Radiation Hardened Single-Board Computer for space applications

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Expanding opportunity in higher orbits

In 1957 the world watched the first successful launch of a satellite into Low-Earth Orbit (LEO). Five years later Telstar 1 was launched into Medium-Earth Orbit (MEO) to facilitate high-speed telephone signals and two years following Syncom 2 became the first operational satellite sent into Geosynchronous Orbit (GEO). And thus the era of satellite use was launched. Since then the higher orbits of MEO and GEO have been primarily occupied by large satellites used for weather, communications, earth observations and defense. Small satellites (SmallSats), although widely used today, have been primarily limited to LEO for a multitude of reasons including the high cost of space-hardened parts. Today a change may be on the horizon. These higher, more exclusive orbits may soon be accessible to small satellite vendors thanks to a novel technology, the Radiation Hardened Single-Board Computer (Rad-Hard SBC). The technology was developed by engineers at Los Alamos National Laboratory's Intelligence and Space Research division and leverages the Laboratory's legacy of designing instruments for satellites and deep space missions for over fifty years.

Significance of the Work

On the ground, the Earth's atmosphere and magnetic field protect inhabitants from most of the harsh radiation from space but satellites have to be properly shielded and designed to withstand the space radiation environment. Designing a satellite able to withstand the shock, vibration and stress of a launch, the ensuing rocket separation, and the high levels of radiation in space is a complex and costly endeavor. Industry and government satellites that occupy MEO and GEO are built with space-grade components designed and hardened for use in a high-radiation environment. Because of size, SmallSats have less room, a lower weight budget and lower weight bearing capability than larger satellites. To achieve the same level of quality and hardening necessary for large satellites, the cost of a space-ready single board computer would fall in the neighborhood of $250K or higher. SmallSat users are often small businesses or universities that operate under lower budgets so accepting some risk is necessary. SmallSats are more likely to use automotive-, industrial-, or consumer-grade parts which have a higher likelihood of failing due to the extreme conditions of launch, and generally have a shorter lifespan in the radiation and temperature environments of space. Due to these increased risks, SmallSat companies frequently mitigate these risks by sending up multiple SmallSats to increase the probability of success and often use a significant amount of additional engineering time and resources to identify design techniques and non-space-grade components that are more robust to launch and space environment—both of which add cost.

The Rad-Hard SBC offers a space-hardened, affordable single-board computer - a market segment not currently represented. The technology is smaller in size and weight, measuring less than 7 inches x 6 inches, cost, coming in around $130K, and lower power, consuming just 6.6 Watts. The Rad-Hard SBC is designed with space-grade integrated circuits, is conduction cooled for operation outside the atmosphere, and is mechanically hardened to withstand the shock and vibration encountered during a satellite launch.

Achievements

The patent-pending Rad-Hard SBC is designed to meet the command- and data-handling requirements for missions requiring true space-grade radiation hardness and fault tolerance, exceeding those that are typical in SmallSat applications but at a substantially lower cost, lower power and smaller form factor than encountered in the current space-grade solution space available from the large aerospace manufacturers.

This patent-pending Lab technology will be a game changer for the satellite industry as it provides a high level of reliability through space-hardened parts at a fraction of the current cost. The Rad-Hard SBC will enable small satellite companies to improve their small satellites' performance, reliability and longevity in space orbits that were not previously available to them. This, in turn, will enable long-term deployment in MEO and/or GEO for SmallSats, increasing the competitive advantage of companies that use this technology. SmallSat missions will have longer lifetimes lasting many years in MEO and GEO orbits because these orbits don't decay the way a LEO orbit would.

The Lab's Rad-Hard SBC technology is built to withstand radiation in space for many years in LEO, MEO and GEO. A dual-core fault-tolerant LEON3 supplies the processing horsepower and a field programmable gate array (FPGA) adds hardware co-processing capability. The SBC complies with a popular industrial computing standard called MicroTCA, which makes it compatible with commercial systems. The next iteration of the Radiation Hardened Single-Board Computer for space applications has been designed and includes a quad-core LEON4 processor and a gigabyte of main memory. It also will be compliant with SpaceVPX and OpenVPX, standards used for commercial, military and space purposes. This compatibility will allow the new design to inter-operate with both low cost-commercial hardware and more expensive flight-grade hardware.

Research Team: Robert Merl and Nikolai Mondragon, Space Electronics and Signal Processing; Paul Graham and John Michel, Space Data Science & Systems; Zachary Baker and Justin Tripp, Applied Computer Science; and Richard Dutch, Space Instrumentation Realization.

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Publications: "Radiation-Hardened SpaceVPX System Controller," IEEE Aerospace Conference, Big Sky, Montana, March 2018.
"A Low-Cost, Radiation-Hardened Single-Board Computer for Command and Data Handling," IEEE Aerospace Conference, Big Sky, Montana, March 2016.

This research supports Los Alamos National Laboratory's Global Security mission area and the Science of Signatures and Information Science and Technology pillars. The technology underlying the single board computer is used as part of the Lab's mission of treaty verification.

For more science news, see the Laboratory Science Highlights.

Caption for image below: *Artist's rendition of the Radiation Hardened Single-Board Computer.*