimination of ionizing spikes from brushes; virtually maintenance-free due to a lack of brushes and mechanical commutators; more suitable for hazardous environments when BLDC motor can be completely sealed.