NASA STTR 2019 Phase I Solicitation

T6.05 Testing of COTS Systems in Space Radiation Environments

Lead Center: LaRC

Participating Center(s): LaRC

Technology Area: TA6 Human Health, Life Support and Habitation Systems

The use of COTS (Commercial Off-The-Shelf) parts in space for electronics is a potential significant enabler for many capabilities during a mission. This subtopic is seeking a better understanding of the feasibility of COTS electronics for High Performance Computing (HPC) in space environments which are already heavily shielded. It seeks strategies based on a complete system analysis of HPC COTS that include, but not limited only to, failure modes to mitigate radiation induced impacts to potential HPC systems in those highly shielded space environments.

As background, spacecraft experience exposure to damaging radiation and that amount of exposure from various sources, (e.g., sun and galactic cosmic radiation sources) increases notably as the spacecraft ventures further away from the Earth's magnetic field, since the magnetic field offers some level of protection. As spacecraft, and their electronic systems, proceed again to the moon and further into deep space, considerable work has and continues to be done to evaluate and determine how to appropriately protect the astronauts and to shield or otherwise protect various spacecraft, habitats, and their electronic systems, depending upon the needs of the missions.

Many of the most protective physical shielding approaches known result in infrastructure which is too heavy for what is considered acceptable for many missions' intended launch and spaceflight conditions. Therefore, typically lighter infrastructure shielding is presently being used when and where possible. Spacecraft faring deeper into space for fly-by missions (e.g., New Horizons), orbiters (e.g., Mars Orbiter), or landers (e.g., Mars Rover) are examples of such relatively lightly shielded systems. The lighter shielding sacrifices some radiation protection and therefore results in some limitations in what their electronic systems, especially High-Performance Computing (HPC), could do (e.g., more on-board processing which could reduce by orders of magnitude the volume of data needed to be transmitted back and forth to Earth; and increase actual data collection rates for the mission at hand). There are already ongoing projects to upgrade the current radiation workhorse CPU (RAD750) by an order of magnitude, but this is not a COTS item and is expensive to manufacture and to buy. For critical systems that must be operational continuously and which may also have more lightly shielded systems, there is no other option at this time. This subtopic does not seek work of that nature.

Unlike the lightly shielded space environments discussed above, space environments which are highly shielded from radiation, such as is inherently the case for the interiors of manned missions and for habitats where humans live and work, high level radiation hardened systems like the relatively expensive RAD750 may not be as necessary even in deeper space beyond most of the present day LEO (Low Earth Orbit) situations. Instead, a less expensive COTS solution for the HPC system may be acceptable for a number of non-critical tasks that are not harmed by power interruptions, hardware failures, radiation upsets, etc. in those environments over what may have been thought likely. In order to assess the feasibility of a COTS solution for those types of highly shielded space environments, this subtopic is seeking proposals.

Successful Small Business Concern/Research Institution teams would be able to do space radiation modeling and a complete analysis of the COTS related HPC systems (e.g., modelling for an appropriate space relevant environment; destructive testing and analysis; and testing in an appropriate space relevant environment (e.g., in particle beams)). Further, since all parts in these HPC systems cannot be tested, an understanding of what parts are susceptible to radiation damage (e.g., Solid State Drives - SSDs) is crucial so as to create the list of potential test candidates.

Phase I Proposers are expected to develop a plan or strategy that explains and details how they would approach solving the problem that helps NASA mitigate radiation induced failures in the HPC system/components, identify COTS equipment that are likely candidates based on environmentally relevant testing, as well as modeling of interior environment and data analysis of similarly known/used approaches like the Orion vehicle testing (EM-1 when released). They should highlight the innovation in the suggested approach and explain why it would be a better solution over what may presently be used. Additionally, they should also indicate how the proposed strategies could be used commercially if developed. Phase I concept studies are expected raise the TRL to at least a 3/4 when completed. Phase II proposals would use that innovative approach to refine any and conduct further relevant interior environmental modeling and conduct the space radiation relevant testing and analysis on the selected COTS HPC parts/systems which could lead toward creating prototypes of the potential commercial items that come from the analysis. The deliverables from a successful Phase II is expected to raise the TRL to 5/6. Phase III would commercialize those items.

Relevance to NASA

The results from a project addressing this subtopic could be relevant to any NASA mission or project (e.g., as originating out of the Human Exploration and Operations Mission Directorate - HEOMD and the Space Technology Mission Directorate - STMD) and any commercial space activity that intends to send humans beyond LEO - Low Earth Orbit with a HPC system for reasons relevant to the mission.

References:

There are many references on each individual aspect of the work involved but very few references on the entire process wanted. For a tool that can model the radiation environment inside a spacecraft:

OLTARIS: On-line Tool for the Assessment of Radiation in Space, NASA/TP-2010-216722, July 2010. R.C.Singleterry, S.R.Blattnig, M.S.Clowdsley, G.D.Qualls, C.A.Sandridge, L.C.Simonsen, J.W.Norbury, T.C.Slaba, S.A.Walker, F.F.Badavi, J.L.Spangler, A.R.Aumann, E.N.Zapp, R.D.Rutledge, K.T.Lee, R.B.Norman.

A reference to help understand the radiation testing of powered COTS parts, see:

Correlation of Neutron Dosimetry Using a Silicon Equivalent Proportional Counter Microdosimeter and SRAM SEU Cross Sections for Eight Energy Spectra, IEEE Transaction on Nuclear Science, Vol.~50, No.~6, pp.~2363-2366, Decmeber 2003. B.Gersey, R.Wilkins, H.Huff, R.C.Dwivedi, B.Takala, J.O'Donnell, S.A.Wender, R.C.Singleterry.