FY19 IRTD Final Report Summary

The KSC Science Payload Computer (19-2)

Kevin E. Smith – PI

James T. Smith – co-PI

Project Description:

Build a computing platform that is small, lightweight, energy efficient, quite capable in terms of computer science, inexpensive, and radiation tolerant for a lunar mission.

Executive Summary:

The KSC team designed and built a Space Hybrid Computer (SHC) which is a capable modern computer. It has undergone integrated tests including vibration, shock, vacuum, and thermal. It is designed to be radiation tolerant using radiation tolerant circuitry (i.e. current protection) and using radiation hardened or tolerant components. The SHC is small, lightweight, energy efficient, quite capable in terms of computer science, inexpensive, and radiation tolerant. It has not yet been tested as an integrated system for radiation tolerance. The SHC is the primary computer for a completed KSC science payload known as MSolo-1 (Mass Spectrometer observing lunar operations) which has been officially delivered to the launch and landing provider. The SHC provides a solution for lunar science experiments that require a reliable computer. KSC is preparing for the payload to launch to the moon in the summer of 2021 via the NASA Commercial Lunar Payload Services (CLPS) Peregrine Mission One.

The team also created a modern Linux-based software architecture called Avionics and Software Technology Research and Application (ASTRA) hosted on the SHC in support of Resource Prospector, then Water Analysis and Volatile Extraction (WAVE), and now MSolo. The SHC running ASTRA software framework can handle tasks that are common to almost any Class B or lower flight instrument or payload. The system provides functions such as host (lander, rover, etc...) interfacing, time services, safe modes, onboard data logging, deep space network data transmission, command validation and precondition checks, automated sequencing, and reactive safing.

The Linux operating system is itself a computer program and instances of it are called kernels. In extreme cases where the kernel cannot use a required interface such as memory or a data interface, the kernel operates in a “safe mode”. This safe mode kernel is called a panic kernel. A Linux panic puts the computer into a halted state where further data processing ceases. The Linux operating system provides a native mechanism to down-grade to a new kernel when the primary kernels panic. A panic kernel was implemented for the SHC’s Linux operating system that allowed the system to record troubleshooting data and transition to a safe mode state.

The generation of Linux and application software code manages the hardware watchdog timer. The hardware watchdog timer was designed to restart the microprocessor if the microprocessor falls silent for a specified period of time. The concept is that if the microprocessor encounters a radiation single event effect that is non-destructive, but never-the-less causes the microprocessor to stop functioning properly, the microprocessor will be

unable to periodically reset the watchdog timer and eventually the watchdog timer will run out of time and generate a reset signal to restart the microprocessor. The ASTRA software on the SHC has a somewhat lengthy start up process as the filesystem is generated from a compressed image stored in non-volatile memory. The watchdog timer software manager takes over control of periodically resetting the hardware timer until the SHC's filesystem is initialized and the ASTRA software components are operational.

The SHC along with the KSC ASTRA software architecture are the starting points for a generic computing platform that can be used as a KSC Science Payload Computer (SPC). The SPC can host Linux and KSC's ASTRA software architecture, provide "soft real time" performance on a Linux platform, provide higher computing performance for science needs, provide computing availability in a radiation environment, is radiation tolerant (will not fail permanently), and is not radiation hard.