Embedded Technologies Meet Space-Based Challenges

ISS Video System Upgrade Leverages Multicore SBC Technology

In order to eliminate the many drawbacks of a non-digital video recording system, the International Space Station is getting a digital upgrade. Advanced SBC and switch fabric technologies are critical to making the new system do its mission.

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The International Space Station (ISS) is packed full of engineering systems necessary to fulfill the station's science objectives. One such system is the upcoming Microgravity Sciences Glovebox (MSG) Video Upgrade Equipment (VUE) from Teledyne Brown Engineering that uses embedded multicore Intel processor technology incorporated into a PICMG 1.3 single board computer (SBC) architecture.

The VUE records experiment science video documenting the operations for the earthbound science teams to analyze once the data has been transmitted to the ground. Ground testing of the VUE is complete and deployment on the ISS is planned for early 2014. The VUE is a significant digital upgrade to the current MSG NTSC analog video system that eliminates the need for digital tapes to record the science and the inherent problems with transporting the physical media both up to and down from the ISS (Figure 1). The VUE also does away with tape media issues related to physical storage space and the crew time needed to change out the media during science operations.

Going Digital on ISS

Tape media storage space and the crew time needed to manipulate the data tapes are critically limited on ISS. The VUE system converts the MSGs' video system to digital data, thereby doing away with the physical media. The VUE's digital data enables transmission to the ground via telemetry networks. This provides faster data accessibility to the ground science teams for starting their analysis within days of any MSG experiment. This compares to the multi-month wait time typical with the current analog tape system.

New advances in open architecture components such as processors, chipsets, memory and network interface silicon, come together in the video controller's single board computer that uses an Intel Xeon E3-1200 series processor. This SBC meets the performance profiles of this demanding video processing application with features such as more processing cores, Intel Rapid Storage Technology for RAID array support, new Intel Advanced Vector Extensions (Intel AVX) and enhancements to the Intel Virtualization Technology (Intel VT). The controller's backplane is capable of supporting up to nine plug-in PCI Express cards for use in monitoring and controlling the VUE system.

Other key MSG VUE building blocks include a multi-slot PCI Express backplane, four Terabytes of RAID data storage boards, three Terabytes of hard drive data storage,

Figure 1

The International Space Station is getting a critical upgrade to its MSG NTSC analog video system. The new Video Upgrade Equipment (VUE) is a digital upgrade that eliminates the need for tapes and the inherent problems with transporting the physical media both up to and down from the station.

two types of video capture boards for both Gigabit Ethernet (GigE) Vision 2.0 and High Definition Serial Digital Interface (HD-SDI) video data, a serial communications board offering selectable RS-232, RS-422, or RS-485 ports, and a data acquisition board to both monitor the health of the system as well as control video cameras and monitors.
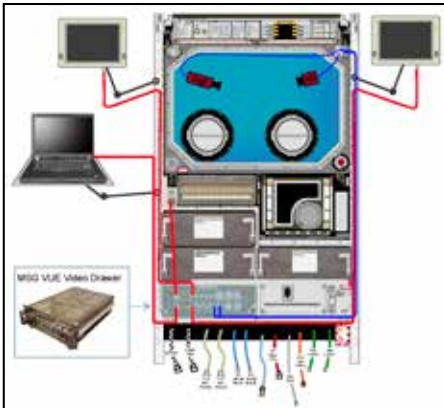
A layout drawing of the overall MSG VUE. The control system or MSG Video Drawer is located in the lower left corner of the drawing.

Application Needs for VUE

It's helpful to understand the VUE's unique operational requirements for the space environment and the technical rational behind using a single board computer architecture solution. A discussion on system interoperability of this architecture should prove useful given the inherent capability to support future technology refresh programs that may occur on the ISS.

The function of the Microgravity Sciences Glovebox is to support a wide variety of scientific experiments in a safe and self-contained enclosure on the International Space Station. The MSG VUE replaces the older analog test data capture methodology with an updated control system that supports digital data storage, multiple video capture boards, and advanced GigE and HD-SDI data communications. A layout drawing of the overall MSG VUE is illustrated in Figure 2. The control system or MSG Video Drawer is located in the lower left corner of the drawing.

A long-life embedded SBC and PCI Express backplane system architecture was chosen for a variety of reasons:

Stability and longevity – Equipment deployed on the ISS needs to remain viable for as long as possible due to the practicalities involved with deploying computer platforms in space.

Flexibility – The ability to support a number of different types of PCI Express plug-in cards is critical in this application.

Scalability – The ability to quickly add custom or standard COTS plug-in cards is a distinct advantage in this application.

Bandwidth – The PCI Express bandwidth and data throughput capabilities of the architecture are critical in the MSG VUE application.

The video drawer of MSG VUE must process, compress and store data from up to four cameras used to conduct the experiments. The video drawer also interfaces monitors and other computer peripherals into the MSG VUE that are used by the onboard scientists to set up and conduct the experiments and enable resultant data transmissions to the ground science teams. All data gathering and transmission operations need to be fast and reliable to withstand the environmental conditions of the ISS. Here's a detailed look at some of the MSG VUE components.

The VUE video data recording is enhanced by the high-definition format and the capability for high-speed or stop frame rate video capture of the payload science. The VUE stores the data on RAID solid state drives and uses video data compression techniques to reduce the volume of data required to be stored prior to data downlink. The digital video data is transmitted to the ground via the ISS Medium Rate Data Link (MRDL) telemetry network, making the science data available to the payload ground teams in near real time. The ISS MRDL also provides the capability for the VUE CPU to receive compressed digital video from other payload cameras via the ISS LAN. The VUE interfaces with the existing MSG Laptop Computer (MLC) for crew control and setup. The VUE functional block diagram is shown in Figure 4. (See the online version of this article for more details and photos of the MSG VUE's various component parts.)

MSG VUE Operations

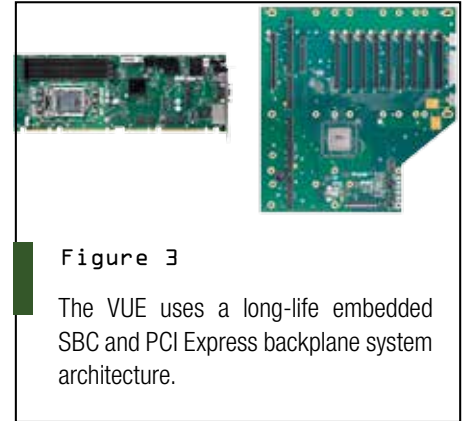The operations scenario entails crew installation of the VUE camera and

Figure 3

The VUE uses a long-life embedded SBC and PCI Express backplane system architecture.

monitor components, MLC–Model T61p, and the MSG payload hardware prior to beginning experimentations. The VUE cameras may be installed inside the MSG Work Volume (WV) or outside in the ISS cabin volume. The VUE video drawer is powered up via ground or crew MLC commands and supplied by the MSG rack ESEM 4A, RPCM 7 and ESEM 4A, RPCM 8 via a power cable. The crew then configures the VUE system settings per the experiment video science requirements using a graphical user interface (GUI) application on the MLC. Setup configuration files will be developed to preconfigure the VUE M VD computer to the video processing requirements for each MSG payload.

The crew uses the GUI application to apply power for each of the installed components and then views the HD monitors to adjust the field of view for each camera used in the experiment run. The ground science teams will view the setup and camera fields of view via the near real-time downlink of the video to approve the configuration prior to the start of the experiment run. The crew is now ready to perform the experiment and the video data are captured and stored for processing and downlink.
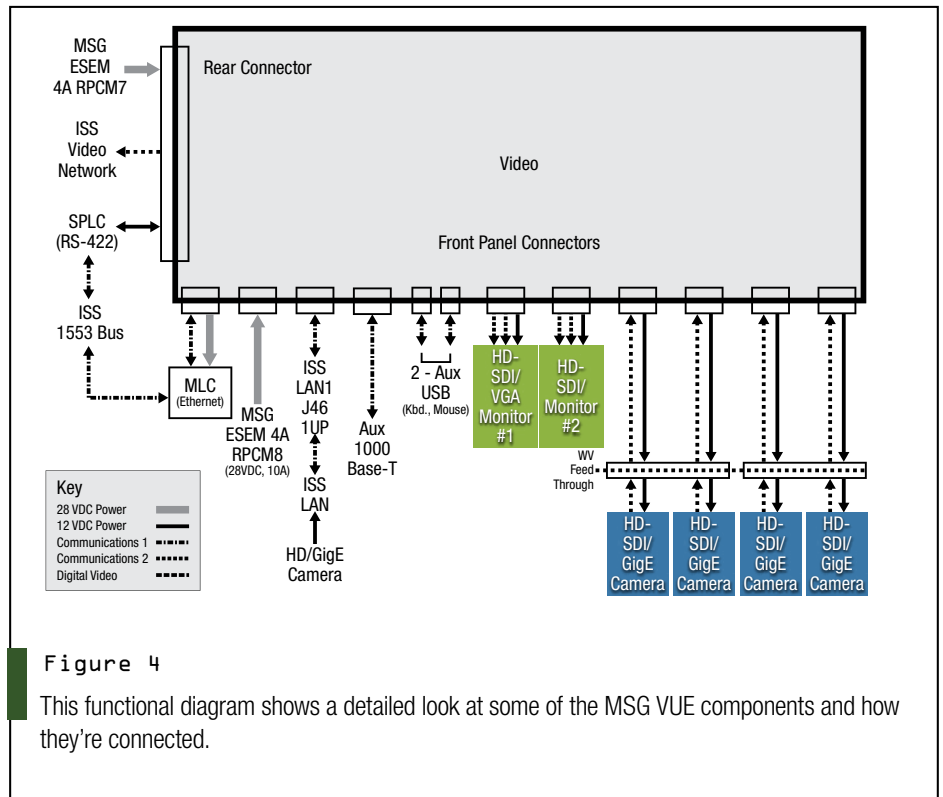
Planned for 2014 Deployment

Extensive MSG VUE ground tests related to key mission parameters like radiation exposure and data operations are complete, and the MSG VUE will be turned over to NASA for a planned deployment on the ISS in mid-2014.

The MSG VUE solves a number of ISS operational issues related to the storage and transmission of science data from experiments conducted in the microgravity environment of space.

The VUE uses advanced multicore Intel processor technology housed on a long-life, embedded single board computer capable of supporting a wide variety of PCI Express standard plug-in cards connected to the system's PICMG 1.3 backplane building block. The computer, camera, sensor and monitor technologies deployed in the VUE will provide years of operational support for the advanced science experiments conducted on the International Space Station. ∎∎

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Figure 4

This functional diagram shows a detailed look at some of the MSG VUE components and how they're connected.