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The Space Environment's Impact on Space Systems

Erwan Yuhan *

Associate Managing Editor, United Kingdom

***Corresponding author**: Erwan Yuhan, Associate Managing Editor, United Kingdom, Email: yuhan.E@gamil.com

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Introduction

Human space travel relies on durable spaceship architecture and advanced life-support equipment, both of which are essential for operating in the harsh environment of space. The problems of the space environment are the topic of this essay. A Dispatch from Space will appear in a future edition, and two other pieces will discuss the acclimatisation required for humans to go and live in space, as well as technology developments that can be applied to health care on Earth. Early space missions moved from suborbital to orbital flights, proving that humans can live and operate in space. Since those first flights, over 50 years have passed, with significant advancements in mission duration and complexity of goals. High vacuum, microgravity, temperature extremes, meteoroids, space debris, ionospheric plasma, and ultraviolet and ionising radiation define the International Space Station's environment as it orbits the planet at an altitude of more than 300 kilometres. The future of human space travel hinges on the development of new technologies that can transport humans farther into space and keep them there longer. The term "spatial border" has several distinct meanings. The National Aeronautics and Space Administration (NASA) designate people as astronauts when they fly above 80 km, although the Fédération Aéronautique Internationale considers the 100 km Karman line as the internationally recognised space barrier. Aerodynamic flight is no longer viable at this height, thus spacecraft must move faster than orbital velocity to manoeuvre and stay in orbit.

Advanced materials for manned spacecraft and satellites have been created by scientists and engineers for a variety of complex uses in space exploration, transportation, global location, and communication. The materials used on the outside of spacecraft are exposed to a variety of environmental challenges that can destroy a variety of materials and components. Vacuum, solar Ultra Violet (UV) radiation, charged particle (ionising) radiation, plasma, surface charging and arcing, temperature extremes, thermal cycling, hits from Micrometeoroids and Orbital Debris (MMOD), and contamination caused by the environment are among the hazards. Because single-oxygen atoms Atomic Oxygen (AO) are present together with all other environmental components, the Low-Earth Orbit (LEO) environment, defined as 200-1,000 km above earth's surface, is a particularly hostile environment for most non-metallic objects in space. Environmental risks to spacecraft components vary substantially depending on the materials, thicknesses, and stress levels of the components. The mission duration

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and specific mission environment must also be considered, including the mission's orbital parameters, the solar cycle and solar events, the view angle of spacecraft surfaces to the sun, and the orientation of spacecraft surfaces concerning the spacecraft velocity vector in LEO. Testing in space is the most effective way of determining how long-term exposure to space conditions affects particular materials and, as a result, which materials are most suitable for spaceship construction. Although ground-laboratory facilities can be used to examine space environment impacts, they typically do not fully model the combined environmental effects and, as a result, do not always correctly simulate performance or deterioration observed in space. This document's section on features of the space environment addresses each component of the space environment and which ground simulation approaches the best transfer to actual flight outcomes. The synergy of all parts of the space environment, on the other hand, is impossible to replicate on the ground. As a result, the most precise data on spacecraft durability comes from actual spaceflight experiments. Since the early 1970s, materials spaceflight experiments have been done to assess the environmental endurance of various materials and components in space, including 57 tests on the Long Duration Exposure Facility (LDEF), which was recovered in 1990 after spending 69 months in LEO. The ISS is an excellent venue for evaluating long-term space environment impacts, especially because experiments may be returned to Earth for post-flight analysis.

Existing anomaly databases have several major flaws. From the perspective of the spacecraft designer, the databases were created to identify the scope of spaceship difficulties. One of their most common applications has been to discover defective parts in a range of spacecraft and manufacturers. Although the environment has been identified as a source of anomalies in some circumstances, spacecraft often lack sensors to detect the status of the environment at the time of the anomaly. It was often difficult to make a diagnostic with high confidence that an anomaly was caused by the space environment since the necessary environmental data was not available at the spacecraft. The information gathered for this study has been compiled into a space environment impact database. Each record includes information regarding one vehicle's class of abnormalities. A group of anomalies with substantially comparable observables is referred to as an anomaly class. Because each anomaly is not captured in a unique record, this data collection cannot and should not be utilised as an anomaly database for counting individual instances of abnormalities. Surface electrostatic discharges on the MARCS-A spacecraft may create one anomaly or, in the worst-case scenario, 617 abnormalities for the main bus, under-voltage, and phantom commands. The space environment impact database includes a description of the anomaly class, the diagnosis, an indication of whether the diagnosis was supported by the material in the references (on a scale of 3 to 0), a description of the impact, any relevant comments from the references or the compiler, and a list of the references from which the information was obtained. To make obtaining statistics for this report easier, the data was put into a Microsoft Access database. Appendix A contains the whole database. Appendix B contains the references for the database's source material. Charged spacecraft ESD has produced the majority of environmental abnormalities on spacecraft, while surface charging has caused the most catastrophic anomalies, including those that have resulted in mission failure. Unfortunately, forecasting the position and severity of spacecraft surface charge is far more difficult than forecasting the location and severity of interior charging.

After a big magnetic storm, internal charging happens one to several days afterwards. As a result, the storm serves as a warning that significant amounts of energetic electrons may soon be present in the radiation belts. Because these electrons tend to spread inward following a storm, their journey might be tracked and flux levels forecast one to two days ahead of time.

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