SPECTRA

DEEP STORAGE EXPERTS

Tape Drive Technology Comparison

LTO-6, TS1150, and T10000D

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ABSTRACT

LTO technology is a commonly used drive technology for tape libraries, but other drive technologies are worth evaluating, as well. Two additional technologies, TS11x0 and T10000D, are evaluated and compared to LTO technology. These two drive technologies provide significant benefits.

INTRODUCTION

Tape technology's speed, affordability, and reliability make it increasingly central to data protection as the volume of data continues along its steep growth trajectory. This growth has propelled tremendous advances in physical tape digital storage technologies over the past ten years. These advances warrant further analysis that can help data storage customers select the right tape technology for each data protection environment.

In 2014, IBM and Fujifilm announced a 154 TB tape, and Sony announced a 185 TB tape.

Tape dominates as the storage industry's preferred form of removable media, and remains the hands-down leader in additional categories that include cost and reliability. The archival lifetime of tape for storing data securely, and maintaining the data's integrity, is unmatched, with an archival life of 30 or more years given an easily maintained environment. Further, the IBM and Fujifilm announcement in 2014 of a 154 TB (native) capacity tape[1] and the Sony announcement in 2014 of a 185 TB (native) capacity tape[2] demonstrate tape has a long, viable future.

This white paper examines the major tape technologies that compete in the medium–sized and enterprise organizations market. The competitors include LTO, offered by IBM and HP, and proprietary drives from Oracle, and IBM. The proprietary drives advantages are performance, capacity, reliability, and roadmap.

The drives reviewed are typically used in automated tape libraries, and are evaluated in that context. Some libraries provide automation features that play a significant role in maintaining data integrity through drive and tape health management, a consideration that may affect tape choices given the enhanced data reliability through automation. Further, some drives have innovative features that warrant mention in this analysis.

This paper examines the following tape technologies:

1. Linear Tape Open/LTO-6
2. TS11x0 Technology/TS1150
3. T10000D

[1] IBM Research Sets New Record for Storing Massive Amount of Big Data, May 19,2014
http://www-03.ibm.com/press/us/en/pressrelease/43945.wss

[2] Sony develops magnetic tape technology with world highest areal recording density of 148 GB/in^2 4-2014
http://www.sony.net/SonyInfo/News/Press/201404/14-044E/index.html

This paper covers the following information regarding each tape drive technology:

- Drive technology introduction
- Recording methodology and mechanics
- Performance/transfer rates and capacity
- Data streaming to optimize performance
- Connectivity
- Price
- Power Use
- Read/write compatibility with earlier generations of tape
- Enterprise-class reliability of media and drives
- Load/Rewind and access times
- Recent technology enhancements
- Technology roadmap

METHODOLOGY

Selecting tape technology is typically driven by capacity, performance, reliability, cost and a documented roadmap. However, this information may be obscured on specification sheets, each emphasizing certain aspects of technology, or using non-standard nomenclature in describing a wide range of features. Distinguishing the useful from the less useful requires some understanding of the technology and how tape has been used.

Unless otherwise noted throughout this paper, the following conventions have been used:

- The values in this paper reflect those specified for each technology's most recent generation/largest media—the largest tape cartridge, for example.
- When multiple values have been identified for any specification, the value from the most trusted source is used. For example, real world testing by a trusted source is used in place of vendor-supplied numbers, unless the delta between the values is large, in which case all values are shown and the discrepancy is discussed.

Data used is typically for Fibre Channel drives operating at maximum typical use.

- All values are native (that is, no compression is assumed).
- Values may have been rounded.

Drive Technology Introduction

Figure 1 shows the progression of open and proprietary technologies.

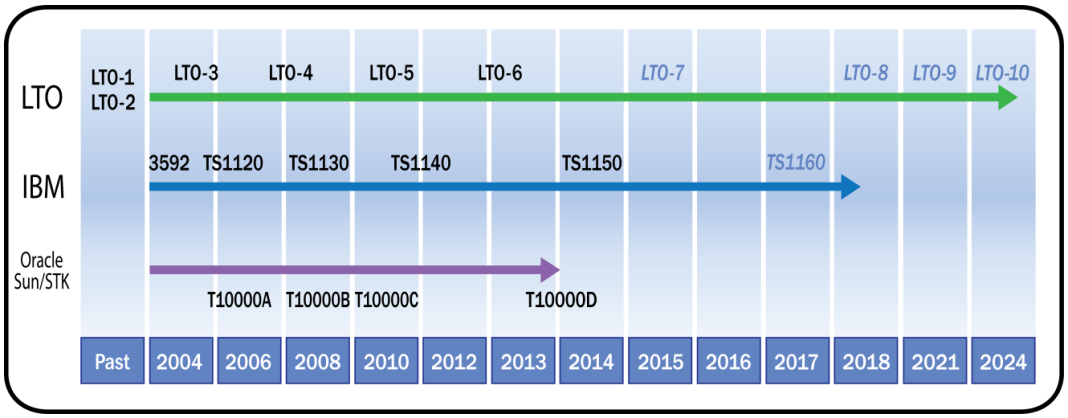

Figure 1: Open and proprietary technologies

The following tape drive technologies all employ a serpentine recording method, but with varying results in performance, cost, and other measures.

Ultrium LTO

Linear Tape Open technology is built on open tape standards developed in a joint venture by Hewlett Packard (HP), IBM, and Seagate. That group created LTO technology in 1997 to provide more choices to users in what had been previously a closed-development arena. The LTO consortium of HP, IBM, and now Quantum oversees LTO technology development and roadmaps.

LTO, built on open tape standards, is controlled by a consortium of HP, IBM, and Quantum.

LTO is an open-format technology, also referred to as Ultrium, with multiple sources for the drives and tapes. Because LTO licenses manufacturing to multiple vendors, LTO ensures compatibility between different vendors' tape and drives. LTO-6, the current generation, maintains the feature sets available in LTO-5 (Partitioning, Encryption, WORM and Linear Tape File System (LTFS)), while offering performance and capacity improvements.

LTO-6, the current generation continues to utilize a Giant Magneto Resistive (GMR) head to reduce wear on media. This technology was implemented in LTO-5 and is also available in IBM TS11x0 drives. LTO generations 7 - 10 are promised on the current roadmap, indicating the technology will be around for a while, which is good news for those charged with protecting data for the long-term. The next generations of LTO will continue to increase capacity and performance: LTO-6 provides native transfer rates up to 160 MB/s. Roadmap plans for LTO-7 COMPRESSED are estimated to be up to 788 MB/s, and LTO-8 COMPRESSED up to 1,180 MB/s.

IBM TS1150

TS1150 has the largest current capacity at 10 TB per tape.

The TS1150 is the newest generation of the TS11x0 drive technology. The TS technology continues to offer extraordinary improvements in capacity and performance with each new generation. The TS1150 offers a 10 TB per tape and up to 360 MB/second data rate. This is a 150% increase in capacity and a 45% increase in data rate, exceptional improvement for one generation.

ORACLE-STORAGETEK T10000D

The T10000D was released in September of 2013. Capacity for the new generation tape drive increased to 8.0 TB[3] per tape. The previous generation, T10000C offered 5 TB per tape. Performance of the T10000D offers a native data rate of 252 MB/second, no change from the previous T10000C tape drive

ACCESS TO SINGLE FILE VS. TRANSFER RATE/CAPACITY

The issue of access time to data is important in understanding data included on specification sheets. When tape was originally used with mainframes, it was the only available media for storing information. Hard drives were too expensive at that time for simply storing data and instead were used to run applications. In this circumstance, when you requested a file, the file was stored only on tape, meaning the speed of data access was significant to users.

Today, tape is no longer typically used as online media, although it can serve well as a nearline medium given its minimal latency through the newest tape technologies. The change in tape use and the growth of data has led to high capacity data storage using drives that can restore and write data quickly.

Contemporary tape use emphasizes performance in terms of data transfer rate. Given that data growth is steady and significant, storing more data more quickly has become the standard measure of a drive, more so than its ability to access a single file quickly.

[3] Oracle states that the T1000D offers up to 8.5 TB with the Maximum Capacity feature. This feature enables the use of tape capacity that is normally reserved to ensure tape-to-tape copy operations succeed and for retry write operations. All tape media has additional capacity for this purpose and it should not be counted towards total capacity.

Recording Methodology and Mechanics

This section covers the following linear serpentine recording, tape drive mechanics, linear drive mechanics, and mechanical speed control.

Linear Serpentine Recording

LTO, T10000x, and TS11x0 technologies write linear serpentine data tracks parallel to the edge of the tape, shown in Figure 2.

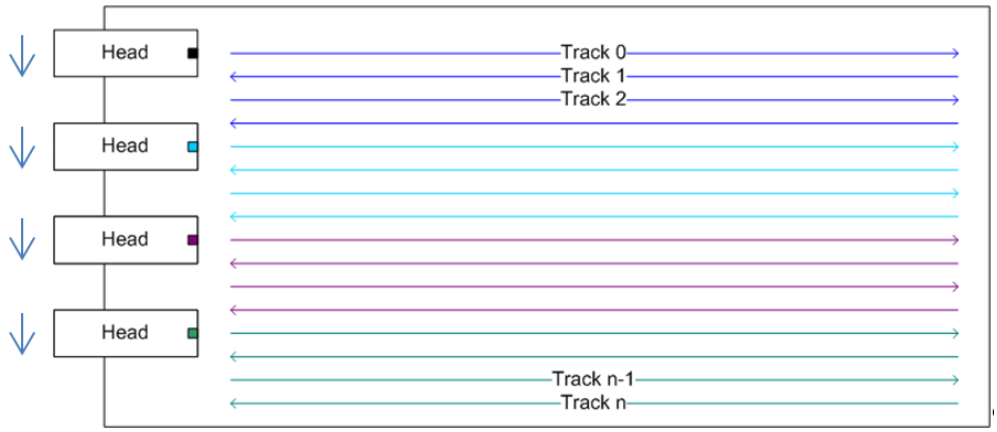

Figure 2: Linear serpentine recording

Using linear serpentine recording, a half-inch tape moves linearly past a head that houses the carefully aligned read and write heads. To create the serpentine pattern on the tape, the head assembly moves up or down to precise positions at both ends of the tape. Once the head assembly is in position, the tape motion is resumed and another data track is written parallel to and between the previously written tracks.

Tape Drive Mechanics

In all tape drive systems, the tape is pulled from the cartridge, guided through the tape path, and then pulled across the read-write head assembly. Tape mechanics have improved significantly, with extra error checking and media handling sophistication that largely eliminates concerns about tape handling.

Figure 3: LTO media

Linear Drive Mechanisms

When the tape cartridge is inserted into a linear tape drive, a load mechanism inside the drive engages with a positioning tab at the beginning of the tape. The tab pulls the tape out of the cartridge and onto a take-up hub inside the drive compartment or tape deck. As the drive reads or writes, the drive spools the tape between the take-up hub inside the drive and the cartridge supply reel inside the media cartridge.

Mechanical Speed Control

In all drives, the tape must be precisely moved through the tape path and across the heads during read and write operations. Also, the relative speed between the tape and the heads must be precisely controlled.

The LTO and TS11x0 drive technology performs dynamic speed matching to minimize data backhitch operations that are the result of transferring data from a host that is unable to sustain the maximum data rate. The drive will automatically perform speed matching to match the logical data rate of the host as closely as possible to the host drive. Eliminating backhitch operations improves performance and minimizes wear and tear on the drive and media.

Linear recording technology controls tape speed using a servo mechanism and pick-up and take-up spools. These linear mechanisms employ a very tight and positive control of the spool-to-deck mechanism, which forces the spool gears into the corresponding deck gears.

Capacity and Performance

Tape capacity is measured by the amount of data that can be recorded on a single tape cartridge. Ideally, tape manufacturers maximize capacity by increasing the bit density on a given area of tape. However, some manufacturers simply increase the length of the tape in the cartridge. Hardware data compression is also used to increase capacity. Native and compressed capacities and transfer rates for each tape technology are shown in the table below.

Table 1: Capacity and transfer rate

Data Transfer Rate, Native	Data Transfer Rate, Compressed	Native Capacity	Compression Ratio	Compressed Capacity
160 MB/s	400 MB/s	2.5 TB	2.5:1	6.25 TB
360 MB/s	700 MB/s	10 TB	2.5:1	25 TB
252 MB/s	800 MB/s	8.0 TB	n/a	n/a

Data transfer rate is defined as the speed at which data is written to tape from the drive's internal buffer. This is usually measured in megabytes per second (MB/sec). Actual performance is greatly affected by the speed at which the host system transfers data to the drive.

If the rate is significantly slower than the drive's transfer rate, the tape drive must stop and wait for its internal data buffer to fill before sending the contents to tape again.

The TS1150 Tape Drive uses the data compression known as SLDC "Streaming Lossless Data Compression Algorithm – (SLDC)." This method of compression is identical to previous models with the exception of the capacity increase from 1k to 16k in history buffer capacity. SLDC is an implementation of a Lempel-Ziv class 1 (LZ-1) data compression algorithms. SLDC is an extension to the Adaptive Lossless Data Compression (ALDC) algorithm, which is used in leading industry tape products. Users of SLDC can expect to experience the same, or better, data compression compared to users of ALDC.

A key difference between SLDC and previous lossless compression algorithms is that record boundaries and file marks are encoded as control symbols. With the use of control symbols to encode record boundaries and file markers, SLDC allows compressed data stream to be separated into a serial stream of records and file marks by the decompression logic without requiring additional information from an attached header.

The Role of Data Streaming in Performance

Shoeshining, a repositioning that damages the tape, is addressed with speed-matching and data buffers.

A tape drive's ability to continuously read or write data–to "stream" data–is a key performance and reliability differentiator. A drive's performance suffers dramatically if the drive is not supplied with data at a rate sufficient to keep it streaming. In cases where these conditions are not met, the tape drive must stop and wait for its internal data buffer to fill before sending the contents to tape again. The tape must be repositioned each time this occurs for the drive to begin writing at the location where the previous write operation stopped. This reposition is called a *backhitch* (also known as a *football* or *shoe shining*). Speed-matching and data buffers help minimize this start-stop action.

Speed matching uses an algorithm in the drive to match the speed of the tape drive to the speed of the application. LTO has 14 different speeds and the TS technology possess 12 different read/write speeds which allows the drives to stream data to the tape from slower hosts. Speed matching enables better throughput and reliability in environments where hosts data rates are less than optimal. The T10000D only offers a 2GB data buffer to mask the backhitch operation unlike LTO and TS11x0 that provides both a data buffer and speed matching.

To minimize shoeshine, high-performance linear technologies employ:

- Mechanical systems to address this through powerful reel motor systems.
- A buffer that stores data and releases it as appropriate to ensure that the drive operates at an optimal speed, caching data that can be used to keep the tape streaming through the drive. The tape stops only when the buffer contains no data to be written (buffer underflow), or when it is full of data during reading (buffer overflow).
- Optimized speed through speed matching that adjusts the drive to move at multiple speeds rather than a fixed linear speed. For example Spectra's IBM LTO and TS1150 drives provide up to 14 and 12 different speeds respectively that can track to variable data rates from the host, ensure optimal throughput from the host, and virtually eliminate mechanical repositions. The drives match the speed of the tape to the rate of data streaming into the drive resulting in the most reliable tape technology ever developed

Table 2: Buffer and speed matching

Drive Technology	Buffer	Speed- Matching
LTO-6	1 GB	14
TS1150	2 GB	12
T10000D	2 GB	n/a

CHANNEL INTERFACES

LTO drives offer three different channel interfaces; SCSI, Fibre Channel and SAS. The TS1150 provides host connectivity via Fibre Channel and FICON. The Oracle T10000D offers Fibre Channel, FICON and FCoE. Refer to Table 3 for specific details on channel interfaces.

Table 3: Connectivity and interfaces

Drive Technology	Interface
LTO-6	Open systems: • Serial-attached SCSI (SAS) at 6 Gbit/sec • 8 Gb Fibre Channel, dual port • 3Gb/s and 4Gb/s backward-compatible for SAS • 4Gb/s, 2Gb/s, 1Gb/s backwards-compatible FC
TS1150	Open systems: • 8 Gb Fibre Channel, dual port Mainframe: • FICON* (*Requires a controller to use FICON)
T10000D	Open systems: • 16 Gb Fibre Channel, dual port Mainframe • Native FICON • 10 Gb native FCoE

PRICE

Consider whether it is worthwhile to invest in a proprietary format, especially given the open-source format LTO, is a decreasingly expensive option available from multiple vendors. Proprietary drives cost significantly more than LTO drives, but offer increased value in terms of performance, capacity and reliability. Generally, **single-sourced proprietary media** has lower sales volumes and much higher overhead (e.g., development costs to recover prior to earning profit), which means that media prices don't tend to decline much between new generations.

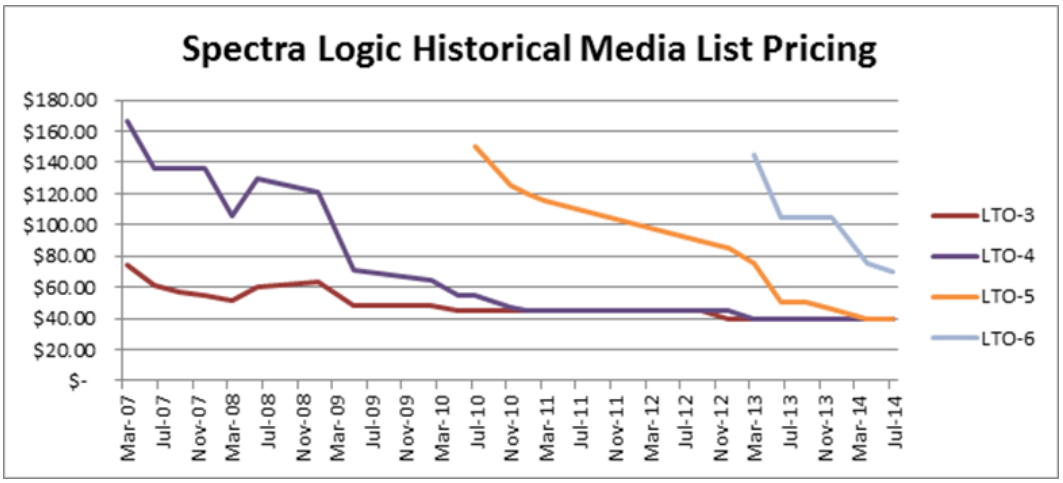

Figure 4: Price listing history

POWER REQUIREMENTS

Power use is an increasingly important topic in data center management. Some regions of the country and world are reaching the maximum power available in specific regions, such as the Northeastern United States. Everywhere, concerns about both costs and the environment are also emphasizing reduced power use. Data centers are significant users of power in the world. Storage uses about 40% of data energy, a percentage that would be drastically reduced by making appropriate use of tape.

Power is best assessed by looking at how much power a specific drive requires. The power required by the drives spans a considerable range. To align power use so that the results can be easily compared, divide typical energy used by quantity of data capacity (for example, watts/TB).

Table 4: Connectivity and interfaces

Drive Technology	Power Use*	Native Capacity	Watts/TB
LTO-6	27 watts	2.5 TB	10.8 w/TB
TS1150	46 watts	10 TB	4.6 w/TB
T10000D	90 watts	8.0 TB	10.6 w/TB

* Typical, not maximum

Media and Backward Compatibility

As tape technologies evolve, a drive manufacturer must weigh the size of its installed base and the willingness of that base to switch to a new media type as the manufacturer introduces new tape drives. In general, new tape drives use new media types to take advantage of the latest head and media materials. Once the drive technology is established, the drive typically provides some backwards read/write compatibility—it can read from and write to older generations of media.

Table 5: Drive technology and supported media

Drive Technology	Media Supported: Reads	Media Supported: Writes
LTO-6	Reads LTO-4, LTO-5, and LTO-6 tapes.	Writes to LTO-5 and LTO-6 tapes.
TS1150	Reads 3592 JC (TS1140), and 3592 JD (TS1150) tapes.	Writes to 3592 JC (TS1140), and 3592 JD (TS1150) tapes.
T10000D	Reads T10000A, T10000B, T1000C and T10000D tapes.	Writes to T10000C and T10000D tapes.

The TS11x0 Technology provides a feature that can significantly reduce the cost to migrate to a new generation tape drive and media. TS11x0 provides the ability a reformat a previous generation tape cartridge, increasing the density of that cartridge over its original capacity as well as providing increased performance when reading or writing to the reformatted tape. This means that a customer does not have to buy all new media in order to gain enhancements in capacity and performance with a new generation drive. This feature is only available on TS11x0 technology.

Table 6 lists the three generations of TS11x0 media and tape drives and the performance and tape capacity achieved by each combination of drive and media.

Table 6: TS11x0 reformat feature

	TS1130		TS1140		TS1150	
	Performance	Capacity	Performance	Capacity	Performance	Capacity
3592 JD					360 MB/sec	10 TB
3592 JC			250 MB/sec	4 TB	300 MB/sec	7 TB
3592 JB	163 MB/sec	1 TB	203 MB/sec	1.6 TB		
3592 JA	143 MB/sec	640 GB				

Reliability

It's not easy to measure tape and drive reliability, because so many factors are involved. Note that there is no single metric to establish drive and tape reliability. Because of this complexity, it's important to note that a simple analysis is an incomplete analysis. Mean Time Between Failures (MTBF) is largely irrelevant, given the variability involved in estimating this value. For example, consider the following metrics when calculating tape and tape drive reliability and overall lifespan:

- Error statistics, where more recent errors are weighted more heavily and errors from which the drive could not recover are more heavily weighted.
- Number of tape mounts and dismounts.
- Number of bytes written and read.
- Head life specifications (typically measured in hours).
- Design attributes that contribute to increased reliability. For example:
    - LTO drives (by IBM, a member of the LTO consortium) improve read/write reliability by storing IBM's media read/write data on every use of the cartridge when using IBM LTO tape drives.
    - TS1150 drives are designed for constant use 24x7, and provides superior data integrity on tape.
    - TS1150 with drive self-monitoring virtually eliminates tape damage.
    - TS1150 and LTO drives use a flangeless tape path, improving media handling.
    - T10000D drives use a dual-head technology which reduces the number of tape passes.
- Data integrity, specified as the bit error rate, which gives the number of permanent errors per total number of bits written. Uncorrected bit error rate is used in this analysis, rather than the undetected error rate.
- The media-use specification by the manufacturer, which indicates how many times the tape has passed over the drive heads. The number of passes differs depending on the technology. To assess these values, the passes must be compared in an apples-to-apples manner because the number of passes required to write to all tracks on an entire tape differs depending on the technology. LTO tapes, for example, have a life span of 260 complete backups (completely filling the tape 260 times), which equals 20,000 passes of the tape over the drive's heads.
- The number of media loads and unloads, each a stressor on the tape, is another way to measure tape lifetime.
- Bit error rate (BER) is the number of bits that have errors relative to the total number of bits received in a transmission. These are errors detected

by Error Correction Code (ECC) but were unable to correct. BER is one measure of the reliability (signal quality) of a data storage solution.

- The Undetected BER is the number of bits (or other units of information) which are received but are not detected or corrected by ECC, divided by the total number of bits (or other units of information) transmitted (also known as residual error rate).
- To put in perspective how reliable tape is with its Undetected Error Rate of a single bit for every 1.6×10^{33} bits read:
- On average for a million tape or disk drives running continuously, at 300 and 200 Mbytes respectively, you get one undetectable tape bit error once every 22.5 billion years (five times the age of the earth) in comparison to 1,577 undetected bad sectors EVERY YEAR with disk.

The usability of each tape can be calculated using internal drive analyses or using Media Lifecycle Management. The latter is a Spectra library method of tracking tape uses and tracking error rates when writing to or reading from tapes. Errors may be due to drive problems or to media problems. Some systems, such as Spectra's Media Lifecycle Management, help you distinguish between the two types of failure, so you can remove the tape or identify the problem drive and clean it or deal with it proactively, as appropriate.

Figure 5: Spectra Logic tape health icons in Media Lifecycle Management

TS11x0 technology tape drives are the most reliable tape technology ever developed. TS1150 offers 1000 times greater data reliability creating enterprise-class reliability. From significant capacity gains with every generation, TS11x0 technology provides investment protection through reformatting previous generation's media.

Table 7: Measures of tape drive reliability

Drive Technology	MTBF Power-On Hours	Uncorrected Bit Error Rate	Head Life
LTO-6	250,000	Less than 10^{-17}	60,000 hrs.
TS1150	237,000	Less than 10^{-20}	8.6 years (75,336 hrs.)
T10000D	290,000	Less than 10^{-19}	5 years (43,800 hrs.)

Load, File Access, and Rewind

Media load and file access times can be considered decreasingly important factors as per-tape capacities rise or when tape drives are integrated into robotic tape libraries. This is because the tape is now used primarily for accessible storage rather than a replacement for disk access speeds, as in the case with mainframes.

When tapes contained very little data and were used to access data continuously, load time was very important. However, in the post-mainframe era, and with disk space affordable, tape no longer functions as "almost-disk."

When tapes contained very little data and were used to access data continuously, load time was very important. However, in the post-mainframe era, and with disk space affordable, tape no longer functions as "almost-disk." Instead tape is used for secondary storage and occasional access. Load times and file access times are relatively insignificant compared to the time it takes to read and write large data sets, even given the ever-increasing performance of next-generation drives.

Media load time is defined as the amount of time between cartridge insertion and drive readiness for host system commands. File access time is defined as the time between the point at which the drive receives a host-system command to read a file and the point at which the drive begins to read the data.

File access times are typically averages, since the requested file might be located in the middle of the tape or at either end. Drive vendors typically state specifications for both tape load and file access.

Table 8: Media load and file access time

Drive Technology	Tape Load Time	Average First File Access Time	Rewind Time
LTO-6	12 seconds	62 seconds	42 seconds
TS1150	12 seconds	55 seconds	94 seconds
T10000D	13 seconds	62.5 seconds	97 seconds

Recent Tape Technology Enhancements

Linear Tape File System

The Linear Tape File System (LTFS) format is a self-describing open tape format developed by IBM to address tape archive requirements. LTFS allows users to organize and search the contents of a tape with the same methodology as a hard disk, improving access time to data. LTFS also makes it possible to drag and drop files in the same manner that files are dragged and dropped to disk. The LTFS format is applicable to LTO, T10000 and TS tape technology.

The LTFS Features

LTFS features[4] are as follows.

- An LTFS Volume can be mounted and the volume content accessed, with full use of the data, without the need to access other information sources.
- Data can be passed between sites and applications using only the information written to an LTFS Volume.
- Files can be written to, and read from, an LTFS Volume using standard POSIX file operations.

LTFS Usages

LTFS is typically used for the following: [5]

- Data export and import.
- Data interchange and exchange.
- Direct file and partial file recall from sequential access media.
- Archival storage of files using a simplified, self-contained or "self-describing" format.

Deep Storage for Exponential Data

DS3 is the first native REST-based interface to deep storage that enables the easy archival of large amounts of bulk data

To meet the demands of extreme data growth and long-term retention, the Spectra Logic BlackPearl™ Deep Storage platform enables users to easily store massive data forever at virtually no cost. Designed for organizations where data is a significant part of their operations, BlackPearl allows data to move seamlessly into mass tape storage in a way not previously possible. With BlackPearl's simple RESTful Deep Simple Storage Service (DS3) interface and embedded tape management software, organizations will confidently store all of their data forever at costs as low as pennies per Gigabyte providing the most cost effective storage solution giving you access to everything you need

Deep Simple Storage Service

Designed by Spectra Logic, DS3 is the first native REST-based interface to deep storage that enables the easy archival of large amounts of bulk data. It is a data transport and communication interface that allows software clients to direct and manage "bulk" storage read and write operations to and from deep storage. DS3 utilizes the standard S3 command set plus additional commands specifically designed to optimize the transport of data objects to and from tape. These additional commands enable modern architecture frameworks to easily and efficiently communicate with massively scalable deep storage technologies.

[4] SNIA Linear Tape Format 2.2 Draft Specification 8/27/2013
[5] SNIA Linear Tape Format 2.2 Draft Specification 8/27/2013

The DS3 interface utilizes the traditional REST client/server architecture and high-level PUT and GET commands to move objects to and from deep storage. The interface is media agnostic such that over long data retention periods data can be migrated from older storage types to newer ones transparently. This groundbreaking technology is a new and innovative method for managing information in the age of exponential data.

DS3 working in conjunction with the Spectra Logic BlackPearl appliance facilitates object storage on tape and is easily integrated with existing applications and workflows. Spectra provides BlackPearl and DS3 integration tools including simulators, software development kits and file copy utilities. DS3 clients for specific applications like Hadoop are also available from Spectra Logic.

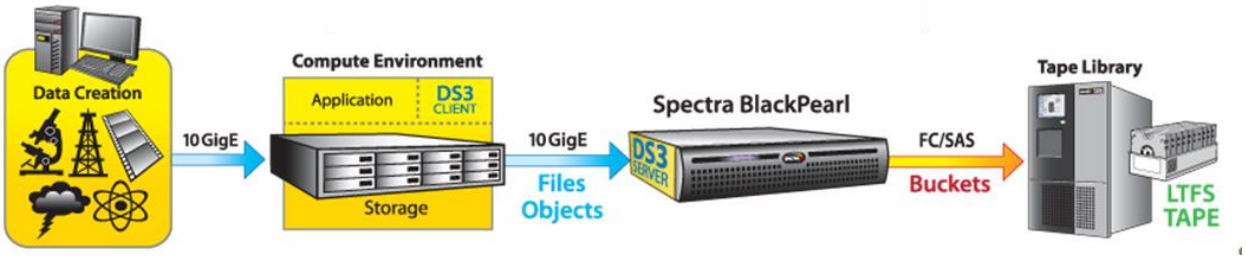

Figure 6: Data moving to Spectra Deep Storage

Deep Storage Applications

Applications and workflows requiring archival, multi-copy, and/or long term storage for large quantities of growing data can benefit from the low storage costs, infinite scalability, and open portability that BlackPearl and DS3 provide. These include:

- Media and Entertainment
- Genomics
- Oil and Gas
- Seismic
- Financial
- Healthcare
- Pharmaceutical

The Future: Migration, Stability, and Roadmaps

At some point, every IT administrator faces the issue of whether to migrate data to a new generation of technology or a new technology overall. With the increasing regulatory vigilance required by many organizations, this can have long-term consequences, since data must be accessible for years after it is created.

One way to manage the problem of technology upgrades in data storage is to identify a tape technology that has a long roadmap *and* to select an automated tape library that supports partitioning. This lets users create a subsection of the library dedicated to older media generations with earlier generations of technology, with a new partition that writes data using the newest and highest performance drive with the highest capacity media. Logical partitioning such as this can prevent or reduce the need for data migration and preserve the site's original investment in older media.

Managing technology upgrades in data storage can be addressed by identifying a technology with a long roadmap; considering whether to maintain multiple types of technology, and evaluating backwards compatibility.

A second option is to consider whether to maintain multiple types of technology. Sites that do so must evaluate whether it is most efficient and cost-effective to keep a smaller, older library or stand-alone drive to read the older tapes, along with using a new library with the fastest and highest capacity technology, or to invest in an automated tape library supporting multiple generations of technology and media.

Lastly TS1150 tape drive technology allows backwards compatibility not offered by any other tap technology. The TS1150 technology tape drive is capable of reformatting a 3592 JC tape cartridge (TS1140 generations) providing up to 7.0 TB of native storage capacity and up to 300 MB/s data rate. When considering tape technologies, evaluate the number of tape automation manufacturers if you want long-term support of the technology and availability of drives and tapes. Note that seven manufacturers make LTO-compatible libraries, while only one manufacturer supports, T10000 (Oracle/Sun) and several support TS1150 (IBM) technology.

Manufacturing Viability

The TS1150 shares its core technology, production line, and volume components with IBM's LTO line. In combination, these deliver around 150,000 drives per year[6]. This drives up quality and drives down open-source LTO technology pricing. Oracle/Sun/STK is limited to very low volumes in enterprise drives that work primarily with mainframes. Oracle/Sun/STK has only 40% of the enterprise tape drive market, and is in a steady decline. IBM, manufacturer of both LTO and TS11x0, owns approximately 60% of the enterprise tape drive market, and that percentage is growing. Along with IBM, LTO drives are manufactured by one other vendor, and LTO media by two manufacturers. This compares favorably to other drives, which have only one drive and media manufacturer.

[6] IDC Tape Worldwide Qview CY2012 4.9.12

ROADMAPS

When choosing a tape drive technology, consider the future of the technology. Succeeding generations typically offer higher performance and capacity while ensuring backward-read compatibility with previously written tapes. You may want to avoid new investments in a technology that is near the end of its life cycle. At this time, LTO has a published roadmap that is openly accessible and the TS Technology roadmap is available from IBM.[7] The roadmap for LTO currently extends to the tenth generation. The roadmap for TX11x0 technology extends two additional generations. No public roadmap is available for the Oracle T10000. The roadmaps for LTO and TSx0 are shown in Figure 7 and Figure 8.

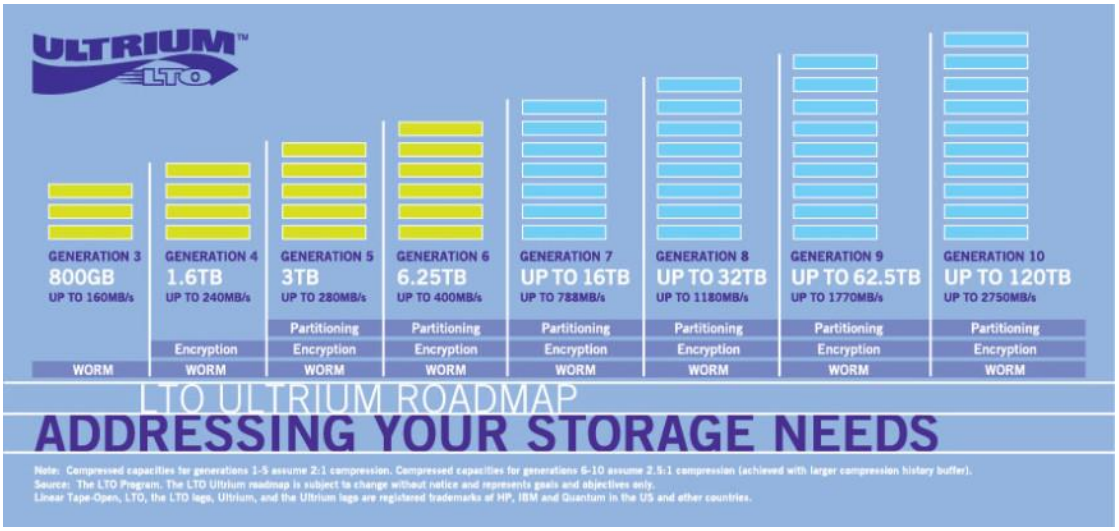

Figure 7: LTO roadmap

[7] IBM® TS1150 Tape Drive Performance White Paper
http://www-03.ibm.com/support/techdocs/atsmastr.nsf/5cb5ed706d254a8186256c71006d2e0a/42a80536c1116a6886257d7400488015/$FILE/TS1150_Performance_White_Paper.pdf

3592 Model	Gen 1 3592 J1A	Gen 2 TS1120	Gen 3 TS1130	Gen 4 TS1140	Gen 5 TS1150	Gen 6 TS1160
Shipped	3Q2003	3Q2006	3Q2008	2Q2011		
Max Cartridge Capacity	300 GB	700 GB	1.0 TB	4 TB	10 TB	15-20 TB
Native capacity	300 GB JA	500 GB JA 700 GB JB	640 GB JA 1.0 TB JB	1.6 TB JB 4 TB JC	7 TB JC 10 TB JD	7 TB JC 15-20 TB JD
Data Rate MB/S	40	100	160	250	360 MB/s	500 MB/s
Cartridge Support JA type JB type JC type JD type	JA/JJ/JW/JR	JA/JJ/JW/JR JB/JX	JA/JJ/JW/JR JB/JX	JA/JJ/JW/JR JB/JX JC/JY/JK	JC/JY/JK JD/JZ/JL	JC/JY/JK JD/JZ/JL
Encryption	N/A	Yes	Yes	Yes	Yes	Yes
Partitioning / LTFS Support	N/A	N/A	N/A	Yes	Yes	Yes
Server Attachment	Fibre FICON ESCON	Fibre FICON ESCON	Fibre FICON ESCON	Fibre FICON ESCON	Fibre 8G	Fibre 16G FCoE

Figure 8: TS1140 roadmap

CONCLUSION

LTO technology makes up a significant share of the drive market. In fact LTO is the industry standard for tape technology offering:

- The only open tape format available.
- A lower price tag than enterprise drives at about 45% of the acquisition cost
- High quality through independent verification of specifications and by leveraging advances in enterprise tape technology

TS11x0 technology offers:

- Robust reliability designed to operate 24x7
- Superior data integrity on tape vs LTO
- 150% more performance than LTO
- 60% more capacity per cartridge
- 65% faster seek time
- Read and write data over 50% faster than LTO
- Significant gains in capacity and performance with each new generation
- Investment protection through reformatting previous generations media

Spectra supports both tape technologies providing customers the “best of both worlds.” Given the many tape and drive performance factors to consider, the key is to prioritize the factors most important to your unique data storage requirements, and use this information to choose the technology that best meets your priorities.

Deep Storage Experts

Spectra Logic develops deep storage solutions that solve the problem of long term storage for business and technology professionals dealing with exponential data growth.

Dedicated solely to storage innovation for more than 35 years, Spectra Logic's uncompromising product and customer focus is proven by the largest information users in multiple vertical markets globally.

Spectra enables affordable, multi-decade data storage and access by creating new methods of managing information in all forms of deep storage—including archive, backup, cold storage, cloud, and private cloud.

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