NASA STTR 2020 Phase I Solicitation

T6.05 Testing of COTS Systems in Space Radiation Environments

Lead Center: LaRC

Participating Center(s): GRC, JSC

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

Scope Description

The use of commercial off-the-shelf (COTS) 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 in space environments. It seeks strategies based on a complete system analysis that include, but not limited only to, failure modes to mitigate radiation induced impacts to systems in the space radiation environment.

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 could do. There are already ongoing projects to upgrade current radiation hardened parts, but these are not COTS items and are 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 may not be as necessary even in deeper space beyond most of the present day low earth orbit (LEO) situations. Instead, a less expensive COTS solution 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 (e.g., modelling for an appropriate space relevant environment; statistical modeling of the electronic parts themselves and their connections in a system; destructive testing and analysis; and testing in an appropriate space relevant environment [e.g., in particle beams]). Further, since all parts in these systems cannot be individually tested, an understanding of what parts are susceptible to radiation damage 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 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 and conduct further relevant interior environmental modeling and conduct the space radiation relevant testing and analysis on the selected COTS 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.

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, December 2003. B.Gersey, R.Wilkins, H.Huff, R.C.Dwivedi, B.Takala, J.O'Donnell, S.A.Wender, R.C.Singleterry

Expected TRL or TRL range at completion of the project: 3 to 6

Desired Deliverables of Phase II

Prototype, Analysis, Software, Hardware, Research

Desired Deliverables Description

Either a prototype or flyable hardware to perform the proposed task. Either software or software reports that show theoretically, the hardware will withstand the space environment with any predictions of failure rates or potential upset rates and mitigation.

State of the Art and Critical Gaps

Many systems have never been subjected to replacement with COTS part based systems, either off the shelf systems or specialty designed systems with COTS parts. The list is long and not appropriate for NASA to designate a list. It is up to the proposer to identify what has been done in the past to mitigate COTS parts in a system, if anything.

Relevance / Science Traceability

This work would benefit all entities flying specialty systems in space. If reduced cost, more reliable and capable systems are needed, then COTS is a pathway to this. It just needs to be confirmed that the system can survive in the space environment.