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Copy That: Disk Cloning Extends Lifespan of Legacy Systems

As **Brian McSloy, CTO of Solid State Disks Ltd**, explains in the following article, migrating from hard disk drives (HDDs) to solid-state drives (SSDs) is a practical way of enabling the legacy computer-based systems used in military/aerospace applications to provide several more years of reliable service.

Many of these systems were designed over 20 years ago. They include mission computers and dataloggers installed on military aircraft, flight management systems on commercial aircraft, ground-based maintenance and diagnostic equipment, plus simulation and training systems.

When new, these systems got fitted with what were then state-of-the-art HDDs, and a popular way of connecting drives to their host computers was via SCSI interfacing (which was standardised in 1986). The standard evolved through a number of iterations, doubling the number of data lines and incorporating differential signalling (both of these helping transfer rates to significantly increase) before finally being superseded by the serial attached SCSI (SAS) interface.

With their moving parts, electro-mechanical SCSI drives within these legacy systems are at heightened risk of failing and will certainly not be as responsive as they once were - see panel 'HDD Failure Modes' for further details. This presents several problems.

Firstly, the original HDDs are long obsolete, and the OEM may no longer even be around. Secondly, it would need to be an exact model/variant replacement (as SCSI was something of a loose standard, and the OEMs of host systems and OEMs of the SCSI drives sometimes made tweaks in order to assure exclusive compatibility between their products). Thirdly, reconditioned 'exact model' units, if they can be found, have little if any warranty and their life expectancy is unknown. It should be noted that in many cases those who had the foresight to buy spares back in the day are finding, to their horror, that they do not actually work. For example, many HDDs

HDD failure modes

HDDs are electro-mechanical devices and have moving parts - such as the spindle motor and read/write heads. These will wear over time. The magnetic disks gradually degrade too, leading to data corruption. Also, lubricants on bearings become more viscous and the drive's motor experiences a greater mechanical load (thus drawing more power). As for the electronic components, their characteristics change with age. For instance, failing decoupling capacitors can make the drive more susceptible to power fluctuations and surges. Transistors and ICs have a finite lifespan too. Lastly, the drive's firmware can become corrupted as the years pass by, preventing the drive from functioning properly or even making it totally unreadable.

have heads that rest on the disk surface when not in use. Over time (years in storage), the heads can stick. When the drive is powered, the disk surface is scratched, and sometimes the head is ripped from its suspension mechanism. Lastly, if the host computer is used in safety-critical or mission-critical applications, it will have been certified and cannot be modified without recertification (which is a lengthy and expensive process, as is making any modifications).

The failure of the HDDs within systems that are several decades old is a case of when, not if. Accordingly, to ensure the reliability of the host system and extend its life, the only logical recourse is to replace the electro-mechanical SCSI drive with a solid-state-based clone.

Cloning

Essentially, an HDD is a set of spinning platters coated with a ferro-magnetic material, a read/write head mounted on an actuator arm, plus electronics for interpreting commands from the host system's software via its operating system (OS). In order to be treated as a storage device by an OS, the HDD must be formatted. This occurs at 2 levels.

The first, physical formatting, or low-level formatting (LLF), defines the physical structure of the disk in terms of tracks, sectors and headers. Part of this is done at the point of manufacture and cannot be changed, while part is achieved via a SCSI command, normally at initial set-up. The second level is user-level formatting, or high-level formatting (HLF), which creates a file system (such as NTFS or FAT32) and builds boot sectors plus a file allocation table. User-level formatting is also performed at the point of manufacture, but, as the name indicates, is something that end user can do too.

Accordingly, for the SSD to be treated by the host computer as if it were the original HDD, it must be cloned - where a block-for-block exact replica of the HDD is made, including the OS, boot sector, system files, the file system structure, partition table, recovery partitions and data. By contrast, copying duplicates only the data (folders and files) from one drive to another.

Cloning a modern HDD (i.e. one that uses SATA or NVMe, for example) is relatively easy. The equipment needed comprises a computer that can access both the source drive and the target SSD, plus cables and/or docking stations. Adaptors, such as SATA-to-USB, may also be required. As for the software needed to control the cloning operation, there are many commercial offerings available.

Cloning an old SCSI drive is far more complex, because it uses a different connector type and protocols (i.e. you cannot simply plug a SCSI drive into a modern PC without special hardware). Specialised solid-state SCSI drives are commercially available, as are the software and hardware needed to clone the SCSI HDD. For instance, Solid State Disks' SCSIFlash technology combines proven SCSI drive architectures (SASI, SCSI-1, SCSI-2) with industry-standard, solid-state CompactFlash (CF) card technology, and has been used to replace SCSI HDDs from Seagate, HP, Sony, etc.

A clone of the source SCSI drive's disk needs to reside on the CF. To make the clone, Solid State Disks can supply DuplicatorPlus (see Figure 1). It can be used out of the box and without needing a PC to clone the image of most SCSI-based drives. It can connect directly to a source drive and cloning starts at the press of a button.

Accordingly, solid-state, swap-in replacements can take the place of SCSI drives in use (and at risk of failure) in many legacy computer-based military/aerospace systems. And in most cases, maintenance engineers can easily carry out the switch themselves. Note that if a secret handshake was agreed decades earlier between the drive producer and the host, all is not lost. Specialised analysis equipment can be employed to capture signal timings and data exchanges so that they might be programmed into the SCSIFlash firmware.

In summary, cloning is a common practice and is very easy to do if the source drive is relatively modern. Older drives that use the SCSI standard (or a tweaked version) present certain challenges, particularly if the host computer cannot be modified, but solutions do exist.

Figure 1: A legacy SCSI HDD (top) being cloned to a CF card using DuplicatorPlus - the card can then be used in a SCSIFlash drive, which presents a form-fit-function replacement of the HDD