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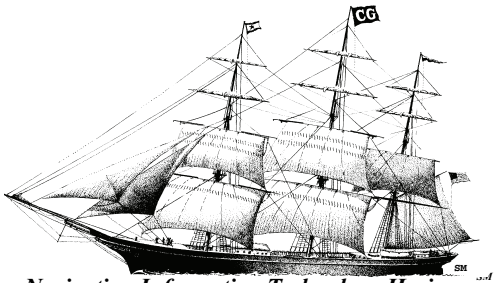

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The Truth about Tape — Nine Myths to Reconsider

Analyst: Dianne McAdam

Management Summary

The IT industry has been the battleground for a number of heated debates about the future of technology over the last few decades. Remember the discussions about the death of the mainframe? The mainframe was portrayed to be similar to a dinosaur, it was big, slow to evolve…and, in the minds of many, extinct. The mainframe debate still continues, although to a lesser degree than before. In fact, the mainframe has evolved from the big, floor-hogging, water-cooled machines of old to small, energy efficient machines today. Mainframes have continued to evolve and, unlike the dinosaur, are not extinct at all.

Later debates discussed the value of centralized versus distributed processing. During this time period, centralized computing, the standard in most data centers, was considered costly and inefficient. Distributed computing put the hardware and software in the hands of the end users, where many thought it should be located. The end users got to experience the thrill of managing and maintaining their own systems. Expectedly, that thrill soon faded, and many end users asked IT departments to take back control of their hardware and software. The proliferation of remote offices has again placed hardware in those remote locations. Stay tuned – in another few years it is possible to see that hardware returning to the main data center...again.

Additionally, there is the *tape versus disk debate* that has raged for years. Disk proponents have proclaimed that tape is dead for many years. Tape proponents claim that tape is thriving - neither dead, nor dying. Like foot soldiers in the Civil War, both sides are entrenched in their bunkers, armed with statements to diffuse the other side. This long-term debate has gone on long enough. **It is time to call a truce.**

Disk technology is alive and well. Tape technology is ***also*** alive and well. The reports of the death of tape (to paraphrase the great American author Samuel Clemens) have been greatly exaggerated. Both disk and tape will exist in the data center for many years. The roles that disk and tape partake, like the mainframe, continue to evolve and are complementary.

Let's take a look at some of the statements, or myths that have circulated that (supposedly) prove that tape is a dying media type.

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Myth #1: *Tape is old technology …and old technology must be dead*

Let's review some of the early history of tape. The first commercially available tape drive, the IBM model 726, was introduced 55 years ago in 1952. It used a 12-inch movie reel to store 1.4 megabytes of data and transferred data at 7.5 kilobits per second. The tape media was manufactured by 3M Corporation[1]. So, is tape old? Perhaps, but it has had time to grow, evolve and improve in to a reliable high performance technology. Today's tape stores nearly a terabyte of data at speeds over 100MB per second. One might think that most modern technology has been developed recently…correct? Hardly! The early 1950s was an active time for computer manufacturers.

A Little Bit About Disk History

Some believe that disk drives arrived much later on the scene than tape, but the first commercially-available disk drive appeared in 1956, just four short years later. IBM called this disk *RAMAC (Random Access Method of Accounting and Control)*. The RAMAC disk was 24 inches in diameter. It had 50 platters and could hold about 5 megabytes of data. It rotated at a blazing rate of 1200 RPM. It was big, slow, and expensive, compared to today's technology. The RAMAC system weighed about a ton, required a forklift to move it around, and you could lease it for about $3,500 a month.

By today's standards, the early tape and disk drives ***were*** old technology. But there are other technologies that are older than tape and have also continued to evolve.

Other Old Technology

Many assume that technology that was developed more than say, ten years old, is outdated and obsolete. However, consider the following.

- Bell Labs demonstrated a mechanically-scanned color television in June 1929. The first demonstration of an electronically-scanned color television was by RCA in 1940. The first commercially available TVs had very small screens in big wooden cabinets. Today's TVs are thin, with large high-resolution screens that can be mounted on a wall. Where would we be without reality TV shows?
- The first telephone call was completed in 1876. In the early days, the phones were heavy and came in your choice of color – provided it was black. Today's cell phones are small and light, come in many colors, can receive and send emails, text messages, and takes pictures. Oh, yes – they can even make phone calls. Remember when you had to look for a pay phone when traveling? Now, do you know where to find the nearest pay phone?
- The first automobile to be produced in quantity was the 1901 Curved Dash Oldsmobile, which was built in the United States by Ransom E. Olds. It had a side crank, two-speed transmission, center chain drive and a mechanical brake on the transmission. The one-cylinder engine had 4.5 horsepower. The engine was less powerful than today's lawnmower. Compare that to today's cars. When was the last time that you had to hand crank your car to start it?
- The first satellite was launched by the Soviet Union in October 1957 and was called *Sputnik 1*. It was 23 inches in diameter and carried four antennas and two radio transmitters. The batteries for the transmitters lasted for three weeks. Sputnik 1 burned up when it re-entered the earth's atmosphere in early January 1958, four months after it was propelled into space. Compare that to today's space station, which is 146 feet in length and houses scientists for six months at a time. Where would we be without satellite TV and radio?

Bottom line: ***Tapes, like disks, phones, televisions, automobiles, and satellites, have continued to evolve. In fact, the latest versions of these products do not look at all like the first version of the products that spawned their development.***

Myth #2: *Tape cannot be improved any further*

There are some that believe that tape can no longer be improved. The technology has reached its limit. However, consider the following.

Increasing Capacities

The first tape reel could store 1.4 megabytes of data. Today's LTO-3 cartridge can store 400 gigabytes of data in an uncompressed format. Later this year, LTO-4 cartridges will store double the amount of data, 800 GBs, in one

[1] In 1996, Imation was spun off from 3M and continues to make tape cartridges, along with CDs, DVDs, and other media for commercial and home use.

cartridge.[2] That means that in 55 years, the capacity of tape in an uncompressed format has increased by 571,426 times!

The fifth and sixth generation of LTO drives will continue LTO's history of doubling the capacity and increasing performance with each new generation.

How does disk compare in the capacity race? Today 500 GB SATA drives are commonplace[3]. These 500 GB drives have increased the capacity of disk drives about 100,000 times over 51 years.

Bottom Line: ***Increases in tape capacities have dramatically exceeded the pace of increases in disk capacities over the last fifty years.***

Increasing Capacities into the Future

Storage vendors have improved capacity by increasing the areal densities of their devices. Simply put, they are writing the bits closer and closer together to achieve greater capacities. But how dense is enough? How closely can we write the bits before we can no longer reliably read the bits? Increasing areal densities is a challenge faced by both disk and tape vendors. Many believe that we are quickly reaching the upper limit in longitudinal disk recording with densities in the range of 100 to 200 gigabits per square inch.

However, technological innovation will prevail. For instance, rather than continuing to write the bits closer together on the same plane, disk vendors are now increasing densities by writing bits perpendicular to the recording surface. This technique, called *Perpendicular Magnetic Recording (PMR)*, was originally tried in 1976 for floppy disks, but did not prove to be reliable. Now, it is being used for hard disk drives (HDD). The promise of PMR is that densities can be increased by a factor of ten.

If you don't think that there are similar advances in tape technology, think again! In May 2006, researchers at Almaden Research Center[4] demonstrated a tape that packed data at a density of 6.67 billion bits per inch - 15 times the density of today's most popular tape products. This means that an LTO cartridge could hold about 8 TBs of data or the equivalent of 8 million books, Eight million books requires about 57 miles of bookcases.

The Multi-Terabyte Tape Storage (MTS) program[5] is an Advanced Technical Program from the National Institute of Standards and Technology of the United States Department of Commerce. This program is a joint effort between the United States government and private industry to develop very high capacity tape storage.

This five year project, which will be completed by the end of this year, promises to increase tape densities by a factor of 250, and develop the foundation for future improvements in density by producing new magnetic film, heads, and new methods for writing the bits on the tracks. In fact, it is expected that 25 TB cartridges will be available as early as 2010.

Bottom Line: ***Improvements in magnetic tape continue with heavy investments in research and development from the United States government and private industry.***

Myth #3: *Tapes fail*

Every data center has experienced the failure of hardware or software components. Servers, disk systems, and tape drives do fail. Hard disk drives are prone to failure, which is why the disk industry has invested a great deal of money in the development of better RAID solutions. Ask any road warrior about the reliability of their laptop and they will probably spend hours telling you stories about how the laptop was infested with a virus or just decided to stop working right before a critical presentation.

Those of us that worked in data centers when tape reels were round, and not square, know about the problems with "round" tape operations. Tapes were manually threaded on to tape drives. In those days, people were allowed to eat and drink in computer rooms. It was not unusual for a person who had just finished a sandwich to run over to mount another tape and leave food particles on the tape media. Tape vendors later encased the media inside square cartridges, thus

[2] Compression, built into tape drives, can increase the capacity of the LTO-4 cartridge to about 1.6 TBs of data per cartridge.

[3] Some vendors are now starting to offer 1,000 GB drives; however, these drives are not available in disk systems today.

[4] This demonstration was the result of a joint effort between IBM and Fuji Photo Film Co., Ltd.

[5] The MTP project is led by Imation Corporation and its partners, Accutronics, Inc., Advanced Research Corporation, Peregrine Recording Technology, Inc., and Read-Rite Corporation.

preventing the media from being handled by operators. That helped to improve the operations and reliability greatly. Interestingly, the vast majority of tape-related backup problems are attributed to other sources, like system or software errors and human or administrative factors and not to tape hardware issues.

Nevertheless, there have been numerous improvements in the magnetic media coating over the years since the days of reel-to-reel tapes. To increase bit density, manufacturers have developed smaller and more-uniform size metal particulate (MP) particles for every new generation of media. These particles are sprayed using thin film coating techniques, on to a layered media. Successive generations of media are smoother than previous generations resulting in more accuracy when reading and writing the bits.

Today's tape systems employ technology to provide outstanding data integrity characteristics. For instance, LTO technology uses servo tracking mechanisms and read after write verification that help ensure accurate reads and writes. In addition, LTO tapes use cartridge memory to store vital information to help maintain the viability of the system. Mean Time Between Failure (MTBF) for tape drives is calculated at the percentage of time that the drive is reading, verifying, or writing data. All of these characteristics help provide LTO drives with an impressive MTBF of 250,000 hours at 100% duty cycle. The first generation of DDS drive, available in 1989, claimed a MTBF of 300,000 hours at a 12% duty cycle; that is 36,000 hours at 100% duty cycle. **LTO drives are about 700% more reliable than the first generation of DDS**.

Of course, critical data should be written to two cartridges and one ported to a remote location to ensure that the data can be retrieved when needed in the event of a disaster. This removable portability is a key attribute of tape technology.

Bottom line: ***Today's tape systems are highly reliable.***

Myth #4: *Nobody buys tapes … anymore*

There are some that claim that the tape market is dead. While some tape drives and tape cartridges that have seen a decline in sales, it cannot be said of the tape market in general. In fact, it is estimated that the tape market is over a $4 billion industry and the midrange segment continues to see impressive growth. Over 1.5 million LTO tape drives have shipped.[6] The total number of tape petabytes[7] shipped continues to show consistent growth. A major supplier of tape cartridges shipped about 600 petabytes of tape storage world wide in the first quarter of 2003. That number increased to about 900 petabytes in the first quarter of 2004. In the beginning of 2005, the supplier shipped almost 1300 petabytes. Over 1700 petabytes were shipped in the first quarter of 2006. That's a growth rate of about 36% every year for the last three 3 years.

Bottom Line: ***Data centers are continuing to buy tape as a critical component of the storage hierarchy.***

There are some that believe that tapes will no longer exist in major data centers. In the section above, we discussed the fact that data centers are continuing to buy tape. Let's assume for the moment that some data centers are planning to do away with tape. So, where will we put the data that is currently stored on tape? Do we just throw away the tapes? Not likely! These tapes contain historical data that may need to be kept for a number of reasons including customer service requests, performance analysis, or compliance. We could take all of the archived information on tape and copy it to disk. How practical is that?

Let's say we have 10,000 tapes. There are 6,000 LTO-2 tapes (which store 400 GB of compressed data) and 4,000 LTO-3 tapes (storing 800 GB of compressed data). That is equivalent to:

- 6,000 LTO-2 tapes x 400 GB = 2.4 million GB
- 4,000 LTO-3 tapes x 800 GB = 3.2 million GB

That's a total tape capacity of 5.6 million GBs.

Consider the following.

- A fully-populated SATA disk storage system can hold 56 TB (or 56,000 GB of data). We would need to buy 100 of these fully-populated disk storage systems.
- A high-performance disk array supports 332 TB of internal storage. We would need to purchase 17 of these fully-populated disk storage systems.

[6] LTO Program: http://lto.org/newsite/html/news_9_25_06.html

[7] How big is a petabyte? A petabyte is 1,000 terabytes of data. It is estimated that The Library of Congress contains about 10 terabytes of data. A petabyte is a large amount of storage.

You can replace your tapes with disk. It will take a lot of floor space – require dramatically increased power and cooling energy consumption and will cost a lot of money – but may make your disk salesperson very happy.

Bottom line: ***It is very expensive to replace tape with disk in medium-to-large data centers. Data centers will continue to use tape to store data.***

Myth #5: *Tapes are just too slow*

Disk can be used to provide fast backup and retrieval for some applications because it provides random file access. Tape must move sequentially through the tape to a specific section. However, not all data needs to be accessed fast or frequently. Some data may go to secondary disk and expire there. Some may move from secondary disk to a tape archive. Some may go directly to tape without having to use expensive disk space. And, when the data is moved to tape, it can be quite fast. The newly announced LTO Ultrium-4 specification calls for native drive data rates up to 120MB per second. That will be able to stream up to 864GB of compressed data per hour. This far outperforms any of today's disk backup speeds.

But tape is not just for backup. Consider the following.

- Weather satellites beam information back to earth, which creates a lot of data that must be stored. The National Center for Atmospheric Research generates over 60 terabytes of data per month, and guess where that is stored and accessed - tape!
- Old Hollywood movies were recorded on film that is fragile and requires strict controlled environments to prevent further deterioration of the film. These classics are being digitized and stored on tape to preserve the movies for future generations. If all of the movies and broadcasts that exist today were digitized, it would require about six zettabytes of storage. How big is a zettabyte? One zettabyte is equivalent to 1,024 exabytes. One exabyte is equal to 1,024 petabytes. One petabyte equals 1,024 terabytes. That's a lot of storage!
- Turner Entertainment Networks must ingest, process, and play out large numbers of video feeds from many sources. They process these videos on tape embedded with a specialized file system that allows them to store metadata about each video clip.

Bottom line: ***The National Center for Atmospheric Research and Turner Entertainment Networks do not think that tape is too slow. They use it for production every day.***

That brings us to our sixth myth, regarding the cost of disk versus tape.

Myth #6: *Disk is now cheaper than tape*

Disk prices have continued to decline. This price erosion became more apparent with the introduction of higher capacity, lower performance SATA disk. Many now claim that disk drives are less expensive than tape systems. They quote the average cost of a gigabyte of SATA disk as proof, but these numbers are averages, and averages tell only a small part of the story and don't always include all of the costs. In fact, averages can be meaningless when comparing what it will cost to store the same amount of data in your environment on disk versus tape. The cost of disk systems varies widely. Dual controllers are more expensive than a single controller. Advanced features, such as management software, can add to the cost.

Last year, I compared the cost of two systems – one LTO-3 automated tape library solution and one SATA disk system – that could store the same amount of data.[8] In this paper, a data center needed to store 150 TBs of data that was growing at 30% per year. At the end of the fifth year, they needed to store 464 TBs of data. This required 15 mid-tier disk storage systems at a list cost of $1,686,705. A similar capacity LTO-3 automated tape library only cost $261,042. When comparing the acquisition costs of the two systems, the SATA disk systems cost about 6.5 times more than the automated tape system. When adding in space and energy costs the LTO-3 tape library system cost 11x less than the SATA disk system

Don't let averages lull you into thinking the cost of disk is less than the cost of tape. The only accurate way to compare costs is to compare the costs of two systems configured with equivalent capacities.

[8] See **The Clipper Group Explorer** dated June 4, 2006, entitled *Tape and Disk Costs - What It Really Costs to Power the Equipment*, available at http://www.clipper.com/research/TCG2006046.pdf.

Bottom line: ***Tape continues to cost significantly less than disk.***

This brings us to the second part of the overall cost discussion.

Energy Costs

Tape is green - not *Kermit the Frog* green, but environmentally-friendly green. Disk drives continue to spin and need electricity to power and cool the devices whether the device is accessed or not. Tape drives, on the other hand, use little power when not reading or writing tape cartridges. Tape cartridges require no power at all, when residing in an automated library.

In the New England area, the cost of electricity is about 14.5 cents per kilowatt/hour. The 15 disk systems configured above will cost about $109,745 in electricity in one year. The electric bill for the automated tape library will only be $4,238 a year. The disk systems costs 25 times more power and cool than the tape system.

If your organization owns a power company or if your data center is located next to a dam, where electricity is inexpensive, then consider yourself lucky. However, for most data centers located in metropolitan areas, the cost to power and cool devices is a growing concern. If electrical costs continue to rise, then storing older versions of backups or archival data on tape can help to keep energy costs in line.

Bottom line: ***The cost to power and cool devices cannot be ignored. Electrical costs must be part of the purchasing costs and tape is up to 25 times less costly to power than disk.***

Data Reduction

Virtual tape libraries (VTLs) are disk-based backup systems designed to emulate tape drives and libraries. These systems were developed to improve the backup and restore performance of small files. Now, many VTL vendors are implementing various data reduction techniques within their systems to reduce the amount of backup data that needs to be stored. The premise is simple. A small percentage of data changes from day to day and we end up backing up the same unchanged data over and over…and over again. What if we could recognize the unchanged data and store it only once? The savings could be substantial. How much storage can be saved? The answer depends on the data reduction technique.

Some data reduction implementations detect identical files and store only one copy of a file, such as a PowerPoint presentation or Word document. However, change the title slide of the PowerPoint presentation and the software detects this as a changed file and stores the new version of the presentation in its entirety.

Other implementations are more granular. They examine segments within files and detect the same segments within that file and across other files. These implementations would detect that the title slide had been changed in the PowerPoint presentation and only save the contents of that title slide as "new" data.

Does data reduction change the discussion about the cost of tape and disk? While it is easy to compare automated tape solutions to SATA disk solutions, it is more difficult to compare the cost of a VTL with data reduction to the cost of an automated tape library or a standard disk system. Why?

- VTL systems contain intelligent software to create and manage virtual tape cartridges. In general, they cost more than pure SATA disk systems.
- Some VTLs have data reduction software; some do not. In general, the more features that are incorporated in VTLs, the more expensive the solution.
- Data reduction implementations vary depending on the type of data being stored and the amount of data that changes over time.
- It takes weeks to achieve maximum reduction rates. Remember that data reduction compares files or segments to existing files and segments and eliminates redundancies. Most enterprises find that it takes weeks and months before they experience maximum reduction rates.

So how can we compare the cost of disk versus tape versus data reduction disk-based systems? The answer is – with a great deal of difficulty. Do we configure the data reduction VTL with sufficient capacity to store all initial backups? Alternatively, do we configure the VTL with adequate capacity, after we achieve maximum data reduction rates? Where do we write those backups that cannot "fit" on the VTL until maximum reduction rates are achieved? What data reduction rates should we use – 20-to-1? How long will it take to achieve those rates? Comparing the cost of two different target media – disk or tape – is more accurate than comparing either the cost of tape or disk systems to the cost

of a specially built backup appliance.

Some disk-based backup appliances with data reduction technology can approach the acquisition cost of tape over a period of time when the maximum data reduction rates are achieved (and after extra storage has been purchased to cover data needs in the early implementation phase) However, tape systems will always have the advantage of lower space and energy costs. In addition, having all of your deduped data onsite can be a data protection exposure. Again, the removability of tape can address your disaster recovery objectives.

Each solution should be evaluated carefully to determine the initial costs to implement these solutions and the on-going costs of operations.

Virtual tape libraries can improve backup and restore times. Many enterprises have implemented VTLs to store a week of backups on disk and copy older backups to tape to take advantage of the economics and removability of tape cartridges. Data reduction allows those enterprises to store additional backups on disk, or retain more weeks of backup on disk. Again, a note of caution - one VTL located in the main data center does not provide disaster recovery protection. A backup solution is not complete without tape. Tape supplements near-line storage by providing removable archival storage, which is the only form of protection against all forms of data loss.

Bottom line: ***Physical tape still maintains its role as the most economical way to provide archive storage and disaster recovery protection.***

Myth #7: *Tapes get lost*

Everyone that has read a newspaper in the last few months or has listened to the news on TV or radio is aware that several large corporations have admitted that their backup tapes have been "lost". These tapes never did make it to the final vault. There should always be a concern that tapes containing sensitive information are "recovered" by people looking to use that information for illegal gains. Tapes will get lost in shipment. Any package that is shipped can, and occasionally will get, misdirected, stolen, or accidentally destroyed.

There is a simple answer to this problem and it is called *encryption*. Any confidential data that is shipped offsite, whether it is shipped on a tape or over a network, should be encrypted. Then, when the data is "lost", the contents cannot be used for malicious gain.

Is it hard to encrypt tapes? Encryption is easy (managing the keys is the difficult part). Backup software has imbedded encryption that can be used to write encrypted backups to tape. There are appliances that encrypt data before it is sent to the tape drive. Tape hardware encryption has recently become available on tape drives and will be available on LTO generation 4 tape drives this year. Tape drive encryption is fast and doesn't consume server overhead like software encryption. The drives can do encryption at rated speeds and they can compress the data first and then encrypt helping to maximize storage capacities. Tape drive encryption can also help reduce the storage infrastructure by eliminating the need to invest and manage an encryption appliance.

Tape encryption is important. Having an enterprise-wide security plan is critical for every corporation. If you don't have a security plan in place today, you need to start planning today. Encrypting tapes must be part of that plan.

There is more work being done. Radio Frequency Identification (RFID) is in use by many corporations and the United States Government to track inventory. Similar RFID technology will soon be available for tape cartridges to track cartridges as they move from one location to another. Other technologies are also under development that will allow tapes in transit to be tracked continually.

Bottom line: ***Any confidential data sent off site must be encrypted and tape drive encryption is a great choice.***

Myth #8: *Tape is not part of best practices*

Oh, contraire! Try telling that to the major insurance, Wall Street bank, and retailers of the world that all have strategic investments in tape technology.

Putting all your eggs in to one technology backup basket is dangerous. Having more than one media type for storing critical data is important in the event of a media catastrophe. Therefore, a copy on disk and a copy on tape or optical is essential. Tape is removable and once removed from the system is not susceptible to system errors, viruses, or sabotage.

Having more than one… more than two…

even three copies of critical data is becoming the standard. Losing access to critical data is more costly to a company than the investment in the storage systems. Best practices dictates that an enterprise should have one copy of critical files at the primary location and then a second copy at a remote location, (or at two different locations) to prevent loss of data if a regional disaster occurs. And as we have previously discussed, tape fits this bill nicely with its portability, reliability, and favorable TCO.

Bottom line: ***Tape retains its role as part of best practices for data protection and disaster recovery.***

Myth #9: *Tape is boring*

Tape is boring – try telling that to a tape engineer that is developing the next higher capacity tape drive or automated library robot. In the reel-to-reel days of tape, it was comforting to watch the tape reels spin. Spinning tape reels gave those of us that worked in the data center a sense of confidence. Spinning tapes meant that jobs were executing and productive work was getting done.

Those of us that worked in the data center were not the only ones that enjoyed watching tapes spin. Spinning tape drives were the backdrop for many movies to give viewers a sense that technology was at work.

The fun of watching tapes disappeared when tape reels were replaced by cartridges that were small, compact, and the mechanics were hidden from view. Nevertheless, the fun returned with the invention of the automated tape library. The robot would move very quickly along the walls that housed tape cartridges, retrieve the correct cartridge and mount it into a tape drive. The original libraries were constructed of solid walls that did not allow people to view the robot. Later, the vendors understood that people were fascinated with robots and windows were added that allowed people to view the high-speed activity of the robot.

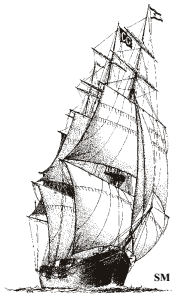
In one data center, the night operators decided to "dress up" each robot. The next morning, the day shift operators were crammed around the windows of the libraries laughing as robots with brightly colored ties, sunglasses and straw hats went whizzing by.

Bottom line: ***Robotics has put the fun back into the data center.***

Conclusion

It has been 55 years since the first commercially available tape drive was marketed to data centers. Tape drives today do not look at all like those first drives. Engineering developments through out the years have brought us faster, more reliable, and higher capacity media and drives and the development shows no sign of abating.

Tape's role in addressing compliance with WORM, data retention with archive, data security with encryption, data protection with safely-removable cartridges and TCO with low acquisition and operation costs is strategic in the storage hierarchy.



Tape, like disk systems, continues to evolve. That evolution ensures tape's place in the data center today and in the future.

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- ***The Clipper Group can be reached at 781-235-0085 and found on the web at www.clipper.com.***

About the Author

Dianne McAdam **is Director of Enterprise Information Assurance for the Clipper Group**. She brings over three decades of experience as a data center director, educator, technical programmer, systems engineer, and manager for industry-leading vendors. Dianne has held the position of senior analyst at Data Mobility Group and at Illuminata. Before that, she was a technical presentation specialist at EMC's Executive Briefing Center. At Hitachi Data Systems, she served as performance and capacity planning systems engineer and as a systems engineering manager. She also worked at StorageTek as a virtual tape and disk specialist; at Sun Microsystems, as an enterprise storage specialist; and at several large corporations as technical services directors. Dianne earned a Bachelor's and Master's degree in mathematics from Hofstra University in New York.

- ***Reach Dianne McAdam via e-mail at dianne.mcadam@clipper.com or at 781-235-0085 Ext. 212. (Please dial "212" when you hear the automated attendant.)***

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Dianne McAdam **is Director of Enterprise Information Assurance for the Clipper Group**. She brings over three decades of experience as a data center director, educator, technical programmer, systems engineer, and manager for industry-leading vendors. Dianne has held the position of senior analyst at Data Mobility Group and at Illuminata. Before that, she was a technical presentation specialist at EMC's Executive Briefing Center. At Hitachi Data Systems, she served as performance and capacity planning systems engineer and as a systems engineering manager. She also worked at StorageTek as a virtual tape and disk specialist; at Sun Microsystems, as an enterprise storage specialist; and at several large corporations as technical services directors. Dianne earned a Bachelor's and Master's degree in mathematics from Hofstra University in New York.

- ***Reach Dianne McAdam via e-mail at dianne.mcadam@clipper.com or at 781-235-0085 Ext. 212. (Please dial "212" when you hear the automated attendant.)***

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