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Introduction: We will briefly review the space environment hazards that have been most important for space systems in Earth orbit and discuss the implications for lunar exploration.

Application: Vehicles in lunar-transfer orbits, in orbit about the moon, and on the surface of the moon, will spend most of their time outside the radiation belts where most satellites have been engineered to operate. We will discuss the extent to which the specifications and understanding of the space environment hazards in common orbits might be applied to lunar scenarios. For example, while internal charging is important for many Earth-orbits, excursions to the moon will not spend as much time in the ~MeV electron environment as a vehicle at geostationary orbit. However, systems must account for the trapped electron fluence during transit to the moon [1], as well as other hazards common to many orbits such as single event effects from solar energetic particles and galactic cosmic rays. There will be surface and subsurface charging while in the magnetotail plasma sheet as is the case in Earth orbit. A new consideration will be the interactions between charged surfaces and photoionized lunar dust particles. Secondary neutrons created in GCR interactions with the surface of the moon should also be considered for electronics and humans.

Regardless of the particular mission profile, the same general principles of how missions must account for environmental hazards also apply to the lunar architecture: awareness of the environment hazards early in the design; proper test and mitigation techniques; enforcement of specifications; and situational awareness at the locations of interest.

Predictions: The 2006 NASA Strategic Plan refers to the role of prediction in understanding the Sun and its effects on Earth and the solar system:

3B.3. Progress in developing the capability to predict the extreme and dynamic conditions in space in order to maximize the safety and productivity of human and robotic explorers.[2]

While there are aspects of lunar operations that will require accurate prediction of space environment hazards, it is the case that some subsystems must operate at all times irrespective of the state of the space environment. For example, consider the electronics in a life-support system, or the electronics that control a satellite while in safehold and control its return to normal operations. In addition, a one hundred percent duty cycle for the entire system (payload and vehicle) is a common requirement for which on-orbit predictions play only a partial role.

Summary: The current design methods for Earth orbiting systems must evolve with understanding of how the environment interacts with technologies. A common source of error is inappropriate heritage arguments when using components in a new environment, such as the dusty lunar surface. We will argue that successful design requires anticipating and mitigating hazards before launch. The most concise form of this understanding is in the form of an environmental specification. These design approaches, and some of the data used to create specifications for Earth orbiting systems, can also be applied with care to systems for the lunar architecture, thus capitalizing on the experiences gained from Earth orbiting systems.

References:

[1] Fennell J. F. et al. (2000) *IEEE Trans. Plasma Sci., 28,* 2029-2036. [2] 2006 NASA Strategic plan (2006) *42*.