High-Speed Mobile Data Acquisition Using Off-the-Shelf Components

Realizing the potential of Intel embedded solutions in mil/aero digital data recording applications

By Kevin Wu, Premio

Battlefield superiority once depended on placing more boots on the ground than the other side. Now it depends on what the military calls "C5ISR" – Coalition Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance. As the U.S. Army stated in its 2011 C5ISR Operational Needs Statement (ONS), it is looking to build a communications system "that allows dissemination of near-real-time intelligence to soldiers operating on the tactical edge of the battle area ... including biometrics and full-motion video" in real time.

C5ISR is just one of the growing number of areas where the ability to capture important data accurately and efficiently is becoming as important as the advancement in weaponry. To achieve increased functionality, performance and extended mission life in electronic systems, size, weight, and power (SWaP) must be managed and reduced across applications.

Using proprietary designs and costly NAND flash memory chips is one way to build embedded storage solutions that are smaller, lighter and use less power. But now, the same job can be done using commonly available commercial off-the-shelf (COTS) components from Intel and other manufacturers, systems developers and integrators can incorporate high-speed data acquisition and storage systems into their designs that meet SWaP standards, but at a fraction of the cost.

In this article we will discuss how to build such a storage system using Intel components. The same principles can be followed in building low-cost, flexible designs with components from other manufacturers.

SSDs Instead of NAND Chips

While most industries use COTS components for office and data center installations, the mil/aero field has long relied on custom devices designed to meet its exacting requirements. In certain cases this is still necessary, but with the advancements in SSD designs, these can often now be used for field data acquisition without compromising reliability.

One such drive is the Intel SSD 520 Series, which is built using a 25 nm process. These 2.5-inch SATA drives use multi-level cell (MLC) NAND flash which allows more data to be stored using the same number of transistors than SSDs with single-level cells, allowing capacities as large as 480GB per drive.

There are several factors that make these drives ideal for meeting the SWaP standards for field data acquisition. These include:

- **High bandwidth:** The drives come with either 3Gb/s or 6Gb/s SATA interfaces.
- **Form factor:** The 2.5 inch drives are just 7mm thick for capacities from 120GB up to 240GB and 9.5mm for 60GB to 480GB.
- **Low weight:** The drives weigh 78 grams or less.
- **Low power consumption:** Drives consume 850 mW active, 600 mW when idle.
- **Security:** Drives come with AES 256-bit encryption.
- **High read/write speeds:** Sustained sequential reads of 550 MB/s; sustained sequential writes of 520 MB/s; random 4 kB writes at up to 80,000 IOPS.
- **Reliability:** Mean time between failures (MTBF) of 1,200,000 hours and an uncorrectable bit error rate (UBER) of <1 sector per 1016 bits read.
- **Harsh operating environment:** Operates at temperatures from 0°C to 70°C, sustains shocks up to 1,500 G/0.5 msec and vibrations of 2.17 GRMS(5-700 Hz) while operating.

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With these types of operating characteristics, it is now possible to switch from using boards of NAND chips to standard IT components, meeting the needs of military and aerospace customers at a fraction of the cost.

**Building an Intel COTS Mobile Storage System**

The most cost-effective method is to use standard reference designs, but even custom storage arrays can be constructed at a lower cost using off the shelf components. Let’s look at one such design using the Intel SSD 520s.

- **Format:** A primary consideration is space. While airplanes, trucks and submarines can use storage appliances with the usual rack width, they cannot be of the standard depth. A 1U rackmount appliance with a short 18-inch depth can hold up to sixteen 7mm high SSDs, with a total capacity of up to 4TB.

- **Power:** The boxes can be built to operate off a 250 watt, high-efficiency, redundant AC power supply; -48VDC for telecom installations or 12VDC for vehicles.

- **Connectivity:** The storage arrays can be built with dual Gigabit Ethernet, dual 10-Gigabit Ethernet, Fiber Channel over Ethernet (FCoE) or Infiniband connections, depending on what is required for connection with the rest of the equipment in the vehicle.

- **Storage controller:** An embedded unified storage controller using readily available components such as the LSI SAS 2116 16-port 6Gb/s controller chip, an Intel i350 (GbE) or X540 (10GbE) Ethernet controller or an ATX motherboard with an Intel Ivy Bridge CPU.

- **Cooling:** Redundant (2+1) quick-swap fans.

- **Data protection:** Hardware RAID level 0, 1, 5, 6 and 10; file system replication; snapshots.

**Building on the Basic Design**

The block diagram shows the simplified logical configuration of one such reference design based on these parameters. The LSI SAS2116 chip is a PowerPC-based server on a chip running a unified storage stack on Linux. The LSI chip operates as the storage controller for sixteen 7mm high SSD drives and is connected over an eight-channel PCIe link to the Intel switch. The PLX Technology 8624 switch then has
8x PCIe connections to an Intel x540 with dual 10 GbE ports that support NFS, CIFS and iSCSI protocols. Those ports are used to acquire data from the sensors or a host.

The switch has a second 8x PCIe bus going to a mezzanine slot which can be for a Fiber Channel connection to a storage array for archiving, for an FC or Ethernet connection to an additional host accessing the same data, or any other pertinent application.

One use for the mezzanine card slot is for connecting to legacy systems or specialized devices that do not use one of the standard protocols supported by the unified storage stack (FC, iSCSI over 10GbE, iSCSI over Infiniband and SAS). In such a case, a custom interface card can be plugged into that slot to translate the incoming data into one of the standard protocols for storage.

In addition, while the reference design calls for the LSI chip to be running the software stack, since it is just an embedded processor, it can run any other Linux-based software as well.

The system can be further modified by using a standard ATX motherboard rather than the LSI chip, so that an x86 or other processor, such as one from Cavium that performs RAID acceleration and hardware encryption, can be used instead.

The key element with any of these designs is using the sixteen 7mm SSDs to maximize the storage capacity in the small form factor. The processors and network connections and other components can be substituted as needed.
COTS/Benefits Analysis
The above design produces a highly-reliable, compact, lightweight (under 30 pounds), high-speed data recording and streaming system that is rugged enough for deployment in vehicles and harsh environments. But current NAND flash chip designs also meet those same criteria, so what are the advantages of such an SSD design?

- **Cost:** Governments throughout the world are facing budget constraints. In the U.S., the Pentagon has already agreed to reduce its budget by $450 billion over the next decade and faces an additional $500 billion in automatic cuts if Congress fails to put together a plan that addresses the nation’s growing deficit. As the money supply tightens, OEMs and integrators will be expected to cut costs while still meeting operational needs. A storage system built with commercial off-the-shelf (COTS) components and standardized architectures, such as the one outlined above, costs about one-third those built with proprietary components and designs.

- **Speed of Deployment:** Using commercially available components slashes the time from design to deployment.

- **Greater Flexibility:** The section above describes the use of Intel 520 drives, but any 7mm drives could be used, including ones from Axiom, Corsair, Crucial, Kingston, Micron, OCZ, Samsung, Western Digital and others. This gives OEMs and their customers greater flexibility in deploying storage solutions with the exact speed and capacity they need. And by simply swapping out the power supplies or network connections, the same basic unit can be deployed in a wide array of locations.

- **Future Proofing:** With SSDs, storage capacity keeps increasing while prices plummet. Using a standard architecture, customers can buy and swap out SSDs with higher speed or capacity drives as they become available.

- **Field Servicing:** With the above design, the SSDs are hot-swappable at the front of the box. The fans are also designed for quick replacement in the field. Spare components can be kept on hand and exchanged as needed by minimally trained operators, rather than having to send the unit into the shop for repair.

Such a data capture and dissemination system makes it easier to meet the military and aerospace industry’s need to rapidly capture, analyze and disseminate critical radio, video, biometric and other information. As the 2011 CSISR ONS states, lack of such a system “restricts the Army’s ability to influence and shape operations on the battlefield.”

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Kevin Wu joined Premio in 1997 and currently serves as executive vice president where he is responsible for overseeing and managing all of Premio’s daily operations. During his career, Mr. Wu has held a broad range of functional responsibilities including information management, project management, and engineering; equaling nearly 25 years of experience in the manufacturing industry. Prior to Premio, Mr. Wu served as the director of the Information Management Division at System Manufacturing Center. He completed his graduate studies in manufacturing systems engineering at Lehigh University.