

CYBERNETICS

The Risk of a Disk-Only
Backup Strategy:

The Case for Disk and Tape

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Testing and Analysis Performed By:



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Abstract

With the dramatic reduction in the price of hard disk drives (HDD) over the years, many IT professionals are implementing disk-to-disk backup strategies to safeguard their data, and some have begun to question whether tape backup has a place in the enterprise at all. This paper considers the risk of a disk-only strategy in light of recent research into HDD reliability in real world environments, and reveals the results of a Tape Cartridge and Disk Drive Handling Test performed by Percept Technology Labs that clearly illustrates the vulnerability of disk and the superiority of tape for disaster recovery and archiving.

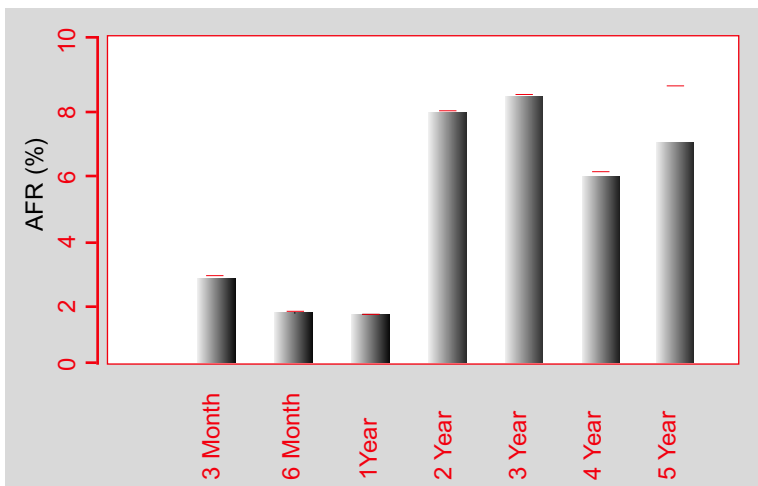
Introduction

IT professionals have long understood that relying on a single hard disk drive is risky business. RAID, a redundant array of independent disks, is designed to mitigate this risk, and has become increasingly cost-effective over time. RAID incorporates the speed of striping across several disks with redundancy through parity and failover spares to lend synergy to a system that will remain operational even in the event of individual HDD failure. As hard disk drives have become less expensive, and the use of RAID ubiquitous, the concept of disk-to-disk as a backup strategy has become quite compelling.

Disk-to-disk backup provides several benefits over tape-only backup. Virtual tape libraries on RAID provide near-line storage to ensure maximum up time. Backup to virtual tape on disk is faster than backup to a single tape drive, and faster than copying files from disk to disk - while restores occur nearly instantaneously at random access speed. Clearly, the performance benefits of disk backup make it a desirable part of a data protection plan, particularly at sites where high availability is paramount. However, any comprehensive plan must also consider disaster recovery and the need to maintain archives off-site – and in these areas, there are serious drawbacks to the use of HDDs.

In February 2007, Google published a study entitled “Failure Trends in a Large Disk Drive Population” comparing the extrapolated annualized failure rates (AFR) advertised by HDD manufacturers with actual results in a statistically significant population set – over 100,000 hard disk drives.

“The observed range of AFRs ...varies from 1.7%, for [hard disk] drives that were in their first year of operation, to over 8.6%, observed in the 3-year old population.”¹



This observed data is clearly significant for anyone considering HDDs as long-term archival media. Computer scientists with Carnegie Mellon University published a similar study, entitled “[Disk Failures in the Real World: What does an MTTF of 1,000,000 hours mean to you?](#)” and concluded that actual failure rates are significantly higher than extrapolated failure rates for HDDs.

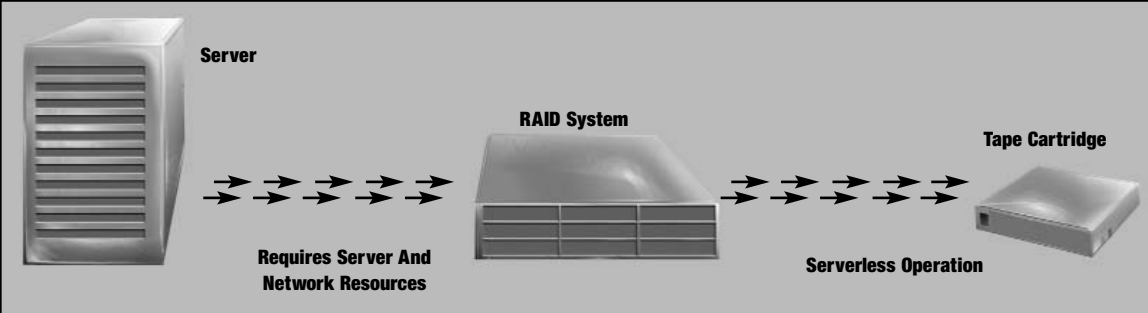
*"The mean time to failure (MTTF) of [hard disk] drives, as specified in their datasheets, ranges from 1,000,000 to 1,500,000 hours, suggesting a nominal annual failure rate of at most 0.88%. We find that in the field, annual disk replacement rates typically exceed 1%, with 2-4% common and up to 13% observed on some systems."*²

Today, disk drives use perpendicular recording technology to achieve areal recording densities in hundreds of gigabytes per square inch. The heads float above the platters on a cushion of air of about 10 Nanomicros – less than the width of a single human hair. These precision devices are by their nature highly shock-sensitive and are simply not rugged enough to be transported to off-site facilities or durable enough for archival requirements spanning more than 10 years. Moreover, the actual recording media, the disk platter itself, cannot be extracted from the drive for safekeeping, and cannot be installed into another device for recovery.

Tape drives are just as sensitive to shock as disk drives, but the cartridge itself is removable, portable, and relatively rugged. Tape cartridges are designed with a hard outer shell rated for tens of thousands of insertions and 30 years on the shelf. Even if something happens to the tape drive, the media can be read by another drive.

The ideal data protection strategy, then, will take advantage of both disk and tape technologies. Although disk-to-disk backup provides clear performance benefits for the very short term, tape backup provides much better durability for disaster recovery and archiving.

Figure 1: Storage System Containing Disk and Tape



Drop Test

Safe transportability of media is important for off-site storage and disaster recovery, and the comparable ability of the HDD or tape cartridge to withstand shock is a critical measure. Simply dropping a hard disk drive or tape cartridge has the potential to cause damage and result in data loss.

To better understand the relative risks, Percept Technology Labs, an independent test and consulting company, performed drop testing in a controlled environment. Hard disk drives and tape cartridges were tested for ability to record and retrieve data, then dropped from a variety of increasing heights, and then tested again for ability to read the media. If the data stored on the disk drive or tape cartridge was no longer recoverable after a drop test, the data was considered lost and the media was considered to have failed.

The drop testing was performed using a drop fixture that allowed the engineer to drop each individual HDD or tape cartridge from a preset distance in a controller, consistent manner. For this test, Percept dropped

The products used for this test and the height dropped from are as follows:





	Type	Disk Drive
	Brand	Seagate Barracuda
	Quantity	10
	Drop 1	24 Inches
	Drop 2	39 Inches
	Type	DLT Tape
	Brand	Quantum
	Quantity	10
	Drop 1	24 Inches
	Drop 2	39 Inches
	Type	AIT Tape
	Brand	SONY
	Quantity	10
	Drop 1	24 Inches
	Drop 2	39 Inches
	Type	LTO Tape
	Brand	SONY
	Quantity	10
	Drop 1	24 Inches
	Drop 2	39 Inches
	Drop 3	48 Inches
	Drop 4	60 Inches

Figure 2: Drop Fixture used for Drop Testing



Prior to beginning the test, each of the tape cartridges and disk drives was subjected to a baseline read/write verification test. Three of the DLT tapes failed to pass baseline, and were disqualified from further testing. Upon successful completion of the baseline test, each tape cartridge and disk drive were dropped from the series of incremental heights. After each drop, a read was attempted on previously written data to determine if the drive or cartridge could still function properly. Provided the data on the drive or cartridge could be retrieved, the media was deemed to have survived the drop, passing the test and remaining in the process until it had completed all scheduled drops or until failure – whichever occurred first.

The following figure shows the read verification bench where each tape cartridge and disk drive was checked prior to testing, and once again after each drop.

Figure 3: Read Verification Station



Type	AIT Tape	DLT* Tape	LTO Tape	HDD	Tape Totals	HDD Totals
Total Media Tested	10	7	10	10	27	10
Total Media Failures	1	0	1	10	2	10
Total Media Survived	9	7	9	0	25	0
Total Drops Survived	39	28	36	6	103	6
Total Drops Tested	40	28	37	16	105	16
Percentage Of Failures Per Drops Tested	2.5%	0.00%	2.70%	62.50%	1.90%	62.50%
Total Inches Tested	1710	1197	1563	474	4470	144
Percentage Of Failures Per Inch Traveled	0.06%	0.00%	0.06%	2.11%	0.04%	6.94%
Percentage Of Survivors To Total	90.00%	100.00%	90.00%	0.00%	92.59%	0.00%

HDD is 32.8 times more likely to fail upon any shock impact
HDD is 155 times more likely to fail as the velocity increases

**Three DLT tapes were DOA and disqualified from testing*

Test Results

Pass
 Fail
 Disqualified

	Serial Number	Baseline Write/Read	24 Inches	1 Meter	48 Inches	60 Inches
Sony AIT Tape Cartridge	2208	●	●	●	●	●
	2308	●	●	●	●	◐
	2708	●	●	●	●	●
	3008	●	●	●	●	●
	3108	●	●	●	●	●
	3208	●	●	●	●	●
	4000	●	●	●	●	●
	5002	●	●	●	●	●
	6003	●	●	●	●	●
	8000	●	●	●	●	●
Quantum DLT Tape Cartridge	0162	●	●	●	●	●
	0211	●	●	●	●	●
	2201	○	○	○	○	○
	2791	●	●	●	●	●
	7488	○	○	○	○	○
	7490	●	●	●	●	●
	8427	○	○	○	○	○
	9205	●	●	●	●	●
	9207	●	●	●	●	●
	9475	●	●	●	●	●
Sony LTO Tape Cartridge	1056	●	●	●	●	●
	1067	●	●	●	●	●
	1070	●	●	●	●	●
	1281	●	●	●	●	●
	1363	●	●	●	●	●
	8486	●	●	●	●	●
	8488	●	●	●	●	●
	9005	●	●	●	●	●
	9009	●	◐	○	○	○
	9011	●	●	●	●	●
Seagate Barracuda Hard Drive	49TT	●	●	◐	○	○
	06R6K	●	◐	○	○	○
	0GK8E	●	●	◐	○	○
	0GXZN	●	◐	○	○	○
	0J7KY	●	●	◐	○	○
	0LK7A	●	●	◐	○	○
	0SNS	●	●	◐	○	○
	42&20	●	●	◐	○	○
	44720	●	◐	○	○	○
	4540V	●	◐	○	○	○

It is easy to see that tape cartridges survive the shock of drop testing significantly better than HDDs. With the notable exception of three bad DLT tapes out of the wrapper, only 2 of the remaining 27 tested cartridges failed to complete the entire test with drops up to 60" (approximately 1.5 meters), even after successive shock trauma events leading up to that height.

None of the 10 disk drives passed the test. In fact, every disk drive tested failed at one meter or less, and after only one or two drops. Given that one meter is approximate desk height - a typical height for an accidental drop - one can conclude that hard disk drives are not well suited to transporting important data off-site and would therefore undermine an organization's disaster recovery plan by fostering a false sense of security.

Test results indicate that ~9% of tape cartridges could experience failure from a height of 1 meter, while ~99% of disk drives could experience failure from this same height. And while dropping a disk drive from this height almost guarantees data loss, not one HDD showed any outward sign of physical damage. The damage was not apparent until the Percept engineer attempted to read the data. In the real world, if a HDD were dropped during transport to an offsite facility, visual observation or inspection would not be sufficient to ensure recoverability of data. Only upon attempt to recover would the data loss be realized, and at that point it would be too late.

Conclusion

Disk arrays are designed for high-speed access to data and, as such, are ideal for near-line storage operations, particularly at sites with high availability requirements. Tape cartridges, built to withstand heavy use and long term warehousing off-site, are critical to any comprehensive disaster recovery plan. Implementing a disk-only backup strategy leaves an organization with greatly increased vulnerability to the loss of data. Employing both disk and tape, and capitalizing on the strengths of each adds levels of protection to ensure that data is quickly accessible and easily recoverable when it is needed.

1 http://labs.google.com/papers/disk_failures.html

2 <http://www.cs.cmu.edu/~bianca/fast07.pdf>

About Percept Technology Labs

Percept Technology Labs, Inc. is an established, independent product test and consulting company with a proven track record of helping customers test and improve their products since 1996. Percept specializes in data storage, ITE and consumer electronic products. To learn about Percept's full line of testing and consulting services, please visit www.percept.com or call 303-444-7480.

About Cybernetics

Located In Yorktown, Virginia, Cybernetics is a privately held corporation, producing the industry's most innovative data storage and backup solutions. Cybernetics has been the driving force behind some of the most important advances in backup and storage technology since 1978, and today Cybernetics is at the forefront of a revolution in storage networking, leading the way in developing new iSCSI SAN solutions with powerful new features for exceptional value.