

Quantum® DLTtape™ Handbook

**Your Complete Guide to Today's
Hottest Storage Technology**

Eighth Edition



FROM QUANTUM CORPORATION

Notice

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Foreword

The world of data storage has changed a great deal since we published the first Quantum DLTtape™ Handbook in 1997. In just this short time, the role of storage has evolved dramatically. It has become clear that effective storage strategies are fundamental to the success of virtually any information technology strategy, whether it's in re-energized smokestack industries or e-commerce.

Since the first Quantum DLTtape Handbook, we now have published a total of eight editions, plus two editions in Japanese and one in Chinese. And, while the roles of storage and DLTtape technology have changed and evolved with incredible speed, the objective of the handbook is still much the same as it was originally: to educate our various audiences by providing an in-depth look at DLTtape system technology and a comprehensive overview of DLTtape products and solutions. The book will also give you a context for understanding how storage technology has evolved into such an integral part of enterprise IT strategy, and the role DLTtape technology plays.

The most notable change in the content of this eighth edition is the inclusion of extensive information on the new Super DLTtape™ technology, the next generation of DLTtape technology. Super DLTtape technology delivers dramatic increases in DLTtape speed and capacity, while continuing the DLTtape commitment to compatibility with previous generations of drives and media. Incorporating a number of important technology innovations, Super DLTtape technology promises to broaden the role of the

DLTtape system as the dominant tape technology for backup, recovery, archiving, vaulting, near on-line storage, and multi-media storage hierarchies.

Because Super DLTtape technology is the newest development in DLTtape systems, we have included in this edition of the handbook a great deal of new information specific to Super DLTtape technology. However, it is important to emphasize that, while Super DLTtape technology includes a number of breakthrough innovations, it is not a “new” technology: it is an extension of all the concepts that have made the DLTtape systems so successful since the original linear tape technology was introduced in 1985. So when we use the term “DLTtape systems” or “DLTtape technology” throughout this book, we refer to all DLTtape technology, including Super DLTtape technology, and the entire DLTtape family of products, including the newest Super DLTtape drives and media.

Welcome to the eighth edition of the Quantum DLTtape Handbook, and to the exciting possibilities of a whole new generation of Super DLTtape systems.

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Introduction

This handbook will introduce you to one of the dominant forces in mid-range storage technology – the DLTtape systems, including the new Super DLTtape systems. These systems are the acknowledged market-share leaders in mid-range tape backup and archiving, thanks to their remarkable performance, reliability, and storage capacity.

Convergence Emergence

Why has a seemingly mundane topic like backup and archiving become such a hot subject in recent years? There are several answers. A number of trends are converging to create a new and seemingly limitless hunger for faster, higher capacity storage backup systems. These trends include:

- The growth of Internet, Intranet, and e-commerce applications, many of which require constant backup of very large databases.
- The popularity of storage-intensive applications like multimedia, data warehousing, video editing, medical imaging, financial analysis, and engineering.
- Centralized backup management of distributed, networked systems.
- Exponential increases in hard disk capacity and performance.

- A shrinking “window” for backup and archiving.
- The emergence of enterprise level storage management strategies, including Storage Area Networks.

In this handbook, we will show you why DLTtape and Super DLTtape drives and media are the best storage solutions for these and many of the other storage challenges you may face. We will also help you evaluate your DLTtape storage options and pick the solution that’s right for you.

We’ve Got You Covered

To help you understand DLTtape technology and how it fits into your IS backup picture, we’ve included chapters that cover everything from the history of DLTtape drives and media to a detailed comparison of competitive backup solutions. Here’s a sample of what we’ll cover:

- What is the DLTtape system?
- What is Super DLTtape technology?
- Why customers want DLTtape drives and media – the DLTtape system.
- Applications for the DLTtape system.
- What makes the DLTtape system so reliable?
- Why the DLTtape system is perfect for autoloaders, libraries, and Storage Area Networks (SANs).
- What makes DLTtape cartridges special.
- Platform connectivity considerations.
- The bright future of Super DLTtape technology.

Welcome to the new world of storage management. Welcome to the world of the DLTtape and Super DLTtape systems from Quantum Corporation.

The Evolving Tape Storage Market

1

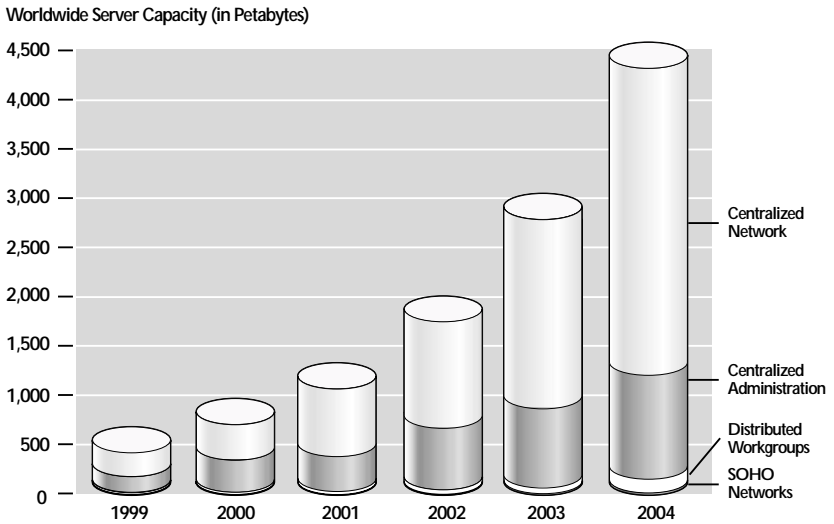
Before we plunge into the story of the DLTtape system, we need some context. Who's buying DLTtape drives and media? And, more importantly, WHY? In this chapter, we'll walk you through some of the market forces that are impacting the industry, including:

- Trends in computing systems: moving away from centralized computing, toward a client/server model.
- Moving to centralized management of distributed systems.
- Growth of mission critical, leading edge applications.
- Dramatic advances in tape technology for backup.

Market Size

The market for tape drives is projected at \$6 billion a year for the next few years, with unit shipments holding steady at about 4 million per year, worldwide. Almost all of those 4 million units are going to be used for backup.

But, while unit shipments will remain steady, the amount of data that needs to be backed up is growing rapidly. For example, it is estimated that in 1999 worldwide server capacity, one important category of data that needs to be backed up, was less than 500 petabytes (Figure 1.1). By 2004, that figure will have multiplied to over 4,300 petabytes!



Source: Strategic Research Corp., Network Demographics, 2000

Figure 1-1 Worldwide Server Capacity is one measure of data to be backed up. The figure is climbing at a much steeper rate than the rate of tape shipments. Backup capacity must increase to match increased storage demands in this and other categories.

With the projected amount of data that needs to be backed up climbing at a rapid rate, and the projected growth in tape drive units shipped staying relatively flat, each of those backup tape drive units must deliver more capacity than ever before. Analysts project that there may be the potential for a melt-down if the backup technology does not keep up with that sharply rising demand curve. The continual evolution of DLTape technology and the dramatic increase in capacity and performance delivered by Super DLTape technology are a direct response to this need. What factors are driving this rising demand for backup capacity? Let's start with computer systems trends.

From Mainframe to Client/Server

The deployment of client/server systems is accelerating. From 1994 to 1996, the percentage of organizations that said they were actually using client/server systems grew from 25 to 44 percent. Today, client/server is the dominant mainstream approach to enterprise

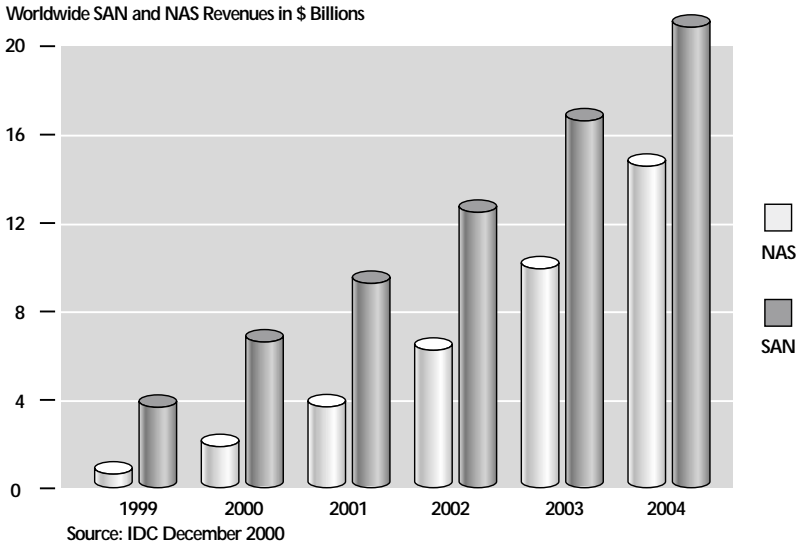


Figure 1-2 SAN and NAS Disk Shipment Revenues *will continue to grow quickly as these storage concepts are implemented widely.*

computing. For storage and backup, this means a shift away from the high-end products used in mainframe environments (reel-to-reel tape), and away from low-end, PC-oriented products (4mm DAT), and toward the mid-range (8mm and half-inch DLTtape systems).

New Storage Strategies

New storage strategies are also driving the market for DLTtape technology. Two good examples are Storage Area Networks and Network Attached Storage. A Storage Area Network (SAN) is a high-speed, special-purpose local network that provides a large pool of storage resources and makes it easily available to the enterprise network. SANs are usually deployed to support applications that require large amounts of storage, and to support large, enterprise-level networks. Most SANs depend on large DLTtape-based libraries to back up disk storage. SAN revenues are expected to grow from under \$4 billion in 1999 to over \$20 billion in 2004, according to IDC. (See Figure 1-2.) Another indicator of the size of this market opportunity for DLTtape

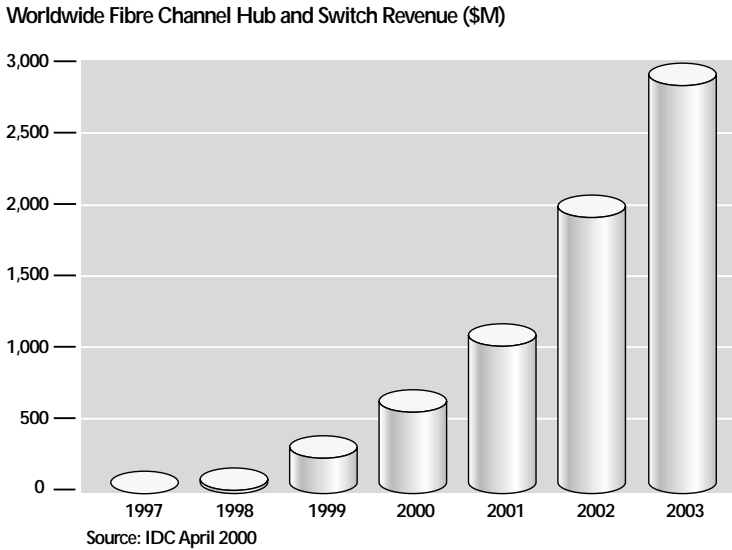


Figure 1-3 Worldwide Fibre Channel Hub and Switch Revenues.

Storage Area Networks (SANs) incorporating Fibre Channel technology will grow as the preferred enterprise storage strategy, as evidenced by the projected growth in Fibre Channel network hardware revenues. DLTape technology plays an important role in the consolidation of backup to these large storage networks.

technology is the rapid growth in Fibre Channel hub and switch revenues. (See Figure 1-3.)

Network Attached Storage (NAS) is simply storage that is deployed independently on a Local Area Network. NAS products feature a plugable Ethernet connection for easy installation. Target market applications include file server, desktop, remote office installations, software distribution, and emerging applications such as audio, video, and Internet storage. DLTape is a perfect complement to the growing storage needs NAS solves. A user can easily grow their storage requirements and still back up the network through a DLTape solution. IDC projects that NAS revenues will grow from under \$1 billion in 1999 to nearly \$15 billion in 2004. (See Figure 1-2.)

Time Regime	System Management	Location of Data Management	Location of Data
Early 1980s	Glass House	Central	Central
Late 80s–90s	Client/Server	Distributed	Distributed
Late 90s	Professionally Managed	Central	Distributed
Early 2000s	Automated	Central and Distributed	Central and Distributed

Figure 1-4 The Storage Management Evolution shows a transition to re-centralized storage management and a continuation of distributed data resources.

Centralized Management

The management of information resources has been evolving from the totally centralized “glass house” systems of the 1970s and 1980s (see Figure 1-4). In the late 1980s and into the 1990s, the client/server model emerged. Computers were distributed, storage was distributed, and the management of distributed resources was itself distributed. To some extent, the mainframe-oriented management structure was weakened.

However, without centralized, professional management, decentralized computing systems are in danger of reducing system reliability, data integrity, and security. Now, at the beginning of the 21st century, the trend is for information resources to continue to be distributed, but for resource management – including storage management – to become more centralized, under a professional management team, using high-level, highly integrated management tools, and more and more automation.

Centralized management of storage resources has a powerful impact on backup systems, creating a demand for universal backup strate-

gies. There is a greater demand for standard solutions, and robust, highly reliable systems for mission critical applications. Large, global enterprises demand global backup and disaster recovery plans.

The system-level trends we've been talking about – the move to client/server, the emergence of Storage Area Networks, and the strong trend toward centralized management of distributed storage resources – are increasing the demand for bigger, smarter tape backup systems. And that's where the DLTape system fits.

Now let's look at another set of trends that are having a major impact on tape backup issues. Namely, trends in applications.

Mission Critical Applications

Yesterday's mission-critical applications were back office tasks like payroll, accounts receivable, and accounts payable. They were mission critical because the business needed them to function. Today's mission critical applications must run 7x24, and they are often very customer-oriented, highly visible, and strategic. E-commerce applications like on-line banking, ticketless airline reservations, or on-line stock transactions are prime examples. Almost by definition, these customer-interfacing applications are client/server applications, so they have to run outside the protection of the old "glass-house" mainframe environment.

This means that there is intense pressure to keep these applications aggressively backed up, and within a shrinking window of time. If the application is up on a 7x24 schedule, when can you do backups? Solutions to this problem include more frequent backups, more servers with their own dedicated backup systems, and bigger, faster systems to fit backup into the shrinking backup window. Clearly, the introduction of new high performance, high capacity Super DLTape systems has a major impact on backup capability.

Vertical Markets

Growth in specific vertical markets is pushing the demand for better backup solutions. Internet/Intranet applications are growing at a very fast rate. They are driving the sales of servers, and they are also driving the sale of a large amount of storage capacity. An increase in storage capacity always drives the need for more backup capacity. Internet and Intranet applications, impose heavy backup demands for several reasons. They run around the clock, so the backup window is always under pressure, they change constantly, they tend to grow in size, and their content is increasingly graphical and therefore storage intensive. Vertical markets driving the demand for DLTape backup include:

- E-commerce.
- Internet/Intranet.
- Archiving.
- Disaster recovery.
- Data mining.
- Medical imaging.
- Graphic arts.
- CAE/CAD/CAM.
- Multimedia.
- Publishing.
- Data acquisition.
- Video-on-demand.
- Digital nonlinear video editing.
- Video distribution.
- Storage Service Providers (SSPs).
- Application Service Providers (ASPs).

In Chapter 10, we will go into more detail on the special backup needs of various vertical applications.

Content is Everything

Another trend driving the DLTtape system market is the shift in application content. When images, color, full motion video, and audio are added to the content mix, storage requirements explode. This growth is generating demand for high capacity storage, and for backup.

Applications that use non-traditional content have other requirements beyond just size. For instance, these applications often involve distribution of content (for example, programming for video-on-demand applications). It is important to have durable, reliable media that can stand up to the abuse of shipping, frequent use, and storage in hostile environments.

Tape Technology Trends

Trends at the system level and in applications are driving changes in the tape backup market. Another factor in the evolving tape market is the changing tape technology itself.

One of the most important trends in the tape environment is the continuing proliferation of incompatible tape formats. New tape formats are being introduced, not by newcomers and start ups, but by some of the biggest names in the technology world. A review of available tape technologies would include 4mm DAT, 8mm, quarter-inch (QIC), and half-inch, including the DLTtape system. There have always been options available, and new options keep coming. There are quarter inch cartridge (QIC) drives that use quarter-inch tape, and there is quarter-inch tape that is actually .315 inches wide. There are three different types of 4mm DAT tape: DDS-2, DDS-3, and DDS-4.

Fortunately, the latest and the highest capacity DDS-4 tapes are backward compatible with the earlier versions. That isn't always true as

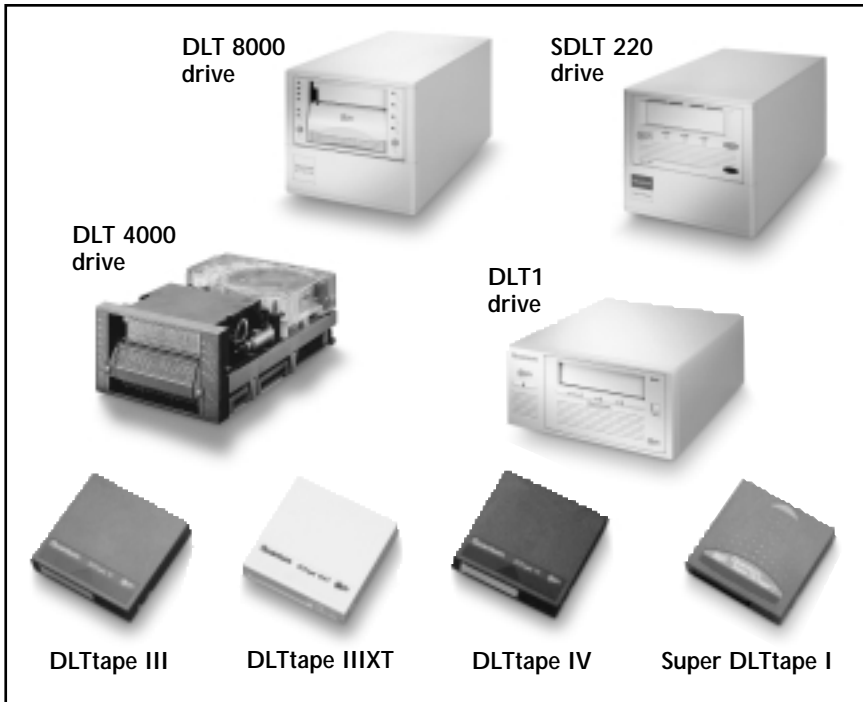


Figure 1-5 DLTape System Product Family includes the DLT 4000 drive, the DLT 8000 drive, the DLT1 drive and the SDLT 220 drive, as well as the DLTape III, DLTape IIIXT, DLTape IV, and Super DLTape I cartridges. DLTape drives are available in desktop and system-installable units.

new technologies come out. For example, Sony's 8mm tape (AIT) and Ecrix's VXA are not compatible with other 8mm tapes on the market.

It appears that there are more formats available than the market can possibly use. To a certain extent, the formats sort themselves out naturally. QIC and 4mm products are designed for low end applications, primarily for PC and small network backup, while 8mm and DLTape system half-inch products are flourishing in the mid- and high-end ranges.

	DLT 4000	DLT 7000	DLT1	DLT 8000	SDLT 220
Capacity (GB, native)	20	35	40	40	110
Data Rate (MB/s, native)	1.5	5.0	3.0	6.0	11.0
Bit Density (Kbpi)	82.5	86.0	123.0	98.0	131.0
Track Density (tpi)	256	416	336	416	896
Media Type	MP-2	MP-2	MP-2	MP-2	AMP
Media Length	1,800'	1,800'	1,800'	1,800'	1,800'
Recording Channels	2	4	2	4	8
Hardware Data Compression	Yes	Yes	Yes	Yes	Yes
Interface	SCSI-2/F SE/HVD	SCSI-2/FW LVD/HVD	SCSI-2/FW LVD	SCSI-2/FW LVD/HVD	SCSI-2/FW LVD/HVD

Figure 1-6 DLTtape Drive Comparison Chart shows some of the important specifications for DLTtape systems, including the industry-leading Super DLTtape system.

Is there room for more new tape technologies? It seems unlikely. No matter how well designed and well engineered a new tape technology might be, it will require a significant new value proposition in order to gain a foothold in the market. A new format would have to offer far greater capacity or two to three times the speed of Quantum's DLTtape system in order to have a big impact. In reality, the new technologies challenge DLTtape technology in some areas, but not in all. DLTtape technology also has a huge amount of "head room" in terms of scalability and an extremely well defined technology road map. So even if a new technology offers a short-term performance benefit today, in all likelihood that advantage will disappear as the DLTtape system continues to evolve. The new generation of DLTtape systems,

the Super DLTtape systems, leapfrog current and proposed competitive technologies, with first generation Super DLTtape products offering transfer rates of 11MB/s and capacity of 110GB, advancing to at least one terabyte (uncompressed) over multiple generations (see Chapter 17 for a product roadmap).

The biggest barrier to adoption of new tape formats is that users are very reluctant to change backup technologies unless the benefits are overwhelming and compelling. The pain involved in converting archive tapes, for example, seems to be so acute that most people don't want to try it. So any new technology that is not backward/forward compatible can face an uphill battle to be widely accepted. Today, DLTtape technology has a huge installed base, with over 1.5 million drives and over 55 million media cartridges shipped to customers. These facts, combined with a clear technology growth path and a proven commitment to generation-to-generation compatibility, add up to an island of stability in a world of changing technology.

Range of Products

Another trend in the tape environment is user demand for a range of compatible products that will address different performance, functionality, and price requirements. Users want a single solution that works at many levels, not a different solution for every situation. Today, the DLTtape system offers a very broad range of choices, ranging from stand-alone drives, to single-drive, multi-cartridge autoloaders, to very large, enterprise-class libraries with multiple drives, multiple ports, and hundreds of cartridges, all sharing compatible media, drives, and storage management software.

Ease of Use

Customers also want backup systems that are easier to use. In response, the providers of backup solutions are starting to offer bundled hardware/software solutions, which should lead to a

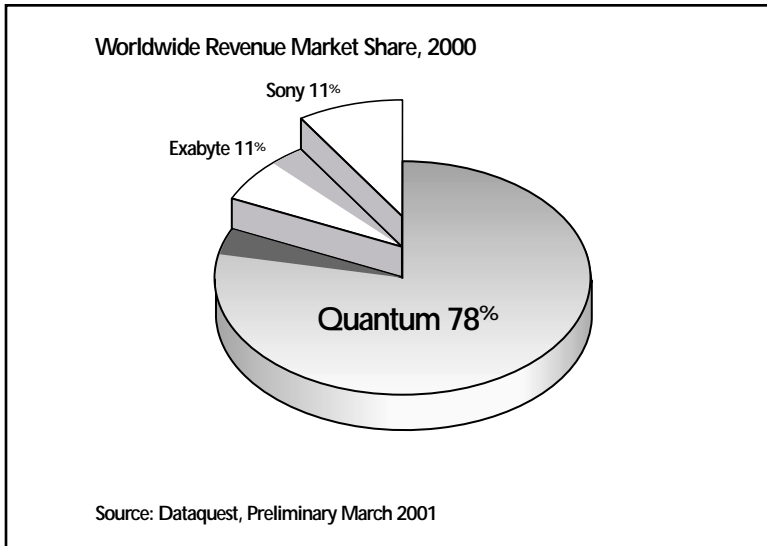


Figure 1-7 The DLTape System Is the Overwhelming Choice among high-performance tape systems.

happier “out of the box” experience for users. There is also a trend toward providing more user-friendly graphical displays that show the user exactly what’s going on with backup, where the process stands at the moment, and what and where a hangup is occurring.

Application Diversity

Over time, the range of applications for tape is diversifying, and that trend will probably continue. Tape, especially the DLTape system, is not just about backup anymore. Tape applications also include archiving, disaster recovery, hierarchical storage management, real-time backup, distribution (especially distribution of video programs and graphics files), near on-line storage, and a host of others. As these applications mature and become better defined, you may see the emergence of different products to fit different sets

of needs. For example, we may see the emergence of a distinct class of “desktop” DLTtape libraries aimed at video and graphic arts applications, while a class of mid-range to very large libraries may be targeted for Storage Area Network (SAN) applications.

The Last Word

In any discussion of the market for DLTtape technology, the bottom line has to be market share (see Figure 1-7). In 2000, the total number of DLTtape drives in use globally was about ten times what it was only four years earlier, and DLTtape dominates its market space, with a market share of nearly 80%.

Next, we'll look at what makes the DLTtape system uniquely superior to other drive technologies.

What Is the DLTtape System?

2

In later chapters we will cover a great deal of technical information about exactly how DLTtape system technology works. In this chapter we focus on what it is about the DLTtape and Super DLTtape systems that makes them unique. When you examine the details, there are dozens of differences between the DLTtape system and other tape systems. In this chapter we stick to the major points. Some are obvious, and some are invisible, buried inside the product.

Speed, Capacity, Reliability

From a performance point of view, the characteristics that distinguish the DLTtape system from other tape storage technologies are speed, capacity, and reliability. When compared to other technologies (see Chapter 11 for a detailed analysis), current DLTtape and Super DLTtape drives offer very fast transfer rates (11MB/s native), DLTtape cartridges store large amounts of data (110GB on a single Super DLTtape I cartridge), and DLTtape drives can run longer, under more demanding duty cycles, than any competitive technologies. Or, as one DLTtape system user put it, “You take the specs for the 8mm solutions we used previously and multiply by about 4x, and that gives you the DLTtape technology spec.”

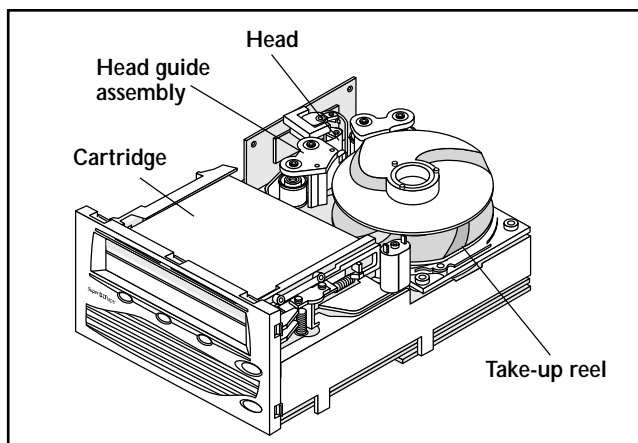


Figure 2-1 Super DLTtape Drive *delivers industry-leading capacity, reliability, and data transfer rate in a 5.25" form factor.*

Half-Inch Tape

The DLTtape system uses half-inch wide tape. That is the widest tape available. The half-inch format was originally used in mainframe products and was adopted by Digital Equipment Corporation when they designed the ancestors of the DLTtape system. What is important about the half-inch format is very straightforward – it's bigger than the other widely used technologies, such as quarter-inch, 4mm, and 8mm tape. Half-inch tape is 60 percent wider than 8mm tape. Therefore, you can put more information on half-inch tape than you can on smaller-format tape.

Linear Recording, Versus Helical Scan

DLTtape drives read and write data in a linear pattern on the tape (see Figure 2-2). That is, each data track goes the entire length of the tape (about 1,800 feet for DLTtape IV and Super DLTtape I media, for example). When data is being recorded, the first set of tracks is recorded on the whole length of the tape. When the end

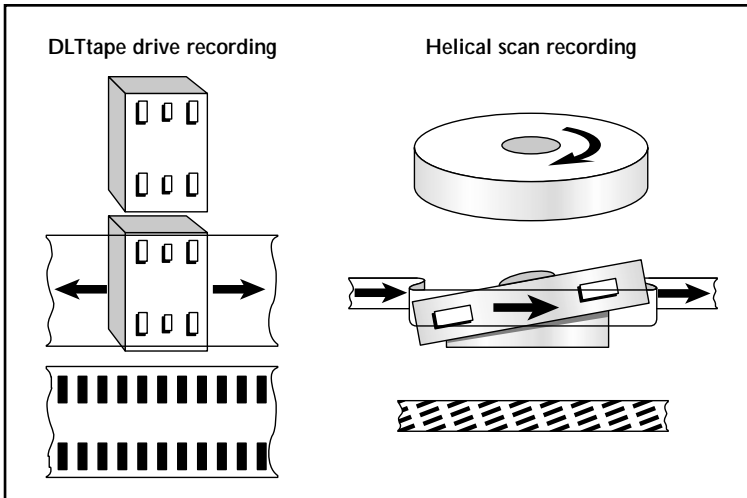


Figure 2-2 The DLTtape System's Linear Serpentine Recording
pattern writes data along tracks from one end of the DLTtape cartridge to the other. Helical scan systems use read/write heads on a rotating drum to record data in angled stripes across the tape.

of the tape is reached, the heads are repositioned to record a new set of tracks, and the tape is again recorded on its whole length, this time in the opposite direction. That process continues, back and forth, until the tape is full. Current DLTtape drives record either 128 tracks (DLT 4000 drives), 168 tracks (DLT1 drives), 208 tracks (DLT 7000 and DLT 8000 drives), or 448 tracks (Super DLTtape drives) on half-inch tape.

By contrast, helical scan systems record data in diagonal stripes across the tape. This diagonal pattern allows data tracks to be overlapped for very high data density. One of the drawbacks of such high density is the increasing difficulty it introduces in error detection and correction. Even a very small defect on a helical-scan tape will probably corrupt the data, because such a large amount of data is squeezed into a very small linear space. With DLTtape

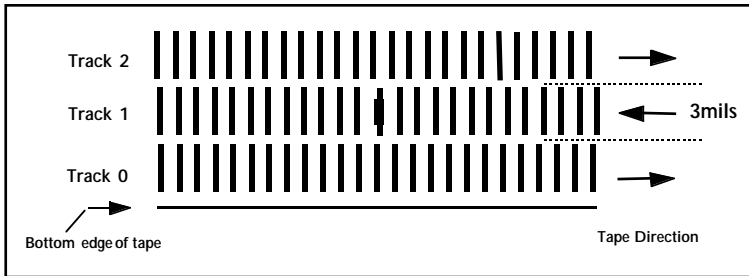


Figure 2-3 DLT 4000 Drive writes data on two channels simultaneously in linear tracks that run the length of the tape. The system has a capacity of 20GB native and 40GB compressed.

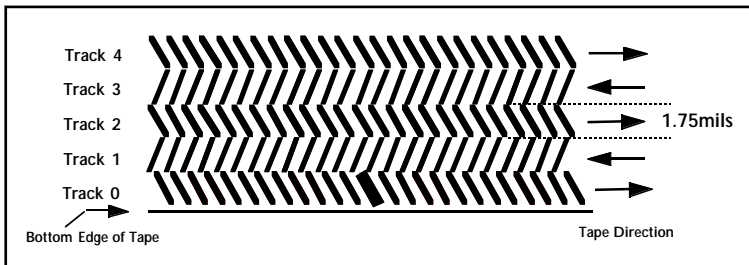


Figure 2-4 DLT 7000 and DLT 8000 Drives' Symmetric Phase Recording™ writes data in an angled pattern, allowing higher data density, with per cartridge capacity of 40GB native and 80GB compressed.

media, however, a defect on the tape – say a scratch – could be as long as an inch without causing an unrecoverable error. That’s because the parallel channel architecture used in DLTape drives enables the system to automatically rewrite bad blocks to parallel channels.

Maintaining Compatibility

Figure 2-3 shows the linear-serpentine recording pattern used in DLTape drives through the DLT 4000 model. The vertically-oriented pattern requires guard bands between tracks to prevent cross-track interference. In the DLT 7000 and DLT 8000 drives (see Figure 2-4), data density was increased by angling the data pattern on

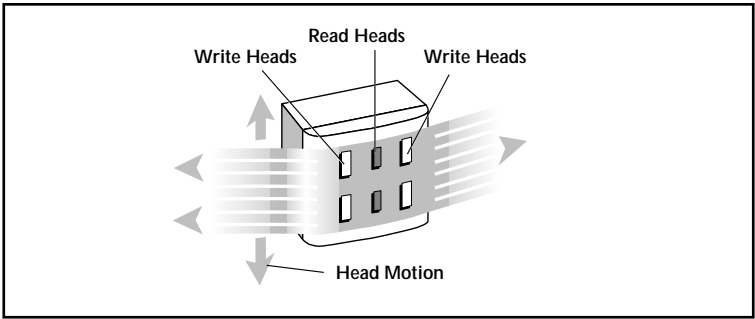


Figure 2-5 DLT 4000 Read/Write Head writes data with the tape running either forward or backward, and performs a read-after-write in either direction to ensure accuracy.

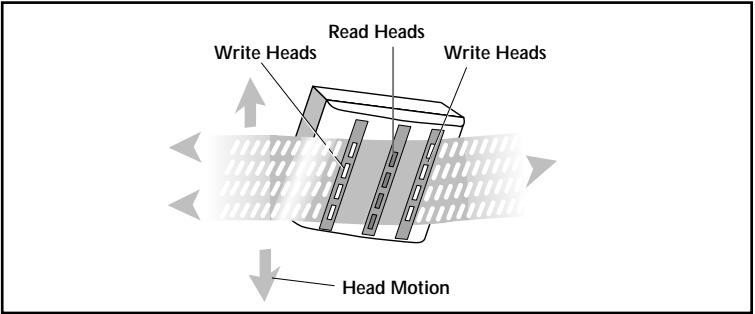


Figure 2-6 DLT 7000 and DLT 8000 Read/Write Head features 4 channels for a data transfer rate of up to 6MB/s (native). Center row of read elements provides read-after-write data accuracy.

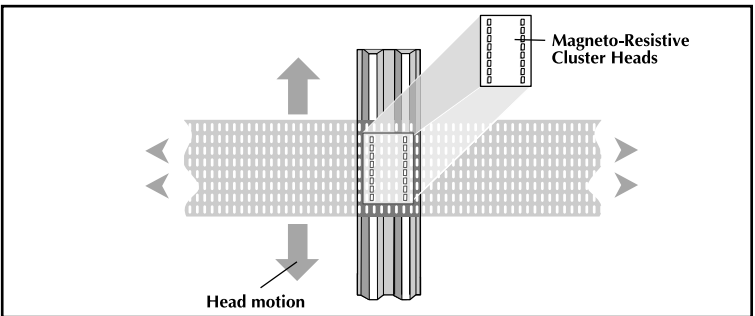


Figure 2-7 Super DLTtape Read/Write Head features 8 channels. Very small Magneto-Resistive Cluster (MRC) Heads yield data transfer rates as high as 11MB/s (native).

adjacent tracks. This data recording technique is called Symmetric Phase Recording™ (SPR). SPR's herringbone pattern eliminates the need for guard bands and thus allows greater track density.

Figures 2-5 and 2-6 show the arrangement of read/write elements on the two-channel DLT 4000 heads and the four-channel DLT 7000 and DLT 8000 heads. When reading DLTtape cartridges recorded on earlier models, the DLT 7000 and DLT 8000 read/write heads automatically shift to a vertical orientation. This feature provides backward compatibility and protects the end user's investment in the DLTtape system.

Figure 2-7 shows the read-write head assembly for the Super DLTtape drive. Super DLTtape drives incorporate newly designed Magneto-Resistive Cluster (MRC) heads. This design features clusters of very small, cost-effective magneto resistive tape heads, densely packed in a small area on the head. MRC heads deliver higher data transfer rates and greater data density than traditional heads of similar size. They are also less susceptible to negative effects due to environmental (temperature and humidity) conditions.

Simpler Tape Path

The design of the head guide assembly (HGA) is at the heart of what makes DLTtape technology superior (see Figure 2-8). More than any other characteristic, it is what makes a DLTtape drive a DLTtape drive. It is a patented design, and it is one of the keys to the success of the DLTtape system.

The head guide assembly positions the tape in front of the self-calibrating read/write heads. The DLTtape system HGA is different from competing technologies. On 4mm and 8mm helical scan systems (see Figure 2-12), the head guide systems are designed to move. These systems must reach out, hook the tape, wrap it around the rotating read/write drum, hold it in position, and then move the tape back into its cassette.

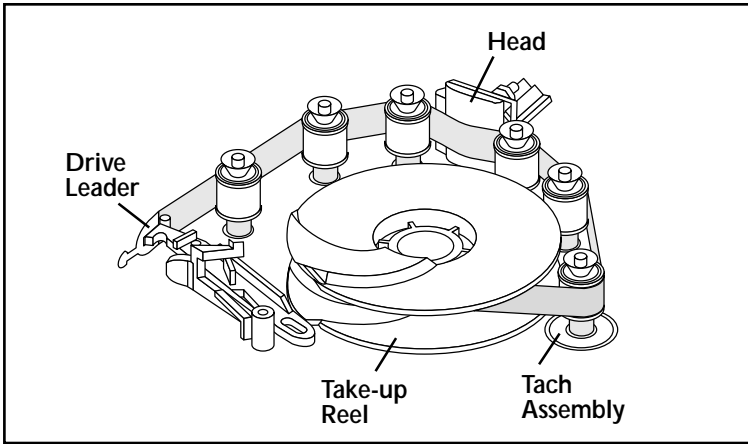


Figure 2-8 The Patented DLTtape Head Guide Assembly, first incorporated in the TF85 drive, is one of the keys to DLTtape reliability. Six precision rollers provide a gentle tape path for long tape life.

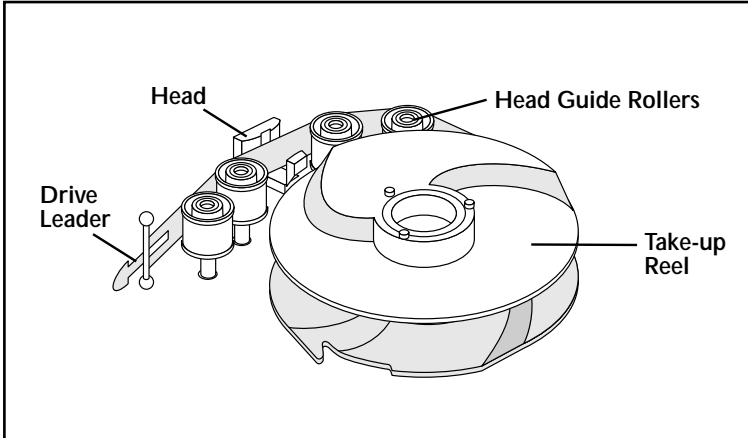


Figure 2-9 The Super DLTtape Head Guide Assembly is a refined version of the DLTtape Head Guide Assembly. It incorporates only four rollers, further reducing contact and tape wear.

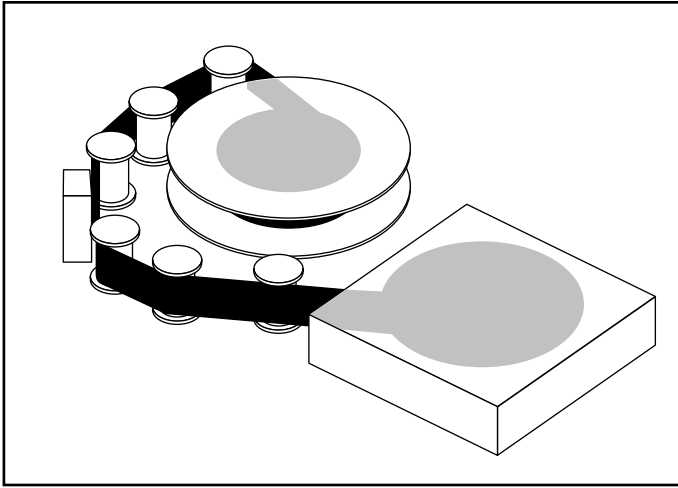


Figure 2-10 DLTtape System Tape Path Is Key reason for the industry-leading reliability, long life, and accuracy of DLTtape technology. Six precision rollers guide tape to internal take-up reel.

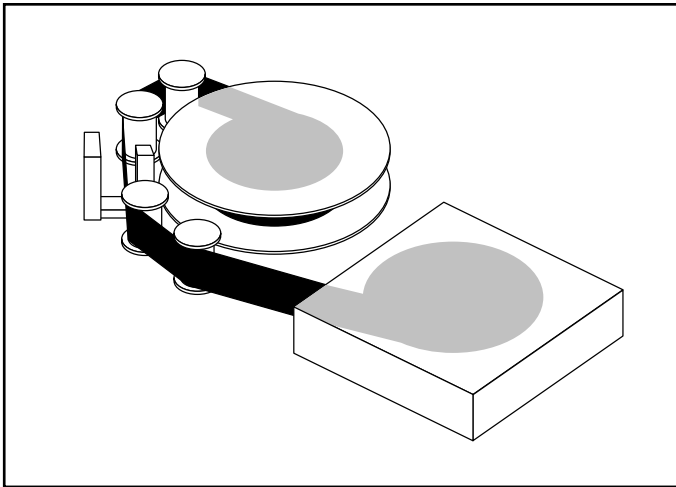


Figure 2-11 Super DLTtape System Tape Path is even simpler than that of the DLTtape drive, requiring only four precision rollers to guide the tape.

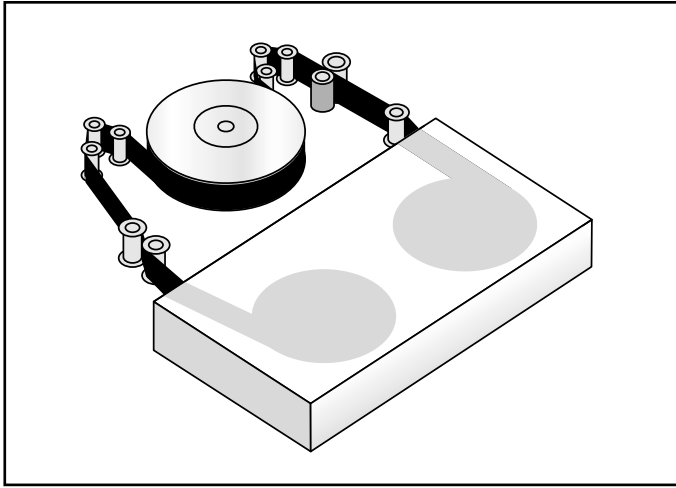


Figure 2-12 Helical Scan Tape System *must pull tape out of the cartridge and around a spinning read/write head. Acute wrap angles and recording-side contact reduce tape life.*

By contrast, the DLTtape head guide assembly is entirely different. It remains stationary. It consists of a series of six precision rollers. Instead of grabbing the tape in the middle and pulling it into place, as with helical scan systems, the DLTtape guide system links a leader strip on the end of the tape and pulls it out of the cartridge, guides it around the head guide assembly in a smooth arc, and gently wraps it around the take-up reel in the drive. The rollers guide, but do not pull the tape. The wrap angles around the guide rollers are gentle. Contact between tape and guide is minimized. The recorded side of the tape never touches the guides, minimizing tape wear. The head guide assembly in the Super DLTtape drives is a refined design that incorporates only four rollers, reducing even further the amount of contact with the tape.

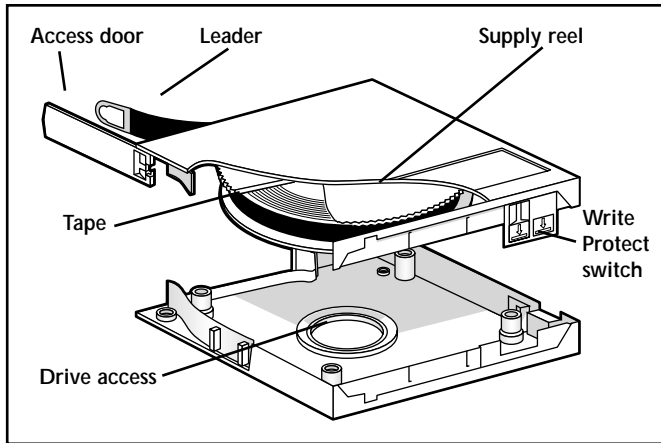


Figure 2-13 DLTtape Cartridge provides low-cost-per-giga-byte, high density data storage. Single-reel design eliminates wasted space.

Single Reel Design

The DLTtape media cartridge is unique in the midrange system market, in that it has only one reel. The take-up reel – the second reel – is in the DLTtape drive itself. This single-reel design leaves a great deal more space for tape inside the cartridge. (See Figure 2-13 and 2-14.)

Most tape cassettes have two reels – a feed reel and a take-up reel. The tape is pulled across the read/write heads between the two reels, kept in alignment by the moving head guide assembly described earlier. So, the part of the tape that needs to be accurately aligned with the read/write heads is actually suspended between two moving points, held in place by a series of movable guides. All that motion makes it hard to maintain perfect alignment.

On the other hand, the DLTtape media is attached at one end to a fixed point, the take up reel, which is mounted within the drive

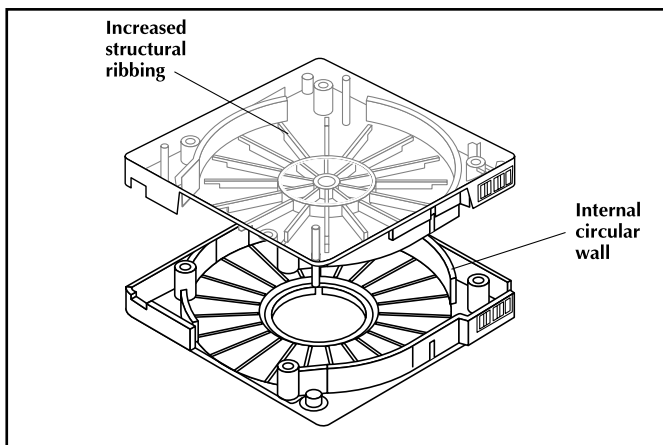


Figure 2-14 The Super DLTtape I Cartridge is a ruggedized design that includes an internal circular wall and ribbing, along with new wear-resistant materials to reduce the generation of debris.

itself, and it is guided by the stationary HGA. It is inherently more stable, because much less movement is possible.

When you look at a conventional two-reel 8mm cassette, it is obvious that the two reels take up a great deal of space, leaving less space for tape. Not only can you see the difference, you can feel it. A DLTtape cartridge, with only one reel, is packed full with tape. Just pick up a DLTtape cartridge, and you realize that it is heavy, because it is all storage, and very little empty spaces.

These characteristics – half-inch format, linear recording, patented tape guide, and the DLTtape cartridge – are some of the keys that make DLTtape technology clearly superior.

Next, we look at the history of the DLTtape technology.

History of DLTtape Technology

3

In 1984, the Berlin Wall was still standing, and the real estate bust, Black Monday, recession, and the collapse of the minicomputer market were still years away. At home, Commodore 64 and Atari computers were selling well. On the IS front, the Apple Macintosh and the 80286 PC/AT were introduced and began to complicate life in the glass house.

In 1984, Digital Equipment Corporation was on a roll, capturing midrange and mainframe market share with its networked minicomputers. Digital's MicroVAX II workstation system was nearly ready for release, but it needed a backup system. A group of Digital storage engineers, led by consulting engineer Fred Hertrick, worked day and night to come up with a drive that could match the MicroVAX performance. With time short and the pressure on, the group decided to use off-the-shelf half-inch magnetic tape, the same kind of stock used in mainframe-class reel-to-reel systems. Hertrick and his team devised a drive that combined the qualities of reel-to-reel and cartridge tape systems.

No Take-Up Reel

The new system used a square cartridge that contained tape, but no take-up reel. The take-up reel was built into the drive itself. This design eliminated the wasted space typically associated with cassette and cartridge drives such as the QIC, 8mm, and video cas-

sette systems (DAT wasn't out yet). Of course, the drive itself had to be made somewhat larger than most to accommodate the internal take-up reel. Dubbed the TK50, the new tape drive was capable of storing 94MB per cartridge.

Using a ferrite read/write head, the TK50 recorded data in linear blocks along 22 tracks using two channels. The TK50's read/write head actually contained two sets of read/write elements. One set was used when reading and writing forward and the other reading and writing backward. The TK50 started recording at the beginning of the tape, recording on one track. When it reached the end, the system recorded back to the beginning along a new track. After every two tracks were written, the system moved the head up the width of one track and began the process again. The read-after-write capability of the system ensured basic data accuracy.

The TK50 was introduced with the MicroVAX II in 1985. The drive fit into a full height, 5.25" drive bay in the MicroVAX. Compared to the DLTtape drive of today, the TK50 was like Neanderthal Man – it walked upright and used tools, but it still had a long way to go. The TK line of drives used only two guide rollers to hold the streaming tape against the read/write head. This was okay for the low data densities of these early systems, but would never work at the extreme densities we've come to expect today.

In 1987, the year of the first IBM 80386-based PCs and Windows 2.0, Digital rolled out the TK70. This new tape drive offered 294MB of storage on the same square tape cartridge, a 3x improvement over the TK50. This was accomplished by upping the number of tracks to 48 and increasing density on the same half-inch tape. Millions of PCs were in use and had become a permanent part of corporate America. Popular PC applications included desktop publishing, word processing, spreadsheet, and database management.

Macintosh and its GUI operating system were growing in popularity, having entered through the back door of corporate graphics departments and in-house advertising groups.

Need for Precision

The TK70 wasn't enough to quench the thirst for greater storage capacity and faster throughput speed in tape backup systems. Disk drive capacity was steadily increasing. Industry was becoming more dependent than ever on information systems technology. Databases swelled to overflowing, and tape drives lagged behind the growing wave.

The storage systems engineers knew that, in order to push the envelope, they'd have to improve the precision of the tape guide. Unless the tape was held rock solid in front of the read/write head, there was little hope of achieving the quantum leap that was needed in tape capacity.

By 1988, digital audio tape (DAT) was about to cross over from the music world to become the smallest entry in data storage subsystems. However, though small in size, these systems were projected to store at least a gigabyte (GB) or more. Eight millimeter and VHS video/data systems were already offering storage capacities of 2GB or more. Clearly the engineers had some serious work to do.

And, they did it. In 1989, Digital introduced the TF85, the first true DLT system. The TF85 (later to be dubbed the DLT 260) incorporated a host of new features that enabled the system to pack 2.6GB onto a 1,200 foot tape (CompacTape™ III, now known as DLTtape III). Less than two years after the introduction of the 294MB TK70, the engineers had increased storage capacity nearly tenfold and made a breakthrough in tape drive performance that we now call DLTtape technology.

Head Guide Assembly

Probably the most important new feature introduced with the TF85 was the patented six-roller head guide assembly (HGA). This mechanism provides a gentle, solid path to precisely move the tape past the read/write head. This boomerang-shaped assembly consists of a forged aluminum base with six precision rollers fixed to it. The new HGA enabled the engineers to safely increase track density from 48 tracks to 128 tracks across the half-inch wide tape.

The six-roller head guide assembly (see Figure 3-1) gave the TF85 a much shorter tape path than helical scan systems like the 8mm drive, which meant less wear and tear on the tape. The rock solid platform of the HGA also provided the industry's most accurate tape path. Helical scan systems have to draw tape around a spinning read/write drum, which requires a moving tape path with many more parts and points of tape wear.

Write/Read/Write

Another innovation in the TF85 resulted in high performance data transfer speed and improved error correction. The read/write head was equipped with an additional write element. The elements now were arranged in a write/read/write pattern, allowing continuous accuracy checking. This pattern enabled the TF85 to read after writing on two channels and in both forward and reverse. Multi-channel serpentine recording was born.

Seven-Cartridge Autoloader

To meet the need for unattended backup of large databases, Digital also introduced a seven-cartridge autoloader, designated the TF857. This system used a single TF85 drive, a seven-cartridge magazine, and an elevator mechanism. Tape loaders and libraries minimized or eliminated operator involvement and simplified tape management.

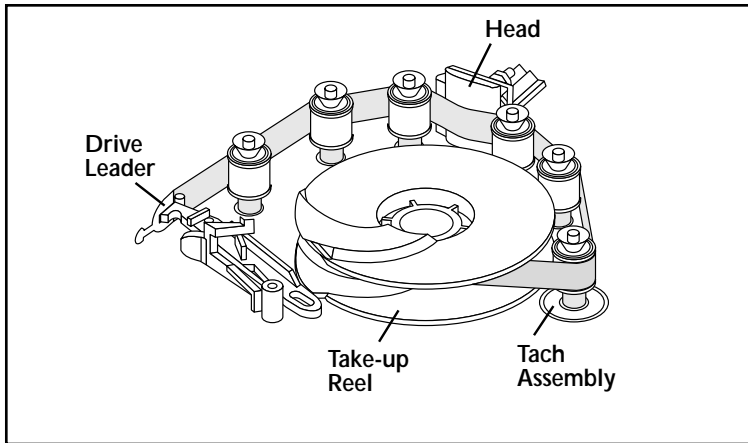


Figure 3-1 The Patented DLTtape Head Guide Assembly, first incorporated in the TF85 drive, is one of the keys to DLTtape reliability. Six precision rollers provide a gentle tape path for long tape life.

In 1991, Windows 3.1 became a standard for PCs. “Mini” manufacturers industry-wide felt the pressure as companies discovered that a string of inexpensive PCs could be networked to do the same work that had once been the province of the minicomputer.

Meanwhile, Digital’s storage group kept advancing DLT technology. In 1991, the company introduced the TF86 (later dubbed the DLT 600), which offered 6GB of storage on the same 1,200’ DLTtape III (known at the time as CompacTape III) cartridge. This new drive was read/write compatible with the TF85, preserving customer investment in drives and media.

Two years later, the company introduced the TZ87, now known as the DLT 2000 tape drive. This advanced system offered 10GB of native capacity on a single CompacTape III cartridge (now known as DLTtape III), 2MB of read/write data cache memory, and a data transfer rate of 1.25MB/s. In 1993, Digital also introduced a compact five-cartridge tape loader (now known as the DLT 2500) that

could store up to 50GB of uncompressed data using the DLT 2000 drive and eventually up to 100GB of uncompressed data using the DLT 4000 drive.

Early in 1994, Digital began to gear up to sell DLT tape drives outside its normal user base. The SCSI-2 interface used by DLT drives was an industry standard that would allow almost any computer to work with the drives. At about this time, Digital renamed its disk and tape subsystem group Avastor.

Quantum Enters the Picture

By 1994, Quantum Corporation, a Milpitas, California-based maker of high performance disk drives since 1980, had built a healthy \$2.1 billion business. The company was the leading supplier of 3.5-inch hard drives for PCs and the third leading supplier of high-capacity drives (2GB and up). In DLT technology, Quantum saw the opportunity to acquire advanced technology that could ensure the company's leadership position and open new markets for it. Quantum acquired Digital's disk and tape divisions and, within them, DLT technology.

Potential for Success

Quantum recognized the undeveloped potential that DLT technology represented. This technology was the perfect complement to their established disk drive business. Almost immediately, Quantum announced new tape drives based on the acquired technology. In late 1994, Quantum rolled out the DLT 4000 drive and leapt to the head of the line in performance, capacity and reliability.

By increasing areal density (bits per inch) from 62,500 to 82,000 and tape length by 600 additional feet (to 1,800 feet), Quantum's storage engineers were able to up the capacity of the DLT 4000 system to 20GB (40GB compressed) on a single half-inch DLTape IV

cartridge. The new DLTtape system provided data transfer at 1.5MB/s (3MB/s compressed) and was fully read/write compatible with previous generations of DLTtape drives. Again, customer investments in DLTtape drives and media were preserved.

Sales Growth

Quantum sales rose to \$3.5 billion for FY'95 on strong growth on all fronts. Quantum had evolved from its role as only a disk drive maker to a provider of mass-storage solutions. The rapid rise of multimedia, data warehousing, data mining, large network storage servers, Internet/Intranet growth, and 7x24 information system operations meant the need for fast, high capacity backup systems was exploding, and Quantum had the products that the market wanted.

In 1995, Quantum introduced an improved DLT 2000 system, dubbed the DLT 2000XT for “extended tape.” The new system provided an additional 5GB over the capacity of the DLT 2000 drive for a total of 15GB native capacity. Quantum was able to achieve this improvement through firmware changes (see Chapter 15), and by increasing the length of the tape used from 1,200 to 1,800 feet (DLTtape IIIXT). As usual, the DLT 2000XT was fully backward compatible with all previous DLTtape drives.

Others Playing Catch-up

Quantum enjoyed a time-to-market gap that had manufacturers of 8mm, DAT, and QIC tape drives scrambling to try to match DLTtape system capacity and performance. Just when it seemed they might come close, Quantum introduced the DLT 7000 drive in 1996. This new drive offered a total storage capacity of 35GB native (70GB compressed) on the 1,800 foot DLTtape IV cartridge.

Thanks to the DLT 7000 drive's new 4-channel head, it could transfer data at the rate of 5MB/s in native mode. Other tape

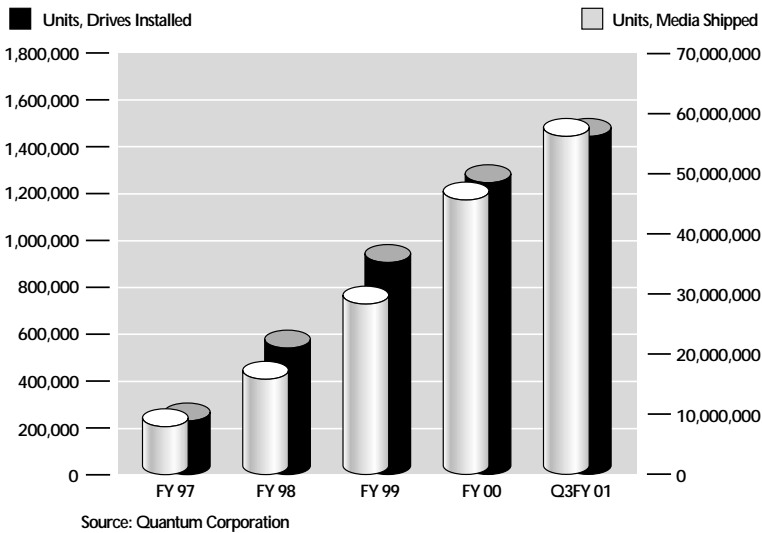


Figure 3-2 The Installed Base of DLTape systems has grown dramatically, with a projected total of over 1.5 million drives installed and over 55 million cartridges shipped to customers by the end of Q3, FY01.

drive makers were left far behind. Demand for the drive quickly outstripped supply as OEMs and resellers flocked to take it on. Library manufacturers wanted the drive in order to up total library capacities into the multi-terabyte range. *Unix Review* magazine named the DLT 7000 drive one of its Outstanding Products for 1996. Press accounts began by stating the DLT 7000 drive’s technical dominance at the high end of the midrange tape backup market.

DLT 8000 Drive

In 1999, Quantum introduced the DLT 8000 drive, a significant step up in performance and capacity over the market-leading DLT 7000 drive. The DLT 8000 system delivered a 15% increase in storage capacity (from 35GB to 40GB native), a 20% increase in transfer rate (from 5MB/s to 6MB/s), and an important improvement in reliability (from 200,000 hours MTBF to 250,000 hours). And, of course, the DLT 8000 system delivered another important

benefit – investment protection: the DLT 8000 drive, which uses the same DLTtape IV tape cartridges as the DLT 7000 drive, is compatible with a very large percentage of all of the DLTtape media ever sold (some 55 million cartridges).

DLTtape System Sales Growth

At the end of FY '99, sales of DLTtape products hit \$1.4 billion, and DLTtape products accounted for nearly 30 percent of Quantum's sales. According to Quantum CEO Michael Brown, "The move to enterprise servers, the proliferation of Internet servers, and the increase in mission-critical content stored on these servers have dramatically increased the demand for backup and archival storage. Quantum's DLTtape drives use advanced linear recording technology and a highly accurate tape guide system to provide exceptionally reliable, scalable data backup and archival storage for mid-range and high-end systems. These drives, which have become the industry's *de facto* standard, provide a strong foundation for market acceptance of our next generation products."

The Next Generation: Super DLTtape Technology

Early in 1998, Quantum had also revealed plans from the most important development in the history of DLTtape technology: Super DLTtape technology, the next generation of DLTtape technology. It incorporates dramatic advances in virtually every important area, from mechanical packaging through head design, tape guidance, and media properties. Yet the Super DLTtape system is also unmistakably a DLTtape product, providing a smooth growth path from today's market leading technology to a new technology that will deliver order-of-magnitude advances in capability.

By mid-2000, Quantum announced plans to deliver a family of competitively priced tape drive products based on Super DLTtape

technology. Volume production and first customer shipments began in Q1, 2001. These products address the individual storage needs of low-, mid-, and high-end customers in the mid-range data storage market. These new products include drives that deliver capacities of 110GB (uncompressed), and transfer rates of 11MB/s (uncompressed). They are the first products based on the Super DLTtape technology, a technology that Quantum will continue to evolve, with coming generations planned to deliver over 1 terabyte of storage (uncompressed) on a single cartridge. And, of course, the Super DLTtape system delivers another and continuing benefit – investment protection. The Super DLTtape system is backward read compatible with DLTtape IV cartridges written on DLT 4000, DLT1, DLT 7000, and DLT 8000 drives.

DLT1 Drive

Early in 2001, Quantum introduced the DLT1 drive. Delivering 40GB per cartridge native capacity (80GB compressed), along with a native transfer rate of 3MB/s (6MB/s compressed), the DLT1 drive is an exceptionally cost-effective backup solution for a wide range of applications. The DLT1 can back up most small- and medium-size storage servers and workstations on a single cartridge. Available for both internal installation and as a free-standing, table-top unit, DLT1 is designed primarily for stand-alone applications. It uses the same DLTtape IV cartridge that is standard for the DLT 4000 drive, allowing users of small and medium-size storage devices and workstations a simple migration path and the ability to make an initial investment in their future storage strategy using the DLTtape products.

Next, we'll take a look at the advantages that make the DLTtape system the most sought after backup solution on the market today.

Why Customers Want DLTtape Systems

4

When Quantum bought DLT technology in 1994, sales of DLT products were running a modest 20,000 units per year. In just six years, DLTtape drive sales climbed to over 500,000 units a year. Why are so many people buying DLTtape systems? Some of the reasons have to do with big industry trends. Others have more to do with the basics of DLTtape technology itself. In this chapter, we're going to look at the forces that are driving customer demand for DLTtape system backup solutions.

The Server Boom

One of the industry trends driving the demand for DLTtape systems is the growth in the population of midrange servers. Not many years ago, 8mm and 4mm DAT (digital audio tape) dominated the backup world. There was no reason to think that wouldn't continue. Many people probably assumed they would keep using DAT for backup until optical disk technology eventually took over. And, in the desktop computer world, that scenario is holding up pretty well. People are still buying 4mm DAT drives by the tens and hundreds of thousands, and optical – in one form or another – is coming up over the horizon.

The midrange field, however, offers a whole different scenario. Instead of the “death of the minicomputer industry,” we have seen

the “birth of the server industry.” Of course, today’s servers look a great deal like yesterday’s minicomputers, and, instead of disappearing, this class of computers is growing very rapidly.

These midrange servers support much larger disk storage than desktop systems. That means you need more backup capability – more capacity, more speed, and greater reliability. These backup needs are the strengths of the DLTtape system. It’s no accident that the growth in popularity of the DLTtape system closely parallels the boom in server use.

The “Mission Critical” Boom

Much of the growth in the midrange market is fueled by a new class of mission critical applications, such as Internet servers, enterprise wide email servers, video editing, electronic commerce, and so on. These applications demand bigger disks, more capacity, and, of course, better backup solutions. This is where DLTtape technology really shines.

Customers are buying DLTtape systems because these mission critical applications need backup solutions that offer more speed, capacity, and reliability: exactly what DLTtape system backup delivers. Don’t forget that DAT (digital audio tape) and 8mm are really consumer entertainment technologies, adapted for industrial use. DLTtape technology is industrial-strength from the start. It just takes one failure of a mission critical application to make people understand that what they really need is industrial strength backup.

A Proven Technology

“Leading edge” technologies sometimes end up on the “bleeding edge.” In this case, however, DLTtape technology is growing so fast because it has been proven. People want DLTtape technology because they know it works. Today, there are over 1.5 million

DLTtape drives installed, and over 55 million DLTtape cartridges in use worldwide. In the understated words of one user, “DLTtape technology is a well understood way to get a lot of data backed up.”

Widely Available

DLTtape systems are available from many sources. The list of OEMs who put DLTtape drives in their systems is impressive and growing. Almost all the leading vendors of mid-range computer systems or workstations sell DLTtape products, including Compaq, Dell, Hewlett-Packard, IBM, and Sun. Every one of these manufacturers offers DLTtape systems as factory installed backup systems and libraries for their high-performance servers.

DLTtape technology is also available from the leading manufacturers of tape storage libraries and autoloaders. DLTtape products are available through major industrial distributors, and from value-added resellers, many of whom serve specialized markets. A good example is Avid Technology, the leader in special effects editing systems for film and video; DLTtape drives come as standard equipment with Avid systems.

Speed Is Critical

Industry trends and good history have created the conditions for success of DLTtape technology. However, trends don't mean much if the technology doesn't deliver performance. Customers want DLTtape technology because it offers blazing performance.

DLTtape drives are very fast: from 1.5MB/s to 11MB/s in “native” or uncompressed mode (see Figure 4-1). That's nearly hard disk drive speed. If you are running a network in a large engineering department, and all the servers must be backed up between midnight and 6 a.m., speed is your best friend. Or, if you're putting the finishing touches on special effects for a TV commercial, and the

	DLT 4000	DLT 7000	DLT1	DLT 8000	SDLT 220
Capacity (GB, native)	20	35	40	40	110
Data Rate (MB/s, native)	1.5	5.0	3.0	6.0	11.0
Bit Density (Kbpi)	82.5	86	123	98	131
Track Density (tpi)	256	416	336	416	896
Media Type	MP-2	MP-2	MP-2	MP-2	AMP
Media Length	1,800'	1,800'	1,800'	1,800'	1,800'
Recording Channels	2	4	2	4	8
Hardware Data Compression	Yes	Yes	Yes	Yes	Yes
Interface	SCSI-2/F SE/HVD	SCSI-2/FW LVD/HVD	SCSI-2/FW LVD	SCSI-2/FW LVD/HVD	SCSI-2/FW LVD/HVD

Figure 4-1 DLTape Drive Comparison Chart shows some of the important specifications for DLTape systems, including the industry-leading Super DLTape system.

clock is running out, you don't want to have to face the long, slow process of putting the ad on tape before you can ship it to the client. You want DLTape system speed.

Bigger Is Better

Users want DLTape technology because bigger is much better. You can put much more information on half-inch-wide tape than you can on 8mm or 4mm tape. Currently, an SDLT 220 drive can store 110GB on a single Super DLTape I cartridge. Add compression of 2-to-1 and you've got 220GB on one four-inch-square cartridge (not to mention 22MB/s throughput). That's enough capacity to store multiple full-length feature films, and you can look for greater capacity in the future (see Chapter 17 for details on Super DLTape technology). For the typ-

ical system administrator running a network backup application, more capacity per cartridge means less need to swap cartridges.

More Reliable

While we were researching this book, we talked to end users and network managers. Over and over again, they told us that they had switched to DLTtape backup because the systems they had been using just weren't reliable enough anymore. Under the pressure of backing up big networks, 4mm and 8mm solutions just don't cut it. This from the people whose necks are on the line when systems fail. They say things like "too many midnight calls," or "every once in a while an 8mm drive would go bang," or "our old 4mm drives could not handle it." So, customers want DLTtape technology because it is more reliable than any other backup technology.

Heavy Duty

Most drive makers base their performance and reliability figures on drive utilization (duty cycle) as low as 10 percent. That means that in a 7x24 operation, other drive makers base reliability figures on as little as 2.5 hours of use during every 24-hour period. At Quantum, we have traditionally calculated our reliability figures based on 100 percent usage. In fact, even at 100 percent duty-cycle, DLTtape drives are rated at up to 250,000 hours Mean Time Between Failures (MTBF). Even when compared to a competing drive offering the same MTBF, DLTtape drives are the clear winner, because we have calculated MTBF assuming 100 percent usage. In practice, few drives will actually be subjected to non-stop operation. But, it's nice to know you could run your DLTtape drive continuously if you had to, without the worry of premature failure or data loss. (See Chapter 5 for a complete discussion of DLTtape system reliability.)

Economy

Because DLTtape technology started life as a proprietary technology, and because its market is primarily in the midrange and high-

end server arena, some people mistakenly characterize DLTtape technology as expensive. That is simply not the case.

One of the great things about the free market is that buyers usually figure out the best deals pretty quickly. Users want DLTtape technology because, as it turns out, in many applications, not only does it offer superior performance, but it's also the least expensive way to get the job done.

DLTtape technology isn't the cheapest backup for desktop applications – yet. That's still 4mm DAT. But once you jump to UNIX workstations or enterprise networks, it's a whole different story. For starters, you need to factor in capacity. At 40GB uncompressed, for example, the DLT 8000 drive compares favorably in price with competitive units of lesser capacity.

The cost equation changes when you factor in performance. If you've got all night and you only need to backup a few files, slow is fine. But, if you're trying to back up a large, constantly changing database, and the only time you can do it is from 2 a.m. to 5 a.m., then speed is money. For more and more applications, with growing storage needs and shrinking backup windows, the critical issues are: Can you complete this backup in the available time, with minimum operator involvement, and provide maximum dependability? With its 110GB capacity and 11MB/s native transfer rate, the SDLT 220 drive is the value leader in these increasingly common circumstances.

Comparing media cost is a similar story. If your total system storage capacity is only one or two GB, smaller capacity, lower-initial-cost tape cassettes may be fine. As soon as you jump up a class and have 5, 10, 30GB or even terabytes to back up, dollars-per-gigabyte becomes the meaningful measure of the cost of media. Generally, the larger your backups are, the more cost-effective it becomes to use DLTtape

technology. No other tape drive system packs as much data in a single cartridge as the DLTtape system; up to 110GB in native mode on a single Super DLTtape I cartridge.

True Cost

The true cost of backup isn't in the drives and the media at all – it's in the people and time it takes to meet your backup goals. If files are small and the windows of time are wide open, administrative costs probably aren't even worth measuring. In these rare situations, the lowest initial cost solution works. As soon as you crank up the volume, however, administrative costs can soar. If you've got 4mm cassettes filling up constantly, just swapping tapes can become a time sink. And if you're really pushing the limits of speed, capacity, and duty cycle of your backup solution, failure rates start climbing. That means serious interruptions and delays as you scramble to replace bad drives. In other words, administrative costs quickly get out of control. One user told us he used to spend 35 hours a week to support 4mm DAT backup for critical client files. When he moved to DLTtape backup, that cost virtually disappeared. That's another reason why people want DLTtape technology.

Scalability

One of the primary reasons people want DLTtape technology is scalability. Scalability means DLTtape system customers solve the backup problem once, and then keep applying the same solutions as needs grow. You can go from a DLT 4000 drive with uncompressed capacity of 20GB, to an SDLT 220 drive with uncompressed capacity of 110GB. Beyond that, you can move up to one of many available automated DLTtape libraries with capacities ranging from “a terabyte on a desktop” to many terabytes or even petabytes on the floor.

Room to Grow

One of your goals should be to pick a backup technology that has a future. While helical scan technologies, for example, are pushing

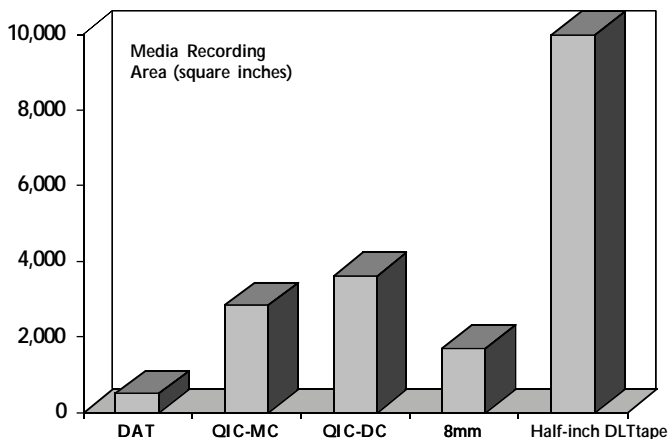


Figure 4-2 Half-inch DLTtape Media *leaves plenty of room for capacity growth for future DLTtape drives. A single DLTtape cartridge has a tape area of over 10,000 square inches.*

the upper limits of their potential, DLTtape technology is just hitting its stride, with plenty of room to grow.

Half-inch tape simply offers more growth capacity than the much smaller 4mm or 8mm formats (see Figure 4-2). Where 8mm and 4mm are pushing their density limits, half-inch DLTtape technology isn't even close to maxing out. For example, the DLT 4000 drive uses 128 recording tracks. The DLT 8000 drive uses the Symmetric Phase Recording™ pattern, allowing it to lay down 208 tracks on the same half-inch tape. The next generation of Super DLTtape systems increased track density yet again, by a factor of more than 2X, to 448 tracks.

Track density is just one parameter. Another is the underlying tape technology. Today, DLTtape IV cartridges use metal particle (MP) media. Super DLTtape I cartridges use state-of-the-art Advanced Metal Powder (AMP) media. AMP media offers increased media capacity, ease-of-use, and lower cost of ownership. Designed to meet the needs of multiple generations of Super DLTtape drives, AMP

media ensures the highest track density available today. AMP uses durable metal powder technology for recording at very high densities. The back side of the AMP media contains specially formulated back-coating to receive the optical servo tracks, so customers can reserve the entire data-bearing side of the media for recording data and eliminate the need for pre-formatting.

DLTtape System Compatibility

In most cases, IS managers are reluctant to change backup technology. You may have dozens, hundreds, or even thousands of old backup

Tape Type (recorded on drive type)	Native Capacity	Native Transfer Rate (read on DLT 4000)	Native Transfer Rate (read on DLT 7000)	Native Transfer Rate (read on DLT1)	Native Transfer Rate (read on DLT 8000)	Native Transfer Rate (read on SDLT 220)
DLTtape IIIXT (recorded on DLT 2000XT)	15GB	1.5MB/s	1.5MB/s	NA	1.5MB/s	NA
DLTtape IV (recorded on DLT 4000)	20GB	1.5MB/s	1.5MB/s	1.5MB/s	1.5MB/s	1.5MB/s
DLTtape IV (recorded on DLT 7000)	35GB	1.5MB/s	5MB/s	NA	5MB/s	3.5MB/s
DLTtape IV (recorded on DLT1)	40GB	1.5MB/s	NA	3MB/s	NA	3MB/s
DLTtape IV (recorded on DLT 8000)	40GB	1.5MB/s	5MB/s	NA	6MB/s	4MB/s
Super DLTtape I (recorded on SDLT 220)	110GB	NA	NA	NA	NA	11MB/s

NA=Tape format is not compatible with the tape drive.

Figure 4-3 Backward Compatibility *is maintained throughout the DLTtape media family.*

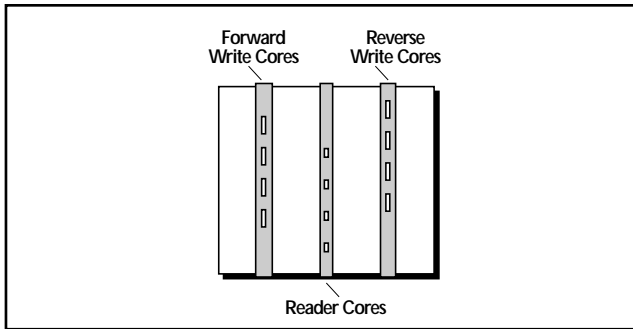


Figure 4-4 DLT 7000/DLT 8000 Read/Write Head *tilts back and forth to record at highest data density, yet it can still read older formats by assuming vertical position shown here.*

tapes. You will never need most of them. But if you do need some old tapes from last year, or 5 years ago, or just last week, you would have a major problem if you had changed backup platforms. That is generally not the case with DLTtape technology. A cartridge recorded on a DLT 2000 drive three or four years ago can be read on a DLT 4000 drive today. You can put a DLTtape IV cartridge in a DLT 4000 drive today, fill it with data, and two years from now you will be able to read it on a DLT 8000 drive (see Figures 4-5 and 4-6). All DLTtape drives up to the DLT 4000 drive use a similar head design and recording pattern that makes possible compatibility among drives. However, the DLT 7000 and DLT 8000 drives use a new recording pattern, Symmetric Phase Recording. The read/write head of the DLT 7000 and DLT 8000 drives tilt forward and back (see Figure 4-5) to achieve higher track density. When a DLTtape cartridge that has been recorded on a DLT 4000 drive, for example, is inserted in a DLT 8000 drive, the drive automatically detects the difference in recording pattern. The DLT 8000 drive then automatically adjusts its read/write head (Figure 4-6) to a vertical position that enables it to read the older DLTtape cartridge.

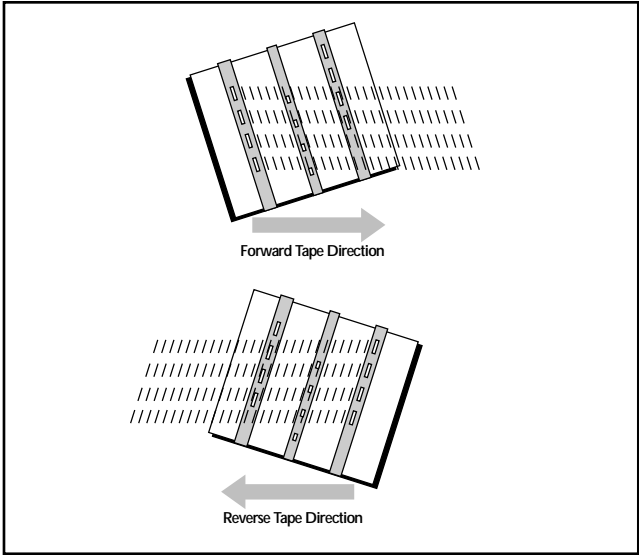


Figure 4-5 Symmetric Phase Recording (SPR), used in DLT 7000 and DLT 8000 drives, angles recording tracks to prevent cross-track interference and increase data density.

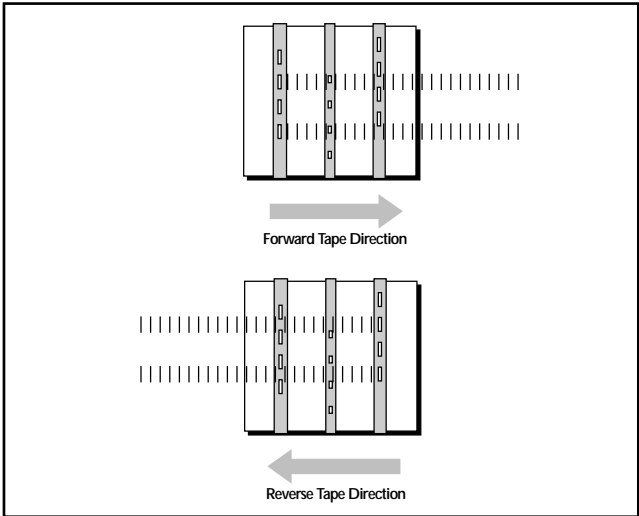


Figure 4-6 DLT 7000/8000 Head Positioned to read DLTtape cartridge recorded on an older DLTtape drive, providing compatibility and data interchange.

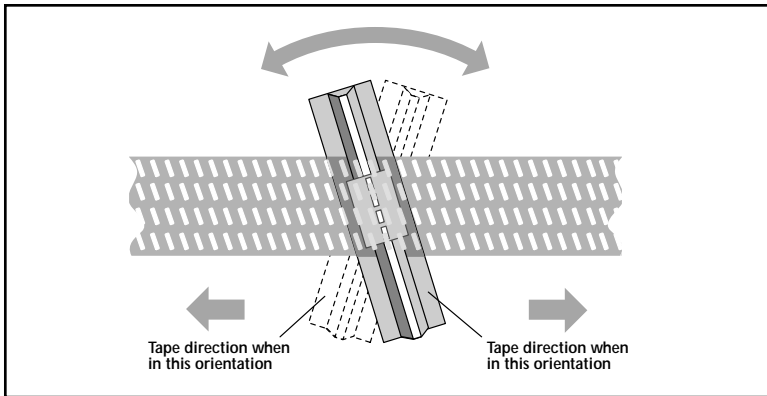


Figure 4-7 The Super DLTtape Backward Read Compatible Head Assembly tilts to read DLTtape IV cartridges recorded on DLT 7000 and DLT 8000 drives, which use Symmetric Phase Recording (SPR).

The DLT1 drive uses DLTtape IV media, so DLT1 drives can read any DLTtape IV cartridges recorded on DLT 4000 drives. And, of course, DLTtape IV cartridges recorded on DLT1 drives can be read by DLT 4000 drives and by SDLT 220 drives.

Super DLTtape I Media Compatibility

Super DLTtape I media provides backward read compatibility with DLT 4000, DLT1, DLT 7000, and DLT 8000 drives using DLTtape IV cartridges. To read DLTtape IV cartridges recorded on a DLT 4000 drive or DLT1 drive, the Super DLTtape Backward Read Compatible head remains in an upright position. To read DLTtape IV cartridges recorded on a DLT 7000 or DLT 8000 drive, the Super DLTtape head tilts to read data recorded using Symmetric Phase Recording (SPR). (See Figure 4-7.) That means data written on any DLTtape IV cartridge using any DLT 4000, DLT1, DLT 7000, or DLT 8000 drive can be read on a Super DLTtape drive. That includes the majority of all the DLTtape drives ever built, and a very high percentage of the 55 million DLTtape cartridges ever built.

Next, we'll take a closer look at the features that make DLTtape technology the most reliable on the market today.

Reliability: The Heart of the DLTtape System

5

There is nothing more frustrating (or costly) than attempting to restore a file or directory, only to discover it can't be done because of errors or worn out tape. An inexpensive tape drive suddenly loses its appeal when a project manager is upset about a corrupted file that can't be restored. It doesn't matter who deleted the original version; it's the IS manager's fault. Suddenly, that too-good-to-be-true low cost tape drive looks more and more like a mistake.

You Count On Tape Backup

Reliability should be one of the main criteria you use to evaluate tape backup systems. You need to match your organization's backup needs to the expected reliability of your tape backup system. In standalone workstation backup or other light-duty applications, a low-end tape system such as QIC or DAT may make perfect sense. This is especially true when you know you'll use a tape just a few times and archive it.

When it comes to network, enterprise and other mission-critical backup situations, you can't afford to cut corners. With data storage capacity at mid-to large-scale companies doubling every 12 to 18 months, you need a fast, reliable tape backup system that will match your needs now and in the future. The DLTtape system was specifically designed for today's demanding mission-critical back-

up applications. In this chapter, we will take a look at the DLTtape system features that make it the most reliable mid-range backup system on the market today.

Unlike drives based on consumer video or audio recording technology, such as 8mm and DAT, DLTtape systems were designed from the start for intensive data storage use in mid-range and high end environments. DLTtape drive components and media work in harmony to provide the fastest, most reliable, highest capacity tape drives in the industry.

The following paragraphs outline the characteristics that give the DLTtape system the reliability edge over all mid-range competitors.

Head Guide Assembly

DLTtape system reliability begins with a solid foundation: the head guide assembly (HGA; see Figure 5-1). The patented DLTtape head guide is a boomerang-shaped aluminum plate. In the DLT 4000, DLT 7000, and DLT 8000 drives, it has six large bearing-mounted rollers. These rollers are free-wheeling guides, with the last roller acting as both a guide and a digital tachometer. The tachometer controls the system's two drive motors to regulate tape position, speed and tension. The Super DLTtape drives have four rollers (see Figure 5-2).

The DLTtape head guide provides a rock solid path for the DLTtape media to follow. The precise head/tape alignment achieved at the factory is maintained by the HGA. Other tape drives, particularly helical scan systems like the 8mm drive, have a much longer and more complex tape path than the DLTtape system. A helical scan system must pull its tape out of the cartridge and nearly all the way around a cylindrical head. In addition, the tape path rollers used on helical scan systems are small and result in acute tape wrap angles

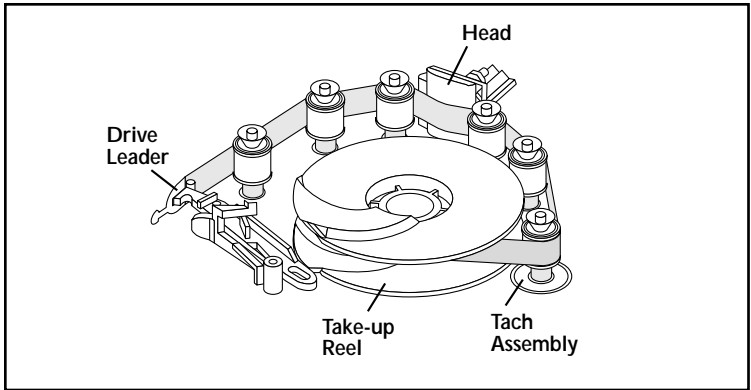


Figure 5-1 Patented Head Guide Assembly (HGA) used in the DLT 4000, DLT 7000, and DLT 8000 drives provides a rock solid tape path for industry-leading reliability and accuracy.

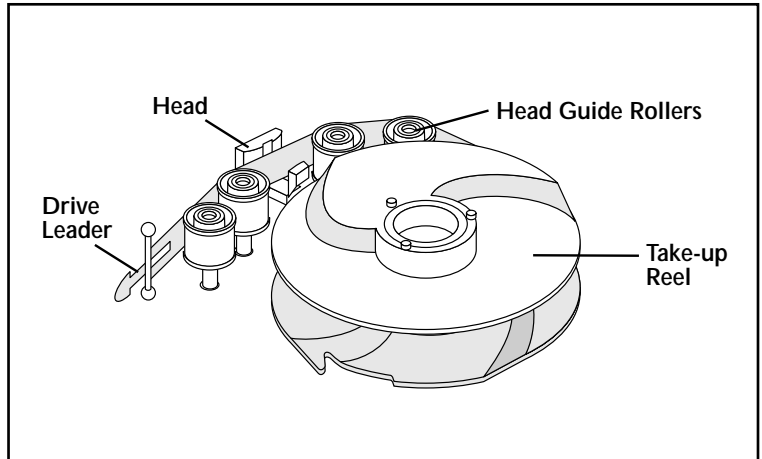


Figure 5-2 The Super DLTtape Head Guide Assembly is a refined version of the DLTtape Head Guide Assembly. It incorporates only four rollers, further reducing contact and tape wear.

that stress the tape. DLTtape rollers are large and are arranged in a gentle arc along the HGA. This roller arrangement results in much less wear than in helical scan system.

When a DLTtape cartridge is inserted into the drive, it is automatically locked into position. A patented buckling mechanism pulls the DLTtape media from its cartridge. Unlike 8mm and other cartridge tape systems, DLTtape cartridges have a supply reel, but no take-up reel. The tape is pulled along the tape path (see Figures 5-3 and 5-4) to a take-up reel mounted permanently inside the drive. In this way, no space is wasted inside the DLTtape cartridge, allowing for more tape per cartridge. This design means the DLTtape system lets you store more data in less space than other tape systems.

Tape Handling

The half-inch DLTtape media passes across the drive's write/read/write head under very low tension. The only time the head moves is

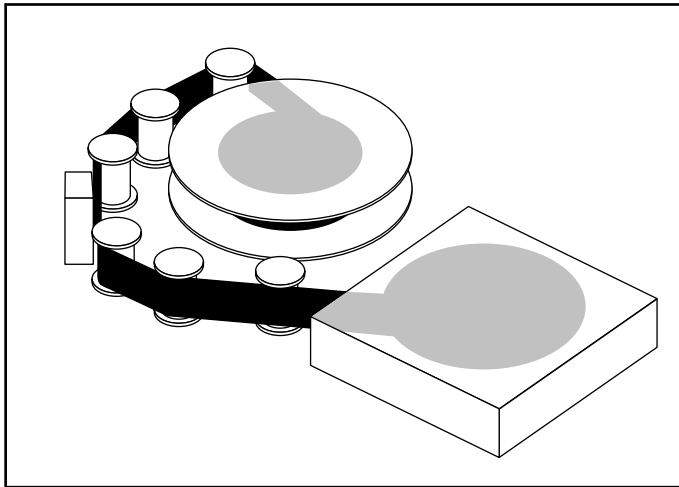


Figure 5-3 Tape Path through the DLTtape head guide assembly is a gentle curve that reduces tape wear and ensures tracking accuracy.

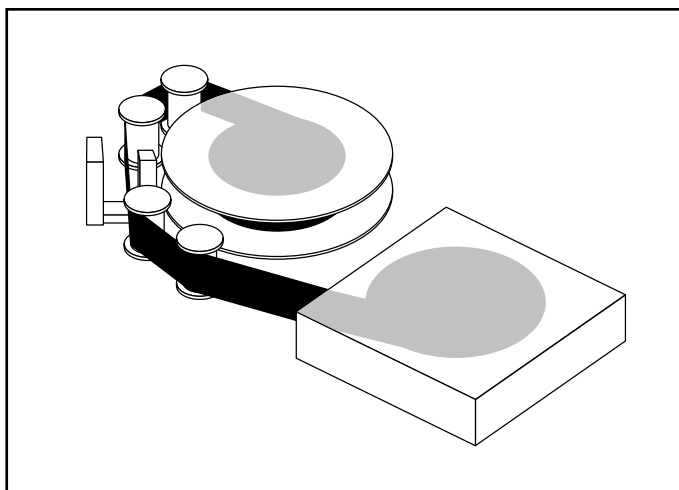


Figure 5-4 Super DLTtape System Tape Path *is even simpler than that of the DLTtape drive, requiring only four precision rollers to guide the tape.*

to step up and down from track to track or, in the case of the DLT 7000 and DLT 8000 drives, to tilt forward and back. The drive's head is gently contoured to minimize tape deflection at the contact point. Low tape tension, a non-rotating head, and special wear-resistant tape coating give DLTtape drives industry-leading head life. The drive head is the only contact point on the data side of the tape. The four or six tape path rollers touch only the back of the tape, so wear is kept to an absolute minimum. In helical scan systems, the tape is wrapped around a large head that is spinning (at over 5,000 rpm in one 8mm system). This large area of contact and high relative tape speed result in wear to both tape and head.

The DLTtape system's tachometer-controlled drive motors act in tandem like an electronic Push-Me-Pull-You. One motor pulls the tape through the tape path while the opposing motor applies just enough drag to maintain optimal tape tension. When the tape reverses direction, the roles of the motors reverse, too. The

tachometer also helps the system keep track of how much tape is wound onto each reel and adjusts the speed of the two motors accordingly. Each time a cartridge is loaded, the drive calculates and sets the minimum tension required to achieve high-quality, consistent read/write signals. This calibration system maintains optimal-contact recording and helps extend the operational life of the drive.

Self-Cleaning Head

Another important feature that helps extend tape life is the DLTtape drive's self-cleaning head design. The write/read/write elements on the head are aligned vertically on three tiny islands. This reduces the point of contact with the tape recording surface to a bare minimum. Along with the write/read/write islands, two additional islands are included (see Figure 5-5). These extra two

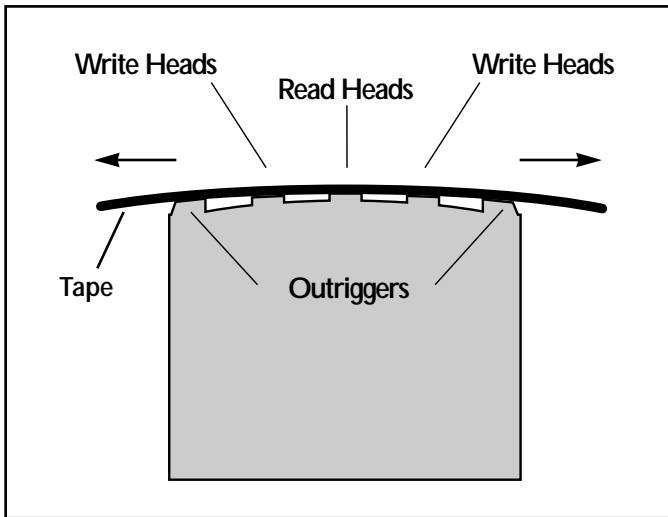


Figure 5-5 Self-Cleaning Contoured Head on DLTtape drives includes two fixed "outriggers" that wipe any debris from tape, reducing head wear (top view of head).

outrigger islands help wipe contaminants such as dust from the tape as it passes. Like tiny stationary squeegees, these non-energized islands continuously clean the DLTape media, ensuring proper tape/head contact, and data integrity.

A low-stress tape path, contoured head, and self-cleaning design team up to provide up to 1,000,000 tape passes. All DLTape cartridges provide a shelf life of up to 30 years with just a five percent loss in magnetic strength.

Error Detection

One quarter of the data on a DLTape cartridge is dedicated to error detection and correction. An application-specific integrated circuit (ASIC) chip containing a custom Reed-Solomon error-correction code (ECC) maintains unfailing data security. For every 64Kbytes of user data, there are 16Kbytes of ECC added. For every 4Kbytes of user data, a 64-bit cyclic redundancy code (CRC) and a 16-bit error-detection code (EDC) are also added. In addition, each user record is tagged with an overlapping 16-bit CRC. To top it off, all DLTape drives perform a read after each write command, and will automatically re-record data on a parallel channel.

This Parallel Channel Architecture (PCA) maximizes rewrite efficiency. Even with one or more channels inoperative due to bad blocks, four-channel DLT 7000 and DLT 8000 drives can continue to write data on a parallel channel (see Figure 5-6). (The dual-channel DLT 4000 drive also uses the PCA block structure and can continue operation even with one channel blocked.)

Thanks to multiple levels of error detection and correction, DLTape drives offer an exceptional level of data integrity. It has been calculated that DLTape drives have an unrecoverable hard error rate of one in 10^{17} bits and one undetected soft error in 10^{30} bits. That is a standard that no other tape drive comes close to.

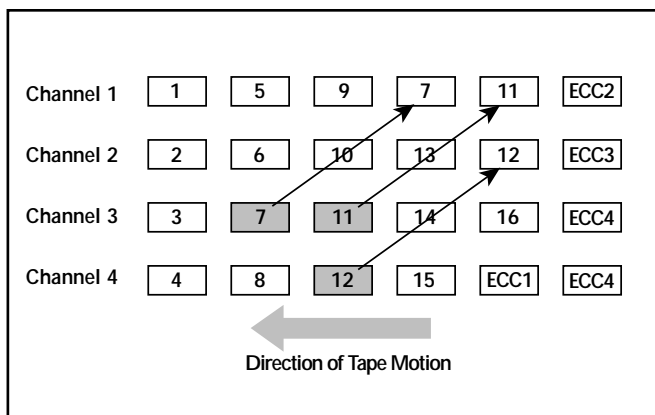


Figure 5-6 Parallel Channel Architecture on all DLTtape drives (DLT 8000 shown here) automatically transfers data from bad blocks to parallel channels for "on the fly" data recovery.

Adaptive Cache Buffering

DLTtape drives feature adaptive cache buffering, which helps reduce stops and starts, reducing drive wear and tear. Adaptive techniques enable the DLTtape system to adjust block sizes to match the host data rate. If compression is on, data is compacted as it enters the cache buffer at a rate that matches as closely as possible the rate at which it is written to tape. While the total throughput rate is dependent on how fast the host can supply data to the DLTtape drive, adaptive cache buffering helps keep the drive streaming as much as possible, and reduces delays due to repositioning. In addition, parity is maintained between the host system and the DLTtape drive over the SCSI interface.

Duty Cycle

Most drive makers base their performance and reliability figures on drive utilization (duty cycle) as low as 10 percent. That means that in a 7x24 operation, other drive makers base reliability figures on as little as 2.5 hours of use during every 24-hour period. At Quantum, we calculate most reliability figures based on 100 per-

cent usage. In fact, even at 100 percent duty-cycle, DLTtape drives are rated at up to 250,000 hours Mean Time Between Failures (MTBF). Even when compared to a competing drive offering the same MTBF, DLTtape drives are the clear winners, because we have calculated MTBF assuming 100 percent usage. In practice, few drives will actually be subjected to non-stop operation. But, it's nice to know you could run your DLTtape drive continuously if you needed to without worry of premature failure or data loss.

The reliability and industry-leading performance that characterize the DLTtape system are the reasons why nearly every major tape library manufacturer offers DLTtape system-based products. The DLTtape system is perfect for heavy-duty-cycle applications like hierarchical storage management (HSM), in which the system is constantly moving data between main memory, disk, and tape, depending on its current level of usage.

According to the president of one of the world's largest library makers, "In HSM applications, we have a highly intensive cartridge-swapping environment. DLTtape drives and cartridges are made for this heavy-duty application. This performance combination makes DLTtape technology solutions ideal within an automated HSM system."

Next, we'll discuss in detail what DLTtape system specifications really mean to you.

Demystifying Tape Drive Specs

6

Specifications can be stated in different formats, using different terms, which may or may not mean the same thing. And sometimes two different vendors will use the same term, but will base their use of the term on very different standards.

For example, identical MTBF (Mean Time Between Failures) figures can be based on very different assumptions for duty cycle or operating conditions (temperature and humidity). While both figures are accurate, different assumptions would make them have very different meanings in real life.

We intend this chapter to be a helpful guide to reading and understanding specs for tape drives in the price and performance category of Quantum DLTape systems. That includes a range of drives typically used for backup, archiving, and near on-line storage applications.

It is difficult to make an exact, apples-to-apples comparison of competing tape drives. That's because all manufacturers tend to state specs in the way that puts them in the best light. And, some products are different enough that you really can't compare them apples-to-apples. We will give you a more in-depth view of what each spec really means, what points you should look for, and how to judge what specs may be important for your application and

	DLT 4000	DLT 7000	DLT1	DLT 8000	SDLT 220
Native Capacity	20GB	35GB	40GB	40GB	110GB
Compressed Capacity (2:1)	40GB	70GB	80GB	80GB	220GB
Native Transfer Rate	1.5MB/s	5MB/s	3MB/s	6MB/s	11MB/s
Compressed Transfer Rate	3MB/s	10MB/s	6MB/s	12MB/s	22MB/s
Drive MTBF (hrs) at 100% Duty Cycle	200,000	200,000	200,000	250,000	250,000
Head Life (hrs)	10,000	30,000	30,000	50,000	50,000
Tape Life (yrs)	30	30	30	30	30
Media Passes	1 million	1 million	1 million	1 million	1 million
Uncorrected Bit Error Rate	1 per 10 ¹⁷	1 per 10 ¹⁷	1 per 10 ¹⁷	1 per 10 ¹⁷	1 per 10 ¹⁷
Warranty (yrs)	3	3	3	3	3

Figure 6-1 DLTtape Drives are the performance and reliability targets for all others on the market today. This chart shows some of the important specifications for DLTtape drives.

which ones you can ignore. Figure 6-1 includes the most important specifications for the DLTtape drives.

Capacity and Data Compression

Some manufacturers specify capacity in native mode. Others list capacity with an asterisk, and a footnote that says something like “assumes 2:1 compression.” Sometimes you might see a figure without an asterisk, but that figure could still very well assume compression of three or four to one.

Compression is the result of applying a compression algorithm to the data before it is written to the tape. For a lot of applications, compression is standard operating procedure. However, compression is only relevant if you actually compress your data, which you may or may not want to do. Big blocks of text can be squeezed down

very effectively, as can big graphics files. Other material, like tables, for example, doesn't compress much at all. Files that have already been compressed may even get bigger if you try to compress them.

The bottom line is that compression may or may not be relevant to your application, depending on the kind of data you deal with. Just make sure that you compare native-to-native, or compressed-to-equally-compressed figures. And, if the manufacturer has not been very clear that the figure you see is native mode, you probably should assume that the figure is for compressed data. For DLTtape systems, the stated capacity is in both native mode and in compressed mode, assuming 2:1 compression.

Performance and Compression

Performance (data transfer rate) is typically described in terms of MB per second. You need to determine if the transfer rate figure is for native mode, or if it assumes 2:1 data compression, or higher compression ratios. Be careful to distinguish between terms like peak transfer rate and sustained transfer rate. Peak transfer or burst rate usually refers to the maximum transfer rate of the bus. It has less to do with the performance of the tape drive than with interoperability with other equipment you may have in your system. The performance figure you should pay attention to is the sustained figure. For the DLTtape system, we list both figures, in native mode.

Another performance-related figure is average access time. That is the average time it takes to locate a file that is halfway into the tape. It assumes this is the first access requested from this specific tape, so the drive is starting to seek the file from the beginning of the tape. This is a very conservative approach. It is appropriate in applications in which files being sought are truly randomly distributed across the tape. However, in many, if not most, applications, the next file sought is near the previous file accessed, and actual access time may be shorter.

Load Time

Load time is the time from the moment you insert a cartridge into the drive, until the cartridge is ready to read or write the data.

When discussing the DLTtape system, competitors often make the accurate statement that the load time spec for a DLTtape cartridge is approximately one minute. While accurate, that statement is not complete. Load time for a DLTtape cartridge is approximately one minute, but only for the first time a blank cartridge is loaded. After that, it usually takes 35 to 45 seconds for the tape to load. The difference is due to the fact that, on the first load, the drive runs calibration tests and writes initial calibration information on the tape. On successive loads of the cartridge, the drive need only read the previously-recorded calibration information.

Compression Algorithms

One last compression related issue: how is compression accomplished? In most cases, compression is done by the tape drive itself. Several different compression technologies are used. Quantum DLTtape systems use the LZ (Lempel Ziv) compression algorithm. This algorithm has advantages over other algorithms, in terms of effectiveness across most types of data. In our experience, we have frequently achieved compression ratios of 4:1, and have had specific instances as high as 25:1. However, for the DLTtape system, Quantum continues to be conservative and uses the industry standard 2:1 figure when using compression data figures.

Reliability/MTBF

If your tape drive is subject to heavy usage, running eight or ten hours a day, or if it runs all night doing backups, then reliability is important, and MTBF is one way to determine reliability. MTBF is the most commonly used reliability spec. It specifies the most likely interval of time that will go by before the unit will fail. With some exceptions, this refers to a failure of any part of the unit, for any cause, under normal usage. A figure of 10,000 hours means that the manufac-

turer claims that, on average, this unit will run for 10,000 hours (or about 416 days) before it will break down and stop working. The bottom line is this: the DLTtape system, with its patented head design, low-tension-tape contact, simple tape path, and stationery heads, has an inherently more reliable design than that of competitive products.

Reliability and Environment

Another spec to look at when you compare reliability is environmental operating conditions. MTBF is calculated based on a formula that takes into consideration multiple factors for all the parts of the product and statistically merges them. Heat is the single greatest enemy of reliability. So one very simple way to increase calculated MTBF is to narrow the temperature range across which the product is assumed to be running. If you assume the unit will always operate in a 70°F room, you get a lot better figure than if you say it might have to function in a 100°F room. Our MTBF calculations for the DLTtape drives are based on a temperature range of 50°F to 104°F (10°C to 40°C), a wide range that reflects the worst conditions the system is likely to encounter.

Head Life

The read/write heads are among the most wear-sensitive and expensive parts of the tape drive. Obviously, they are an important factor in overall unit reliability. Head life for DLTtape drives is also calculated in a fashion similar to MTBF for overall drive reliability (i.e., under severe temperature and humidity conditions). The numbers would be even more impressive if we calculated for a typical office environment. Because head life is a critical reliability measure, we are extremely conservative in making our calculation.

Durability: Tape Passes

Media durability is measured in tape passes. How many times can the tape be run through the unit before it wears out? The figure we use for the Quantum DLTtape media is 1,000,000 passes. However, you should not compare that figure directly against competitive drives, which usu-

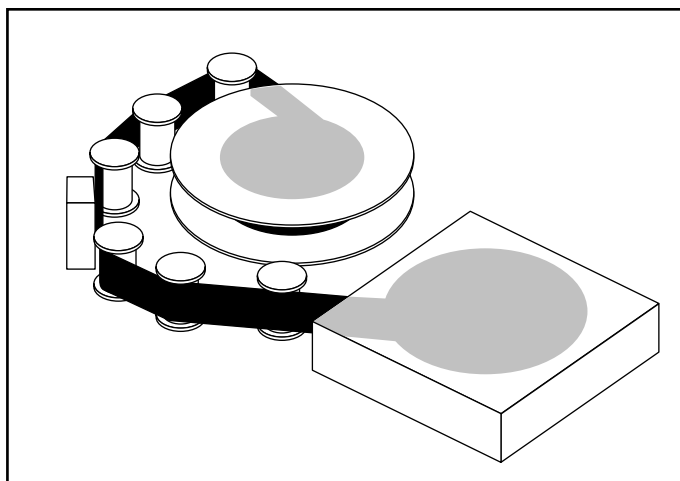


Figure 6-2 A Gentle Tape Path in all DLTape drives reduces stress and wear resulting in industry-leading tape life of up to 1,000,000 passes.

ally use far lower figures. A DLTape drive lays down data in a series of parallel tracks that run the length of the tape. As a result, it takes multiple passes to read or write the same amount of data on DLTape media that should be read or written in a single pass on competitive drives.

In general, a four-channel DLT 8000 drive will need 52 passes to cover 208 tracks. If you divide 1,000,000 passes by 52, you get a figure of 19,230 head passes. Durability figures for some competitive units are in the range of 1,500 passes. Which still makes the DLTape system more than 10 times more durable, even after adjusting for the difference in technology. (This is the worst case scenario for DLTape recording. In operation, it is unlikely to require 52 passes to retrieve the requested data in a typical cartridge usage, as only a small part in the tape will be read in most cases.) Again, this big advantage is based on the basic design of the drive: the tape goes over the heads with minimal tension (see Figure 6-2), and the heads are stationary while reading and writing. Wear and tear on the tape is dramatically less

than for a drive with rotating heads. DLTtape media is more durable than other types of media by a very wide margin.

Data Integrity – Error Correction

The important figure in terms of data integrity is the uncorrected bit error rate, sometimes referred to as the hard error rate. Uncorrected bit error rate is the number of erroneous bits that cannot be corrected by error correction algorithms. For DLTtape and Super DLTtape drives, we have calculated an uncorrected bit error rate of one bit in 10^{17} bits. That is one error in 100 quadrillion bits, or one error in 12 quadrillion bytes. How does that compare to other technologies? Most DAT drives, for one example, quote a spec of one uncorrected error in 10^{15} bits. 10^{15} is 100 times less than 10^{17} . Therefore, you can expect 100 times more errors on the DAT drive than on the DLTtape drive.

Modern high-density tape technologies, which record more data on smaller segments of tape, have made error correction quite complex. High-density tape drives have to recover a higher per-

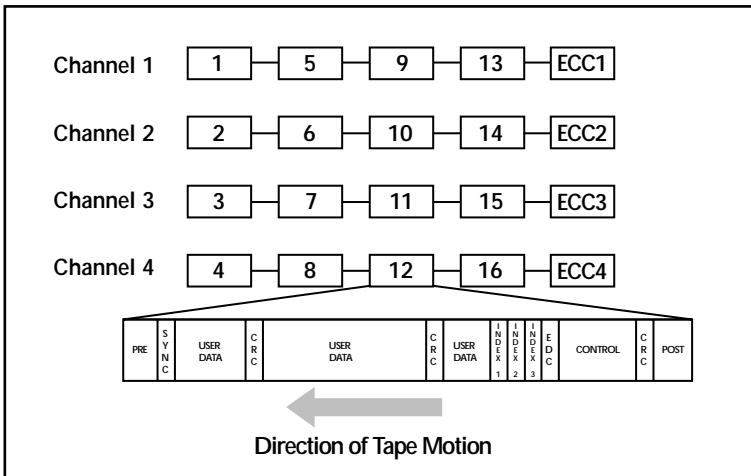


Figure 6-3 A DLT 8000 20-block Data Entity is shown above. Each entity contains 16 data blocks and 4 blocks of Error Correction Code, ensuring data integrity.

centage of recorded data, and in larger blocks (measured in number of consecutive bytes) to prevent data loss.

During write operations, the DLTtape drive assures that the data written is correct by performing a read after write. If an error is detected, the drive rewrites the data block (see Figure 6-3) further down the tape until the read-after-write check validates that the block is now correct. In addition, the drive records powerful Reed-Solomon ECC blocks on tape.

During read operations, if an error occurs, DLTtape drives recover the data using powerful ECC code. DLTtape drives can recover up to four bad blocks of data within a 20-block entity. At a recording density of 62.5Kbits per inch, four consecutive blocks translates to two inches of DLTtape media. That means that, even if as much as two consecutive inches of tape are damaged on a single track, a DLTtape drive can recover the data.

Conclusion

Comparing the specifications for the DLTtape system to the specifications for other technologies reveals significant benefits in a number of areas, including overall capacity, capacity per cartridge, and transfer rate. In other areas, primarily reliability, a comparison of specs shows that the underlying DLTtape technology results in an order-of-magnitude advantage. Leadership in speed and capacity are certainly important, but it is in the area of reliability that the specifications reveal the most dramatic differentials between the DLTtape system and competitive products.

Next, we'll take a look at DLTtape media and discover the benefits of Quantum DLTtape cartridges.

DLTtape Media

7

A DLTtape cartridge is 4.16 inches wide, by 4.15 inches deep, by 1 inch high. It weighs between 7.7 and 7.85 ounces, depending on specific model. A DLTtape cartridge holds between 1,200 and 1,828 feet of half-inch wide metal particle recording tape. A specially designed 18-inch leader is at the front end of the tape. The tape cartridge enclosure includes a drive gear that engages with the DLTtape drive, and a panel that opens to provide access to the tape.

Six types of half-inch DLTtape cartridges are currently in production: CleaningTape III, DLTtape III, DLTtape IIIXT, DLTtape IV, DLT1 CleaningTape, and Super DLTtape I. Different cartridges are designed to work with different models of DLTtape drives. However, one of the things that has made DLTtape technology so successful is the fact that, when we introduce a new DLTtape drive, we don't make old DLTtape media obsolete. Old tapes still run on the new drives. They won't run as fast as the newest model cartridges designed specifically for the new drives, but they will run just as fast as they did on older DLTtape drives. A tape originally recorded on a DLT 2000XT drive will run on a DLT 8000 drive just as fast as it did on the DLT 2000XT drive. Even more important, millions of DLTtape IV cartridges sold in the past few years can be read by Super DLTtape drives.

Tape Type (recorded on drive type)	Native Capacity	Native Transfer Rate (read on DLT 4000)	Native Transfer Rate (read on DLT 7000)	Native Transfer Rate (read on DLT1)	Native Transfer Rate (read on DLT 8000)	Native Transfer Rate (read on SDLT 220)
DLTtape IIIXT (recorded on DLT 2000XT)	15GB	1.5MB/s	1.5MB/s	NA	1.5MB/s	NA
DLTtape IV (recorded on DLT 4000)	20GB	1.5MB/s	1.5MB/s	1.5MB/s	1.5MB/s	1.5MB/s
DLTtape IV (recorded on DLT 7000)	35GB	1.5MB/s	5MB/s	NA	5MB/s	3.5MB/s
DLTtape IV (recorded on DLT1)	40GB	1.5MB/s	NA	3MB/s	NA	3MB/s
DLTtape IV (recorded on DLT 8000)	40GB	1.5MB/s	5MB/s	NA	6MB/s	4MB/s
Super DLTtape I (recorded on SDLT 220P)	110GB	NA	NA	NA	NA	11MB/s

NA=Tape format is not compatible with the tape drive.

Figure 7-1 Backward Compatibility Is Assured among the DLTtape system family. Drives and matching DLTtape cartridges are shown here, along with transfer rate for each.

What Makes DLTtape Cartridges Better?

For many DLTtape system users, the biggest difference between the DLTtape system and other tape systems has nothing to do with transfer speed and cartridge capacity. It has everything to do with confidence that the information they put on a DLTtape cartridge two years ago is going to be accessible with DLTtape drives they might buy two years from now. With other tape technologies, this level of media compatibility across generations has not been the case. Figure 7-1 shows which models of DLTtape cartridges are compatible with which models of DLTtape drives.

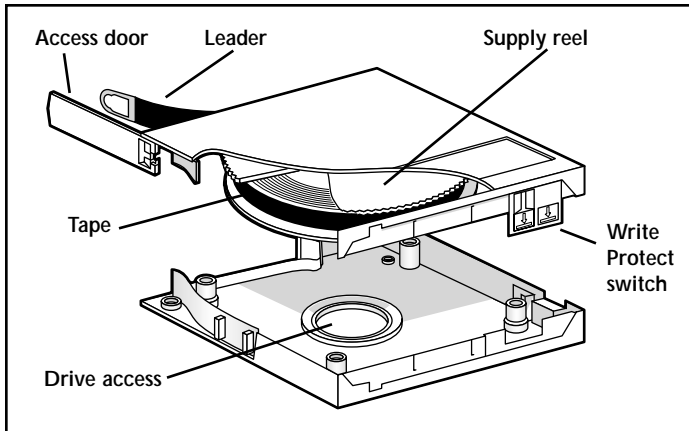


Figure 7-2 One-Reel Design of DLTtape Cartridge *eliminates the wasted space found in competing technologies and offers the highest data density on the market.*

The one-reel design of the DLTtape cartridge offers two major benefits. First, the DLTtape cartridge has no wasted space. It is packed full of tape, which means more capacity per cartridge. Second, the tape path between the supply reel in the cartridge and the takeup reel in the drive is very stable. Instead of traveling between two loosely-anchored reels, as found in most dual-reel cassette systems, the DLTtape media travels between the supply reel in the DLTtape cartridge and the firmly anchored internal take-up reel. (See Figure 7-2.)

Another feature very specific to the DLTtape cartridge is the tape leader. Every DLTtape cartridge includes a specially designed tape leader at the front end of the tape. The leader on DLTtape III, DLTtape IIIXT, and DLTtape IV cartridges includes a specially designed loop. When the cartridge is inserted in the tape drive, a hook at the end of the take-up leader securely mates with the tape leader loop and gently pulls it through the HGA to the take-up reel. This procedure is reversed when the cartridge is removed from the drive.

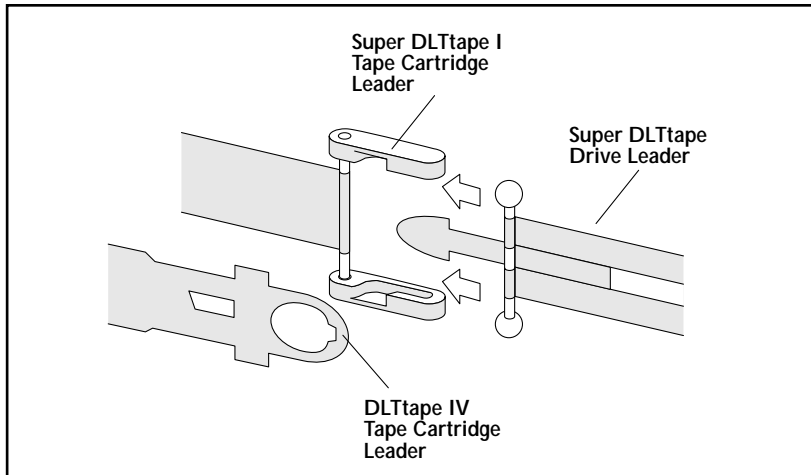


Figure 7-3 The Super DLTtape Positive Leader Link supports linking of both DLTtape IV and Super DLTtape I cartridges.

On Super DLTtape I cartridges, a unique new buckling system increases cartridge life and supports heavy-duty-cycle environments. (See Figure 7-3.) A solid metal pin attached to the drive leader links with molded clips that are permanently attached to the tape leader inside the cartridge. The Positive Leader Link design makes the buckling of Super DLTtape I media a highly reliable mechanical process. In addition to supporting Super DLTtape I cartridges, the buckling mechanism supports existing DLTtape IV data cartridges to ensure complete backward-read compatibility.

This whole process by which the DLTtape system cartridge interacts with the DLTtape drive is essential to the very high reliability and long life of both the drive and the media. The combination of DLTtape cartridge and DLTtape drive results in a very stable, low-tension tape handling that results in longer life for both media and read-write heads.

Understanding The Differences

There are differences between DLTtape media, both minor and major. For example, one of the subtle differences between DLTtape media is a

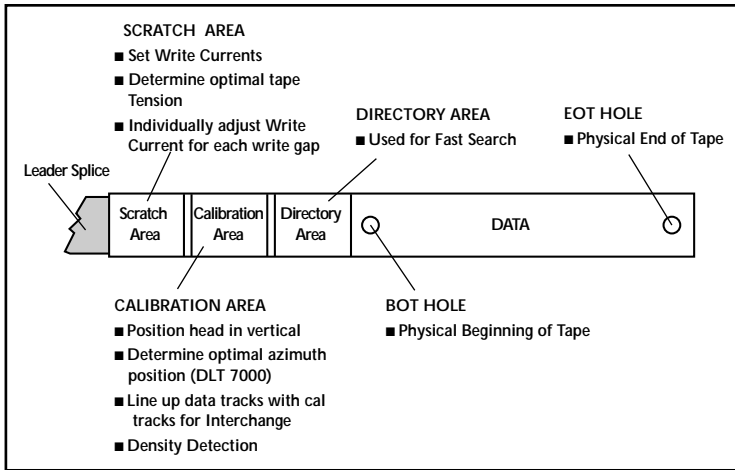


Figure 7-4 DLTtape Media Format features areas for calibration, directory, and holes to indicated beginning and end of tape. Position of BOT hole helps drive identify cartridge type.

difference in the position of the BOT (beginning of tape) hole (see Figure 7-4). The BOT hole is a small hole in the tape that tells the drive that the leader has passed the read/write heads and it's now safe to start recording. The distance from the beginning of the leader to the BOT hole tells the tape drive what type of cartridge is loaded, the maximum native capacity, and the length of the tape in feet.

Another small difference is that DLTtape cartridges come in four different colors. The casing for DLTtape III cartridges is dark gray, DLTtape IIIXT cartridges are white, DLTtape IV cartridges are black, and the CleaningTape III cartridge is cream colored. Super DLTtape I cartridges are black, and have a distinctive textured finish, (See Figure 7-5.) These differences make it easy for users to differentiate between tapes, especially in a situation where there are several different models of DLTtape drives working.

A major difference among the types of DLTtape media is capacity. The DLTtape III cartridge has a native capacity of 10GB, the

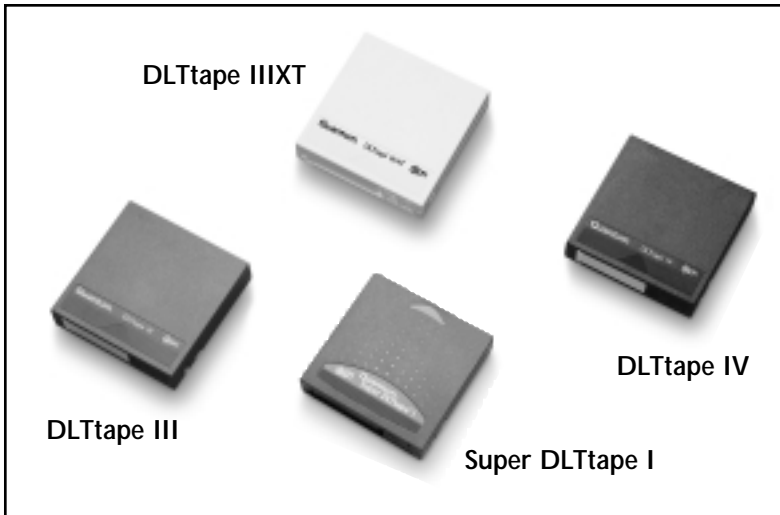


Figure 7-5 DLTtape Cartridges Are Color Coded for easy identification.

DLTtape IIIIXT cartridge has a native capacity of 15GB, and the DLTtape IV cartridge has a native capacity of 35 or 40GB. Super DLTtape I cartridges have a capacity of 110GB.

What accounts for the difference in capacity between cartridges? There are several factors. First and most obvious is tape length. Both DLTtape IIIIXT cartridges and DLTtape IV cartridges have a longer tape than the DLTtape III cartridge – 1,828 feet versus 1,200 feet. As a result of the length of tape, combined with its half-inch width, the total tape area contained in a DLTtape IV cartridge is over 10,000 square inches. (See Figure 7-6.) That is significantly more tape area than competitive technologies offer, creating far greater potential for capacity growth.

DLTtape IV media has significantly different magnetic properties that result in higher capacity. DLTtape IV media is double-coated tape with a significantly smaller coating particle size than earlier

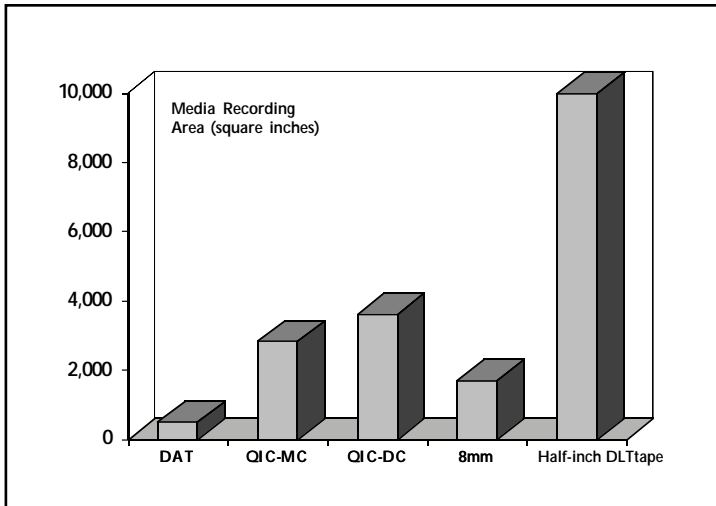


Figure 7-6 Half-inch DLTape Media leaves plenty of room for capacity growth for future DLTape drives. A single DLTape cartridge has a tape area of over 10,000 square inches.

tapes (see Figure 7-7). Smaller particle size translates into the ability to pack more data tracks into the same half-inch wide tape. The higher-capacity DLTape IV media also has different magnetic properties. For example, its “coercivity” rating is 20 percent higher. Coercivity is a measure of the strength of the magnetic field needed to change the magnetic orientation of a bit on the tape. The higher the coercivity, the more magnetic energy it takes to change orientation, and the less likely it is for a particle to be “flipped” accidentally. Therefore, higher coercivity means you can pack more data tracks into the same space, and thus gain more capacity.

Super DLTape I cartridges use state-of-the-art Advanced Metal Powder (AMP) media. Designed to meet the needs of multiple generations of Super DLTape drives, AMP media ensures the highest track density available today. AMP uses durable metal powder technology for recording at very high densities, making possible a dramatic increase in capacity.

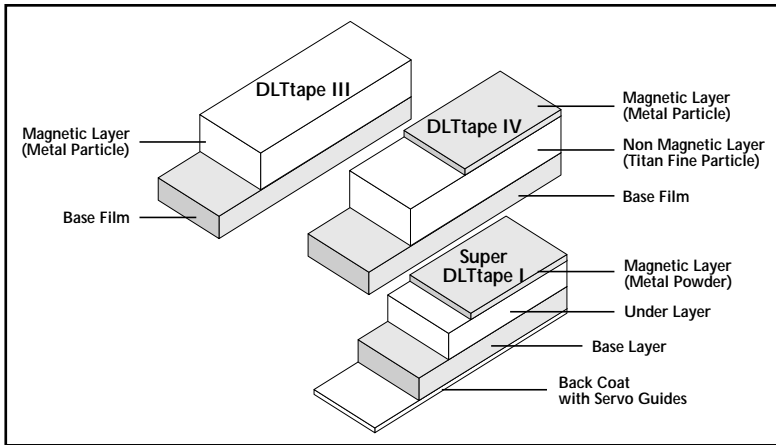


Figure 7-7 DLTtape III, DLTtape IV and Super DLTtape I Media Compared. *Finer magnetic particles used on DLTtape IV media allow for higher data density, while the Advanced Metal Powder Media in Super DLTtape I media supports even higher density.*

Media Availability

Quantum Corporation sells all types of DLTtape and Super DLTtape I cartridges. By setting up multiple channels of distribution for DLTtape media, Quantum has sought to assure customers all over the world that there will be an adequate supply of media available from multiple sources, ensuring both availability and competitive pricing. At the same time, customers can be assured of the quality of all DLTtape media and DLTtape equivalent media, because it all meets Quantum's high quality controls.

Limited Warranty

All Quantum brand media carries a limited lifetime warranty that the product is free from defects in material and manufacture. Only **Quantum-branded** cartridges come with this warranty. Our warranty reflects our confidence in the extraordinary quality of DLTtape

media. That quality has been proven by over 55 million DLTtape cartridges sold. These cartridges provide unsurpassed durability and reliability. They are rated at one million tape passes, and have an archival life expectancy of 30 years.

CompacTape

CompacTape was the name used for DLTtape media until 1996, when the name was changed to “DLTtape.” The change was made in order to make it easier for users to associate the correct media with their DLTtape drives. DLTtape cartridges are clearly marked with the DLTtape logo.

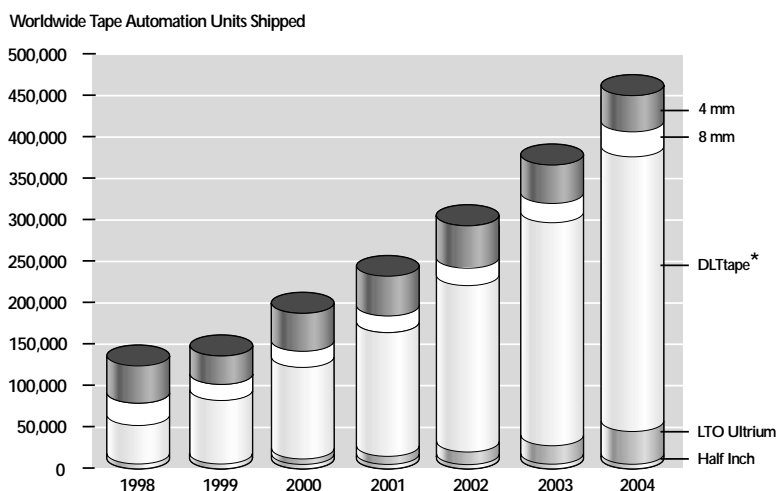
Next, we'll take a look at one of the strongest areas of DLTtape system growth – the automation market.

According to a report from the market research firm IDC, the overall market for tape libraries is growing at an annual rate of 25 percent, while the market for DLTtape system-based libraries is growing at a rate of 35 percent. Analysts estimate that 1999 shipments of DLTtape-based tape autoloaders and libraries were 79,000 units, and will grow to over 250,000 units by 2003.

The DLTtape System & Libraries: A Perfect Combination

At present, there are at least a dozen or more DLTtape system-based library manufacturers serving the mid-range market. As the DLTtape system has become the leading standard for standalone tape drive performance, capacity, and reliability, it makes sense that tape library developers have very aggressively incorporated DLTtape technology into their systems. (See Figure 8-1.)

The leading tape library manufacturers are also making commitments to incorporate Super DLTtape technology into their products. The introduction of Super DLTtape technology into advanced tape automation solutions has had a dramatic impact on the tape automation industry. The increased speed and capacity offered by Super DLTtape technology is enabling library manufacturers to offer significantly more capability at every point in the product



Source: IDC June 2000

*Including Benchmark's DLT1 tape drive and future generations of compatible DLTtape drives.

Figure 8-1 The DLTtape System Is the Overwhelming Choice among high-performance tape systems for automated libraries.

spectrum, from compact desktop libraries to enterprise level systems. Super DLTtape technology also incorporates features designed specifically to support library applications. Optional library-ready models offer the high reliability demanded in continuous and random operations. Optional Memory Addressable Cartridge (MAC) tracking systems let libraries and autoloaders quickly review cartridge contents without loading them. Super DLTtape's high data packing density means important savings in valuable data center floor space.

And, because both the physical and control interfaces are compatible with previous DLTtape drives, Super DLTtape drives can be integrated cost-effectively and seamlessly into existing automated storage solutions.

Backup To The Future

There are many reasons for the rise in popularity of tape automation systems. One of the main challenges facing network managers

is the need to gain control of their rapidly expanding information storage resources. The world of the mainframe is probably gone forever. We now live in a world of distributed computing resources, heterogeneous system environments, pervasive Internet/Intranet influence, and sky's-the-limit application size.

The growing demand for more storage capacity among UNIX and PC LANs, coupled with shrinking backup windows, has led to a strong move toward recentralization of network computing power. One of the key ways data managers are meeting this challenge is through the use of backup automation in the form of tape stackers, autoloaders, and libraries. By creating a centralized network backup system, using automated storage management, network managers can eliminate many of the scenarios that keep them awake nights.

Applications For Tape Automation

As with standalone tape drives, the market for tape automation systems is predominantly focused on backup, archiving, and restore, the bread-and-butter of tape storage. Until computers can be built that eliminate human error, this will probably always be the number one application for tape storage systems.

Hierarchical storage management (HSM) is picking up momentum among high-end installations. HSM systems are used to manage large, critical databases and near on-line storage, and are not true backup systems. If it's truly critical that an application or data be kept a key stroke away, a larger disk drive is increasingly the solution used most often.

Other applications for tape automation systems include: near on-line storage, archiving, data collection, remote vaulting, tape arrays, and image and video storage and distribution.

Growth of SANs and NAS

One of the major factors in the continuing growth of the market for DLTape-technology-based automated libraries will be the emergence of new storage models, including Storage Area Networks (SANs) and Network Attached Storage (NAS). Both of these storage concepts place increased emphasis on the need for high-performance, high-capacity backup and recovery capabilities. Those capabilities are being delivered by DLTape libraries. (See Figure 8-2.)

A Storage Area Network is a specialized network that provides servers with fast, reliable access to a large pool of storage resources. A SAN typically includes storage management software, a network infrastructure of hubs, routers, and switches, and may include Fibre Channel (FC) connectivity. A SAN also includes a large pool of disk storage, often in RAID configurations, and most often a large-capacity tape library (or libraries) for backup. Applications for SANs are typically ones that require large or very large storage capacity. They can be conventional horizontal applications (backup and archiving), as well as data intensive vertical applications (e-commerce, data mining, medical imaging, video, and multi-media). DLTape-based libraries provide the critical advantages of high capacity and performance, as well as reliability and a high-level of automated operation, reducing the need for management and operator intervention to virtually zero.

Network Attached Storage (NAS) involves attaching storage resources directly to the network, making them active nodes on the network, easily available to servers on the network. The major benefits of the NAS concept is that it is relatively simple to implement, because it takes advantage of existing and proven network infrastructure. Typically NAS is used in file-oriented applications, such as CAD, graphic arts, and medical imaging. In these applications, NAS makes high-volume storage available on the network to many users at low

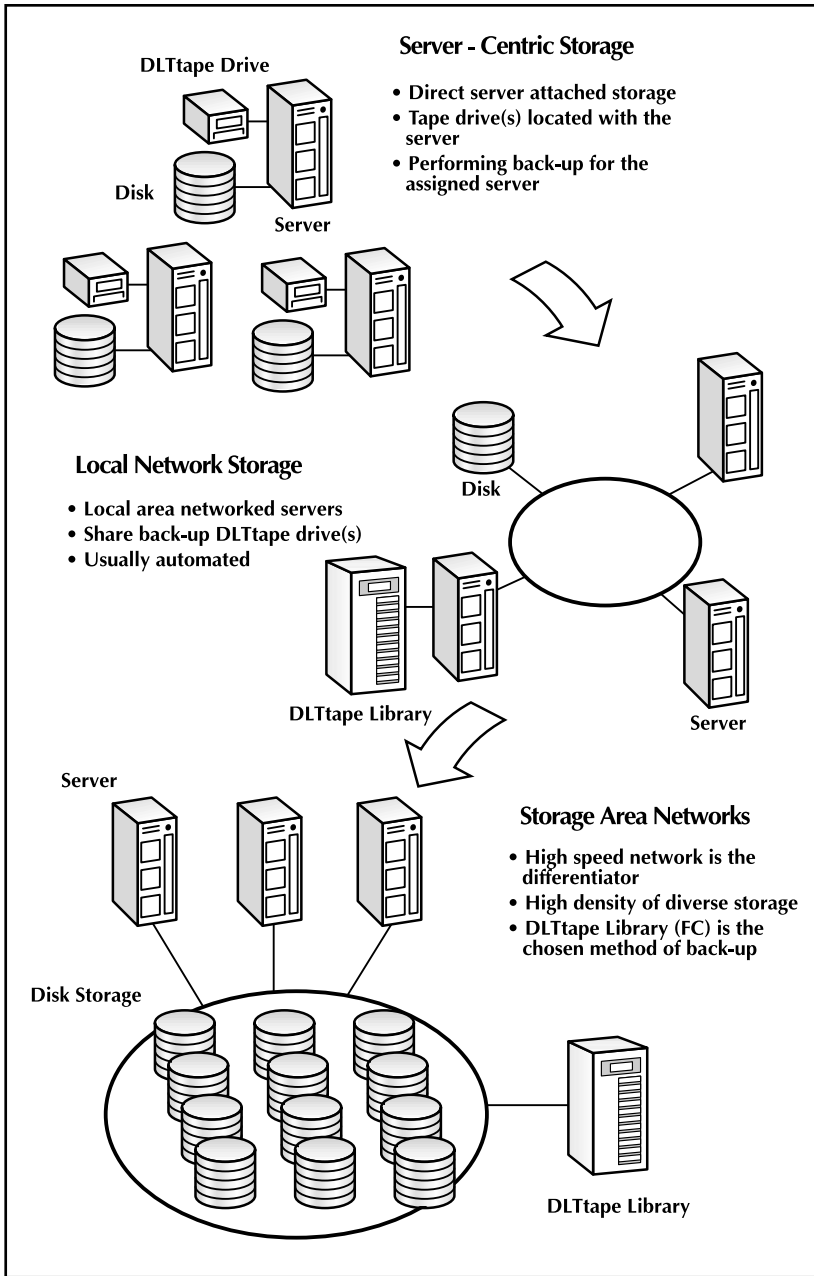


Figure 8-2 Evolution of Storage Management

cost and with little management overhead. NAS, however, is not the same as backup. In fact, by making it possible to easily expand storage, NAS creates the need for expanded backup capacity. This is where DLTtape-based libraries fit in the NAS concept. In a typical configuration, a DLTtape library is attached to a server designated as the backup server. DLTtape libraries offer the speed, capacity, and scalability to support the growing NAS capability, while delivering reliable, automated backup.

Benefits of Tape Automation

The main reason for seeking a tape automation solution is probably because the previous backup system can no longer get the job done in the available backup window. In addition, there are a number of other benefits of tape automation.

Reduced human intervention. People make mistakes. Reducing human intervention in the backup process invariably reduce errors and downtime. In addition, it also reduces administrative overhead, provides hands-free file restoration, eliminates missed backups, and ensures data integrity.

User-friendly file management. Tape automation systems can provide users with self-service file restoration. Time is saved and users are empowered.

Cost-effective/fast ROI. Tape automation systems can often pay for themselves in a matter of months through labor savings, reduced downtime, and reduced media expenses.

Manages media rotation and storage. Your backup software and tape automation system will let you set the media rotation strategy that works best for you.

Improved data security and availability. Backups become automatic, and backups are never missed. Data is secure and available at a moment's notice.

Seamless disaster recovery. With a two-drive system, a complete copy of a full backup can be made at the same time the primary copy is running. Disaster recovery becomes almost effortless. It is still necessary to test disaster recovery procedures on a regular basis, but you'll know the data is secure.

Stacker, Autoloader, or Library?

The primary difference among tape automation systems is in the way they handle data backup and access management. Stackers, sometimes referred to as autoloaders, were the first tape automation products for small and mid-size IS operations. These systems typically have one drive, and tapes are inserted and removed by the system's mechanical picker, sometimes called an elevator, in sequential order. So, for instance, if a stacker is set up to perform a full backup of a database, the system would begin with tape "0" and continue inserting and removing tapes until the backup was completed, or the supply of cartridges exhausted.

An autoloader, again, has one drive, but has the added capability of providing any tape in its magazine upon request. This ability to randomly select tapes makes autoloaders appropriate for small-scale network backup and near on-line storage applications.

Libraries offer the same type of functionality as autoloaders, but are often equipped with multiple drives for handling large-scale network backup, near on-line access, user-initiated file recovery, and the ability to serve multiple users and multiple hosts simultaneously. On large libraries, multiple robotic mechanisms may also be employed to improve system response time.

How To Buy a Tape Automation System

What should you look for in a tape automation system? As in buying a standalone tape drive, it's best to begin with an evaluation of your current situation and your future needs. For instance, how much data do you need to back up? How fast is your data growing? How long is your backup window? How much time do you and your staff spend performing incremental and full back ups? How often will your automation system be accessed? How critical is it that any new tape system be compatible with your old system? Are you currently using an enterprise backup software system, and does it support leading tape automation systems? How much budget is available for a tape automation solution? Be sure to factor in savings you may be able to achieve in labor, media, and lost production time.

Inside Tape Libraries

Let's take a moment here to look more closely at tape libraries. What are you buying when you buy a tape automation system? Every tape library comes equipped with certain basic elements. (See Figure 8-3.) The next few pages describe these basic elements briefly.

One or more tape drives. This is the heart of the system. The drive capabilities and characteristics will determine, to a large extent, the overall performance of the library, including capacity, throughput, reliability, data compression, compatibility, and media consumption. Can you add additional drives (or higher performance drives) at a later date to reduce user wait time, increase transfer rate, and increase availability?

Multi-cartridge magazine or rack. Many library systems use cartridge magazines that can be loaded outside the library, then plugged into the library when needed. This type of system makes life easier for the system operator. Some systems require cartridges

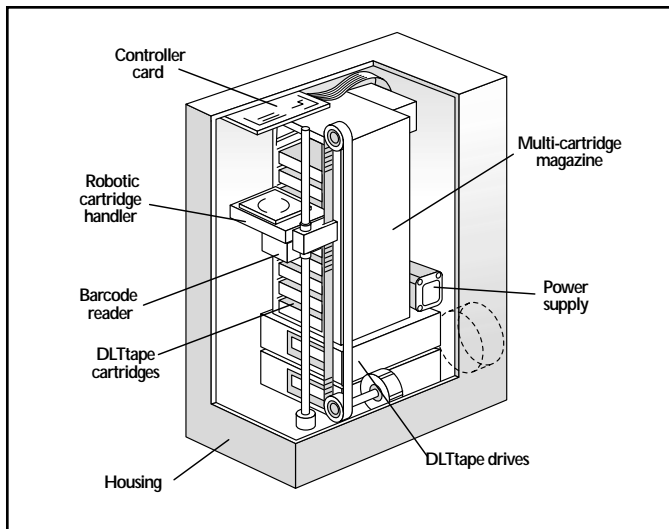


Figure 8-3 "Typical" DLTape System-Based Library Design shows DLTape drives, robotic cartridge handling system, DLTape cartridges, and controller mechanism.

to be loaded individually into storage slots inside the library.

Important Note: be wary of manufacturers' total capacity claims.

Some library makers assume a 2:1 compression ratio in advertising their total capacity. Compression is highly variable and data dependent and should not be used as a guide in evaluating library capability. It's best to use total native (uncompressed) storage capacity in comparing libraries. By multiplying the maximum number of tape cartridges your library can hold by the total native capacity of each, you can easily calculate the total native capacity of the library.

Robotic loader mechanism. Every library provides some type of mechanical device to load and unload tape cartridges. This is the part of the library that saves you time and allows you to perform unattended backups. The tape handling mechanism can also provide users with self-service file recovery and near on-line storage access.

Each library maker has their own tape handling mechanism. Some of the different mechanisms you'll find include robotic arms, elevators, and carousels. Some libraries are equipped with multiple mechanisms.

Another feature to look for in larger libraries is a "mailbox." This is a slot or compartment at the front of the system that allows the operator to load one or more tapes without opening the main door and interrupting library activity. The key characteristics to look for in the tape handling mechanism are proven performance over time (reliability), tape load/unload speed, and extra features like pass-through tape handling. A pass-through capability allows multiple libraries to be connected and share tape cartridges. This is especially important in high availability applications in which a requested tape can be passed between libraries to the next available drive. A proper drive-to-cartridge ratio can also provide high availability in most situations.

Library and loader controllers. Most libraries contain two physically-separate control devices to oversee overall library activity, as well as loader movement. Both of these control devices are equipped with microprocessors, local memory, and other electronics. Both devices communicate with library components and the host computer via a SCSI interface. The loader controller follows the directions of the library controller or the tape drive itself.

Power supply. Features you should look for in a power supply are autoranging and growth capacity. If there's a chance you may need to ship your library to Europe, you may want to look for an auto-sensing power supply that automatically adjusts for U.S. or European voltage (110 volts vs. 240 volts). If the library or loader you're considering is expandable, you should ask if the standard power supply can handle additional drives, or does it have to be replaced to accommodate them.

Protective housing. The higher the capacity of the library, the larger the housing. From table top to room size, tape libraries come in every shape and size. If you buy an expandable library system, you should consider future space requirement when locating the library. Some libraries expand by stacking one on top of the other. Others are only expandable from side to side.

Bar code reader. Most high-end libraries today come equipped with bar code readers that help keep a running inventory of available cartridges and help speed tape selection. Among very large libraries, you may want to compare tape inventory speed and selection time.

Start with DLTtape Technology

A good place to start research on DLTtape libraries on the Internet, at Quantum's site at www.quantum.com or at www.DLTtape.com. Every DLTtape library maker today has a Web site. They offer at least basic information on library features and options. In addition, ask library makers for user references and make some calls. Ask associates and friends if they use tape libraries. Many computer magazines carry reviews and evaluations of tape automation systems.

Focusing on DLTtape system-based automation makes sense for a number of reasons. The market-leading benefits of the DLTtape system have made it the favorite of library makers and users alike. This popularity also extends to enterprise backup software. All of the major software vendors support DLTtape standalone drives and most of the DLTtape system-based libraries on the market today. DLTtape technology is proven, it has wide market acceptance, and it has tremendous potential for even greater performance (see Chapter 17 on the future of DLTtape technology). The introduction of Super DLTtape technology into library automation systems has had a dramatic impact on the capabilities of library solutions from the desktop to the enterprise.

By starting with DLTtape system-based automation systems, you know you're getting rock-solid drives at the heart of the system, drives that are renowned for reliable, error-free operation. Once you've made the decision to select a DLTtape-based system, you can focus on the automation vendor, robotics reliability, the number of drives available, and the total capacity. With a DLTtape system-based library, you'll know that you're getting industry-leading data transfer speed, tape media capable of up to a million passes, and head life of up to 50,000 hours.

It's important in comparing the advertised reliability of tape automation systems to compare apples to apples. For instance, in comparing MTBF rates, be sure to ask the maker what duty cycle was used to calculate the rate. If you plan to use your library for hierarchical storage management, near on-line storage or other high usage applications, duty cycle should be an important factor in your search for the ideal system.

Don't forget to consider what your future may hold. Is the library system you're considering expandable? Most high-end tape automation systems can be expanded either by adding additional drives and cartridges within the existing housing, or by adding additional library modules. These modules are usually a duplicate of what you have and are linked by a common controller. Libraries that link in this way often have a pass-through feature that allows cartridges to be moved to the next available drive, no matter where it may be located.

Software And Centralized Backup Management

As computing resources continue to become more decentralized, IS managers are attempting to cope with this situation by centralizing as many network resources as possible. Centralized data storage

management and backup are becoming increasingly popular. Storage Area Networks give users anywhere on the network access to a large, centralized pool of storage resources sitting on their own high-speed network – and backed up by DLTtape libraries. Tape automation systems and new versions of backup software make this a viable strategy. The use of high speed network backbones enable IS managers to centralize file services without crippling network performance. With the main file server in close proximity to the tape automation system, a high speed link can be made that speeds backup even further. Some organizations install dedicated backup servers to offload backup overhead from the main file server. In a Network Attached Storage (NAS) configuration, storage resources are attached as nodes on the network, making available expanded storage resources with minimal management overhead.

Most backup management software today supports library systems and a centralized approach to data backup and information management. It's important to find out which solutions will support the tape library you're considering. In addition, if your library will be equipped with multiple drives, it's important to discover up front if your backup software supports simultaneous data transfers to multiple drives. Not all do.

Next, we'll take a look at the primary uses of the DLTtape system, including backup and archiving.

Horizontal Applications

9

No matter what business you're in, or what industry-specific applications you may use, you almost certainly need data backup and archiving. These are fundamental applications in the data storage world, and this is where the DLTtape system is used most. In fact, nearly 90 percent of all DLTtape systems sold are used for backup and archiving. The remaining 10 percent are used in applications such as Hierarchical Storage Management (HSM), near on-line storage, tape RAIT (Redundant Array of Independent Tape drives), library management systems, data interchange, and tape-as-disk applications.

The widespread use of DLTtape technology for backup and archiving applications is easy to understand: DLTtape systems offer the highest capacity, throughput, and cost effective reliability of any tape systems on the market. If you are managing a computer network, data warehouse, or large Internet/Intranet application today, no doubt you are experiencing tremendous growth in data storage requirements. At the same time, your backup window may be shrinking. In some 7x24 operations, there is no backup window – backups must be accomplished during regular business hours.

Increasing data storage demands, coupled with shrinking backup windows, have led users to embrace the advantages of DLTtape

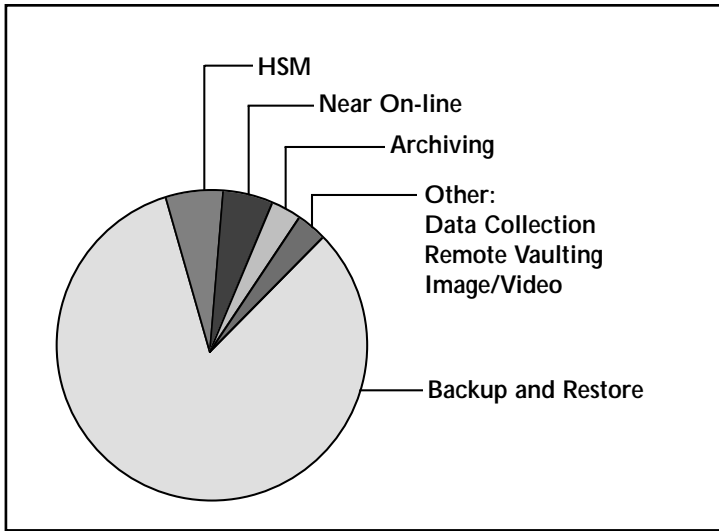


Figure 9-1 Current DLTtape System Applications include traditional applications such as backup and archiving, as well as newer applications like HSM.

technology. What follows is a look at the leading uses of the DLTtape system and the data management issues you may encounter when implementing them (see Figure 9-1).

Backup and Archiving

Basic backup and archiving are fundamental information management chores that every computer user should practice. From home PCs to the largest computer systems and global networks, data backup is your insurance policy against hardware failure, human error, natural disasters, viruses, and theft.

Overall, there is little difference between backup and archiving. Backup is your day-to-day security, and may include incremental updates and daily, weekly, or monthly full backups. Archiving is simply a full (or image) backup that is then placed in some type of

protective spot for a period of time. Some companies, especially those required by law to maintain historical records such as insurance companies and banks, archive data to special vaults or storage sites specially designed to protect valuable records.

File-by-file vs. Image Backups

There are two basic forms of backup: file-by-file and image backup. File-by-file backups take much longer than image backups, because the backup system must request each file from the operating system. File-by-file backups rarely achieve maximum tape drive performance because the tape stops and starts frequently, preventing optimal streaming. System performance can usually be improved by performing regular disk de-fragmentation. Fragmented files and disks can take much longer to back up.

Image backups are like a snapshot of your disk at a moment in time. Because data is sent to the tape in large, virtually seamless chunks, the tape drive is typically able to achieve optimal streaming and maximum performance. Image backups are important for data restoration following a disaster or other catastrophic data loss, when you want to restore everything on your system. Most image-based backup systems also allow individual file restoration as well.

Real-time backup, a variation on file-by-file backups, is available with some data management software packages. These new software packages log changes to your data in real-time as they occur on your network or file servers. This type of solution is a cost-effective way to provide up-to-the-minute accuracy in data backup. Real-time backup is increasing in popularity among 7x24 hour operations where the backup window has been slammed shut.

The penalty for this type of system is degradation in server and network performance. However, as with any backup solution, the value

of the data must be weighed against the cost of the system required to back it up. If the data is important, the cost in system performance and the cost of acquisition can be more than justified. DLTtape systems are ideal for real-time backup because they minimize the drag on system performance caused by continuous updates.

Near On-Line Storage

Near on-line storage is similar to hierarchical storage management. It provides a large tape-based repository for information that is important, but not important enough to take up valuable hard disk space. It is also good for a set of information that is too large for the disk space available. Near on-line storage can be provided by a single high capacity tape drive or by an autoloader or library. Rather than simply backing up data to tape, and then removing the tape and storing it in a closet, the information is left in the drive, where it is available to users.

Depending on the type of near on-line storage system used, it may take several minutes to locate a file. However, file location and restoration can be accomplished unassisted, saving time and labor. Applications for near on-line storage include marketing databases, backing up multiple servers, report management, image storage, video on demand, data warehousing and unattended backups.

The DLTtape system is ideal for near on-line storage applications in which, unlike traditional backup systems, users repeatedly send information to and from the drive. Inherent reliability, along with market leading storage capacity and throughput, make DLTtape systems the perfect choice for this application.

Tape-as-disk is a form of near on-line storage in which you use a tape drive like you would a disk drive. The tape drive actually acts as a second or third disk drive. You read and write to the tape drive

as if it were a disk. Only a handful of companies provide this type of software application, and it's typically used with desktop systems and not with servers or network access. DLTape systems are typically not used in this type of application. Most tape-as-disk systems use lower end, inexpensive tape drives.

Hierarchical Storage Management (HSM)

Hierarchical storage management is a multi-level approach to providing access to little-used, but critical information (see Figure 9-2). An important fact to note here is that HSM is not a backup system in the true sense. In fact, HSM presents a new set of challenges to IS managers.

HSM systems migrate little-used files to and from your server's hard disk to lower cost storage media, usually tape. The data that is migrated is still 100 percent accessible to the user, but recall speed is slower. In many cases, HSM systems have solid state, hard disk or

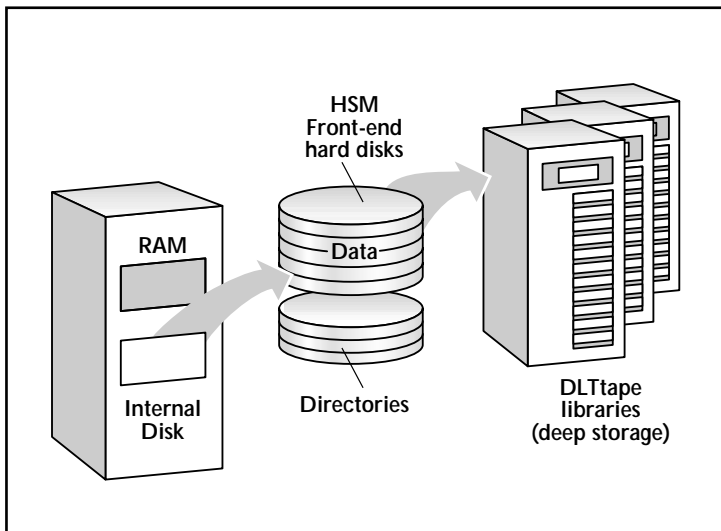


Figure 9-2 Hierarchical Storage Management (HSM) is a structured way to migrate aging files to increasingly less expensive storage media and still provide rapid access.

optical disk front ends that act as a high speed cache. The HSM management software attempts to “anticipate” the file usage needs of your users, based on criteria you set.

Files may be moved to progressively deeper storage based on the date they were last used or the importance of the files. Newer or more critical files may be kept on the HSM’s hard disk cache for fast recall. As these files age, they may be moved off to storage in the system’s tape library.

The challenge that HSM poses to IS managers is that HSM’s deep storage tapes are generally not sent off site or archived in a traditional manner. HSM is active near-online storage and not a data backup system. When data is moved further out in the hierarchy by the HSM, a marker or pointer is left on the network server. This pointer tells the HSM software where the file is located for retrieval.

Your backup software must know what these pointers mean and, if necessary, request the file from the HSM for inclusion in your full backups. Not all backup management systems have this capability. You should check with your HSM vendor to make sure the HSM can be integrated with your backup management system.

With HSM systems, it’s important to consider the quality of the deep storage component. Unlike normal backup systems, HSM tape drive utilization will be on the order of 80 percent or more. The drives and media used must be reliable and proven to withstand the heavy use it will be subjected to. DLTtape drives have become the standard for many HSM system vendors due to their inherent reliability, high density data storage, and high speed transfer rates.

Surprisingly, HSM systems are not proliferating as rapidly as originally expected. This is due in large part to the drop in price and increased capacity of today's disk drives. In addition, many library and autoloader tape systems can perform many of the functions that are typically associated with HSM systems. Libraries and autoloaders can provide vast amounts of near on-line storage, unattended access for users, and fast backups. HSM systems vary in features and capabilities; however, many allow for the hot swapping of components such as power supplies, drives, and cooling fans without shutting the system down.

Virtual Tape

In many organizations, while applications are growing more data intensive and more time critical, the time and resources available for system management are diminishing. In situations in which very large volumes of data must be backed up in very short windows of time, this situation has reached a crisis – even though these organizations are already taking advantage of high speed tape drives, probably running in multi-streaming mode. It is in these circumstances that virtual tape is most likely to be an option.

Virtual tape is an emerging storage strategy that, like HSM, uses multiple storage technologies to achieve performance goals. The basic concept of virtual tape is that backups can be made dramatically faster by using high speed hard disk storage for a part of the backup system. Most of the system's backup capacity is still in a tape library or libraries, but part of it is in the form of hard disk drives, most likely a RAID unit. This disk capacity, however, presents itself to the system, not as a hard disk, but as a “virtual” tape unit. This means the system can take advantage of the speed of the hard disk, while still using all the existing backup software and procedures; it is as if there is a super fast tape drive or library in the system. While hard disk is a relatively small part of the total

backup capacity, it can have a significant impact on overall performance. The system incorporates software algorithms that select which files are backed up to the disk portion of the backup space. In general, the most active files are backed up to disk. Then as these files become less active, they are migrated to tape backup. Thus, with a relatively small investment in hard disk storage, system managers can use virtual tape to deal with ever smaller backup windows, without disrupting established, reliable backup processes.

RAIT

When data transfer rate is your number one concern, and downtime or lost data must be avoided at all costs, you might want to consider a tape RAIT system (see Figure 9-3).

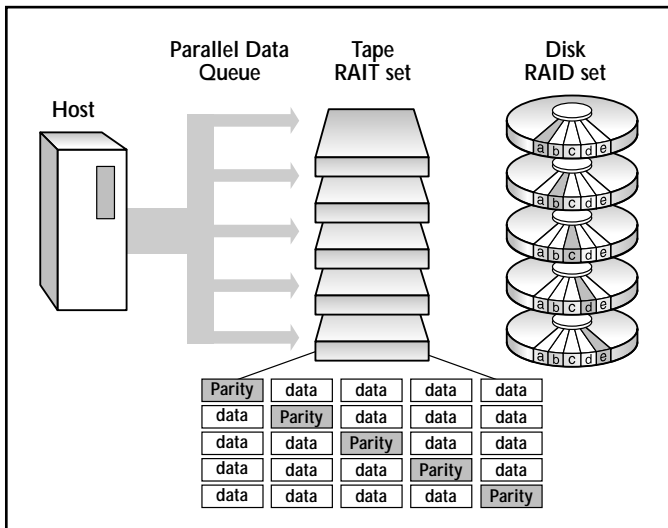


Figure 9-3 RAIT (*Redundant Array of Independent Tape drives*) provides many of the same benefits as RAID, but on less costly and more portable media.

RAIT systems work in essentially the same way as RAID. RAIT is ranked by six increasing levels of security and capability from Level 0 to Level 5. For example, Level 1 RAIT provides disk mirroring in which your data is written to two drives simultaneously. Each drive contains the same data. This is known as disk mirroring or disk duplexing. Should a drive fail for any reason, the other drive continues operation unaffected.

Level 3 and Level 5 RAIT use data striping, in which the data stream is divided into equal parts, depending on how many drives are in the array. In Level 3 RAIT, a drive is dedicated to maintaining parity. This parity drive can sometimes cause a bottleneck because all read/write requests must first go through the parity drive. Should there be a drive failure, the parity information is used to reconstruct the lost data.

Level 5 RAIT divides the parity information equally among all drives. This type of system provides maximum data integrity, typically at the expense of data throughput.

Disaster Recovery

Backup and archiving are not only important for the periodic restoration of files that have been deleted or lost, but critical in disaster recovery situations. Just because your business isn't located in Tornado Alley or on a fault line in Missouri doesn't mean you won't experience a "disaster."

In fact, most disasters are related to human error or system failure, not natural disasters. Among the leading causes of business disruption are computer viruses, power outages, fire, vandalism, terrorism, and weather-related disasters.

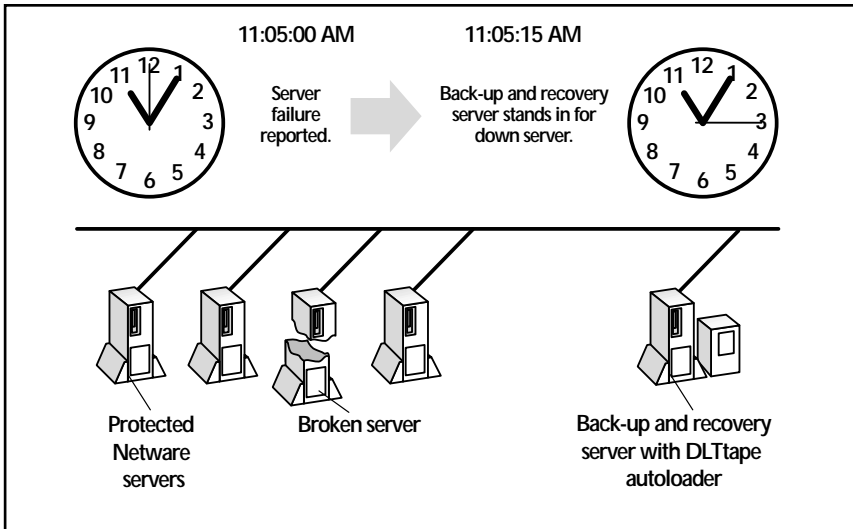


Figure 9-4 New Backup And Recovery Systems *provide real-time backup and recovery features.*

Every business and organization should have some provision for business continuity should a calamity strike. The level of protection that's right for your business will depend on the resources you need to provide to ensure continuity (see Figure 9-4). In extreme cases, this may mean a fully-functional backup site of your own located an appropriate distance from your primary IS facility. Many businesses enlist the services of hot-site vendors that provide recovery systems and facilities on a contractual basis.

Most backup management software includes features to help you recover your data following a disaster. Image backups are often used for disaster recovery purposes. It's important that you store data off site on a regular basis.

Library Management

This class of software application allows your network to access information stored on tape libraries and autoloaders. Library management applications can either be used as stand alone systems that allow the operator to move cartridges around, take inventory and find out what's on various tapes, or they can be used as a layer of software between another application and the library. For instance, the library management software may reside between your backup software and the library itself.

Library management software is the choice of the user and varies depending on the needs of their application. It makes sense that many library vendors also provide library management software; however, some do not provide it directly, but recommend a package that is compatible with their hardware. More and more vendors of backup and archive applications are including support for tape library systems. In many cases, dedicated library management software includes a richer feature set than that included as part of a backup and archive application.

The need for a dedicated library management application increases with the number of storage applications running on your system. For instance, a single tape library may be acting as a repository for engineering data, as well as providing backup for your e-mail system.

Next, we'll look at some of the vertical applications in which DLTtape systems are helping end users protect valuable information and solve complex information distribution problems.

Vertical Market Applications

10

DLTtape System Records Moments of Creation

CLEO is a 1,200 ton detection apparatus at the business end of the half-mile-diameter linear accelerator buried beneath the athletic fields at Cornell University in Ithaca, New York. CLEO's 100,000 detectors surround the points where electrons and their anti-particles, positrons, collide and annihilate each other. The resulting flash of energy unleashes new, sometimes exotic, matter.

CLEO captures a digital "snapshot" of each collision, which occur at a rate of approximately one per second. This data is fed into an Alpha workstation for preliminary reconstruction. The raw collision results are stored on DLTtape systems. Later, the results are analyzed and each collision reconstructed more fully. These results are stored on new DLTtape cartridges and used by scientists for complex analyses.

DLTtape technology has played an important role in ensuring safe storage of this information at Cornell's Floyd R. Newman Laboratory of Nuclear Studies (LNS). Every detail describing the direction, identity, and momentum of the particles produced by the collisions is stored on DLTtape cartridges.

8mm Couldn't Take It

LNS selected DLTtape systems because of the technology's reputation for reliability in heavy-duty-cycle environments. Twenty-five out of the 30 DLTtape drives used by LNS are running at 75 percent duty cycle or greater, every day. At that rate of usage, the research center's 8mm drives lasted only two months. At last count, the center's DLTtape systems had been running for over 18 months with no problems!

Another advantage offered by DLTtape systems was time saved in tape interchange. Before converting to DLTtape technology, the Cornell laboratory had such problems with 8mm reliability that it would make up to four copies of tapes containing especially critical information, with the hope that at least one would be readable by other 8mm drives. The DLTtape system solved the problem. Now, the center can rely on a single copy on DLTtape media for use in data interchange.

Not Just For IS Anymore

The use of the DLTtape system to record critical research data at Cornell is just one example of how the DLTtape system is finding homes outside the traditional information system realm. The use of DLTtape systems for scientific data acquisition is one example of a "vertical" application.

Vertical applications are typically focused on a specific industry, and are closely associated with the work done in that industry. By contrast, "horizontal" applications are found across all industries and often have little or nothing to do with the specifics of the industry. For instance, an incremental daily backup and a full weekly backup are pretty much the same no matter where you work.

Increasingly, system developers and end-users are discovering that the unique benefits of the DLTtape system make it ideal for demanding vertical applications, including:

- E-commerce.
- Internet/Intranet.
- Data mining.
- Graphic arts.
- CAE/CAD/CAM.
- Multimedia.
- Publishing.
- Data acquisition.
- DVD mastering.
- Video-on-demand.
- Digital nonlinear video editing.
- Medical imaging.
- Disaster recovery.
- Video distribution.

Vertical applications for DLTtape technology (see Figure 10-1) often differ from conventional IS applications in several important

Typical DLTtape System Applications	Performance	Reliability	Cartridge Capacity	Storage Media Cost	Storage Density
E-commerce	•	•	•	•	•
Medical Imaging	•	•		•	•
Engineering Network Backup	•	•	•		
Video Production Backup	•	•	•		
Internet Backup	•	•	•	•	•
Data Acquisitions	•	•		•	•
Disaster Recovery	•	•	•	•	•
Graphic Arts	•	•	•		

Figure 10-1 The Special Qualities of the DLTtape System
is making it increasingly popular in a variety of vertical applications.

ways. Probably the most common difference is the standalone nature of many vertical applications. While these special-purpose systems may be linked to a network system, they often don't rely directly on the network for their operation. The special-purpose application is usually substantial enough to require its own backup system, rather than share a networked system.

Another characteristic common to many vertical DLTtape applications is the use of graphics. Because graphics files are usually very large, any application that features graphical files produces vast amounts of data that must be stored and recalled. The DLTtape system is perfect for these types of applications because it offers an economical way to quickly store and retrieve large graphics files.

A third characteristic that makes certain vertical applications ideal for DLTtape system technology is high data volume. Applications such as data acquisition often require very high data transfer rates to keep pace with real-time events such as seismic recording, satellite telemetry, instrument output, and financial markets. These types of "firehose" applications demand high bandwidth, the kind of bandwidth that only DLTtape technology can provide cost-effectively.

Super DLTtape Technology in Vertical Applications

Super DLTtape technology has a powerful impact on virtually every application, horizontal and vertical, in which DLTtape technology is used. Clearly, however, there are applications in which Super DLTtape systems have a bigger impact than others. For example, many emerging e-commerce applications depend on having vast amounts of customer data available very quickly. This class of applications can take advantage of the speed and capacity of Super DLTtape drives, probably in library configurations.

In film and video editing and special effects creation, it is critical for editors to be able to move jobs quickly and safely on and off their workstations. In many organizations, each editing workstation has a dedicated DLTtape drive for near on-line storage. The introduction of Super DLTtape drives allows editors to move jobs on and off their workstations faster, thus eliminating down time, and lets them manage even larger files more efficiently, again saving time. As video and film files grow larger, dedicated Super DLTtape-based libraries could become the industry standard.

Other applications in which Super DLTtape technology has had an immediate impact are image-based applications, such as medical imaging, and real-time scientific data collection applications, in which there is an essentially unlimited need for more speed and more capacity.

In order to meet the varying needs of these and many other applications, Quantum will offer a range of Super DLTtape technology-based products. These products address the individual storage needs of low-, mid-, and high-end system users in the mid-range storage market. This range of offerings will make it possible to meet the needs of an expanding range of vertical market applications.

Let's take a closer look at some of these vertical applications and how the DLTtape system is making life easier for a growing number of users in speciality markets.

E-Commerce

E-commerce is information-based business – the information is the business, and the key to success is making information available, accurate, and reliable. That usually means very large volumes of data must be available very quickly, and must be recoverable with absolute reliability. Data storage strategy is critical in e-commerce environments. Storage systems must be able to provide the

capacity, room for growth, speed, and (most importantly) reliability to support the e-commerce mission.

DLTtape technology fits into the mission-critical e-commerce storage environment at multiple levels. For example, a business-to-business equipment auction house uses server-attached DLTtape drives for conventional backup of its Web-based and live auction data. The firm's IT manager explains that, "Loss of data would translate into a huge loss of business. I don't think there's a better option for avoiding a disaster from lost data than DLTtape technology."

DLTtape technology also fits in e-commerce in a number of roles beyond traditional backup. Terraserver.com sells satellite images from sources in the West and the former Soviet Union. DLTtape technology provides primary storage for much of the image data on which the business is built. Raw satellite image data, in-process data, and final processed image data are all stored on DLTtape cartridges in stand-alone drives and libraries. DLTtape technology is also used to store backup and archive copies of the image data.

In other e-commerce applications, the sheer volume of data involved makes DLTtape technology the first choice. Alexa Internet provides a powerful Web navigation service. Called Alexa, the service suggests to users sites they may want to visit, based on analysis of the collected knowledge of which sites other subscribers actively visit. The key to Alexa's value is that it provides access to some 1.2 billion Web pages, far more than other services offer. To protect that enormous asset, Alexa backs up its Web page data on DLTtape systems – to the tune of well over 100 DLTtape IV cartridges per month, just to back up new pages Alexa identifies as it relentlessly crawls the Web. Alexa also uses DLTtape systems to reliably store data that may not be available anywhere else – a huge archive of

pages that have disappeared from the Web, leaving behind “This Page Not Found” messages. These “lost” pages have enormous potential value for academic and industry research – value protected by DLTtape technology.

Working in the Data Mines

Data mining is another good example of the kind of vertical application we’re talking about. It usually involves taking huge blocks of information that the organization has had for years – typically customer account information – and finding new ways to look at it. For example, a retail chain might gather all the sales data off its scanner-driven checkout registers, including every SKU code down, and every credit card and checking account number. The store chain may then mine that data looking for trends based on every parameter, including time of sale, store location, discounts used, and so on. Data mining applications are characterized by very large databases ranging from hundreds of gigabytes, to hundreds of terabytes. They are usually used for marketing, new business prospecting, and revenue and profit maximization. The requirements of these tape backup applications include the need for very high capacity (DLTtape system-based libraries used in these applications often have many drives and hundreds of cartridges), high transfer rate, and superior data integrity and reliability.

These applications tend to put a premium on fast access, 7x24 service, and virtually 100 percent availability – if the system is down, you’re not open for business. All these characteristics point to the need for a backup strategy that allows large files to be backed up in a short time, fast system restoration in the event of a system-level crash, fast file recovery, and absolutely reliable disaster recovery.

Medical Imaging

An increasing number of hospitals, laboratories, doctors, and medical research centers are relying on digital imaging to help speed diagnosis, save money, improve treatment quality, and accelerate medical training. Images from diagnostic tools such as CAT scanners, MRI, echocardiograms, and X-rays are increasingly being stored digitally and used either locally or in remote locations.

A single 30-second echocardiogram, for instance, can take up to 10GB of disk or tape storage. Forty radiology rooms at a major Chicago medical center generate over two terabytes of images each year. As the use of 3-D images, animation, and digital video increases, the need for high capacity, high speed data backup will grow with it. Some of the key requirements in medical imaging backup include long media life, cost-effective performance, rapid data transfer and ease of media interchange. The DLTtape system is the ideal choice for medical imaging applications. DLTtape media offers a 30-year shelf life and is compatible across multiple generations of DLTtape systems. DLTtape systems also provide the industry's highest data transfer rates in the mid-range market. This enables doctors to access archived records faster and reduce patient wait time. DLTtape technology makes near on-line storage a reality for medical imaging applications.

Data Acquisition

The use of DLTtape technology at Cornell University, mentioned earlier in this chapter, is just one example of a data acquisition application. These types of applications vary greatly, but share several common traits, including the need for absolute reliability, fast throughput rates, high capacity (you don't want to have to change tapes in the middle of that volcanic eruption!), scalability, and media interchange.

When the developers at Metrum-Datatape Incorporated went looking for an off-the-shelf tape drive to incorporate in their Multi-Application Recorder/Reproducer (MARS-II), they quickly discovered that the DLTtape system offered exactly what they needed. MARS-II systems are used to record critical flight and instrument data during testing of prototype military aircraft, avionics, and weapons. The DLTtape system offered Metrum-Datatape a cost-effective, highly reliable system that could withstand the rigors of military use.

Metrum-Datatape standardized on DLTtape systems for the MARS-II system because of the technology's inherently stable tape tracking mechanism, because it offers an upward migration path within the same footprint, and media compatibility among different DLTtape drives. This last feature was important because the DLTtape cartridges used during flight tests were then sent to labs for data analysis. Many researchers already had DLTtape drives in their systems and could read the flight tapes without having to convert the data.

Geophysical Data Collection

Geophysical data collection is usually associated with the collection, archiving, and distribution of seismic data used in oil exploration. "Well-head logging" is the collection of seismic data generated by a series of explosions set off in an array of exploratory drill holes – an array that can cover hundreds of square miles. Seismic exploration is expensive, and is carefully regulated by governments, which limit where and how often seismic shots can be carried out. It's critical for the exploration company to collect the maximum amount of data from each seismic shot. That means setting up a data acquisition system that can accept masses of data in real-time.

That's where DLTape technology comes in. Ontario-based Avax International specializes in unattended tape backup and data interchange solutions. The firm supplies DLTape systems for a wide range of applications, including oil and gas exploration. In the words of Andrew Senior, an applications engineer at Avax, "DLTape systems can record a lot of data fast."

Another important geophysical application is transcribing data from old tapes to DLTape cartridges. Gary Dunand is president of Direct Digital Online, a Calgary firm that specializes in handling seismic data. He explains that, "Oil and gas companies can reduce their data storage and insurance costs by transcribing old tapes onto new DLTape cartridges. We can fit two hundred to three hundred 3480 cartridges onto a single DLTape cartridge."

"Data recorded in the 70's and early 80's was mostly stored on old nine and twenty-one-track round tape reels," Dunand explains. "It's worth preserving that old data, because new processing techniques help companies uncover new information about those geological structures. Some of the land that is covered by that data is now closed to exploration, so it makes that data even more valuable."

Disaster Recovery

At first blush, disaster recovery seems like a traditional "horizontal" application for backup and archiving. However, as more and more organizations transition to 7x24 operations, the need for new approaches to backup and disaster recovery preparedness are emerging. For many organizations, gone are the days when you could send your weekly or monthly full backups offsite and feel secure about your recovery prospects.

Today, new disaster recovery schemes are emerging that place greater importance on keeping a backup database up-to-date at all times. For instance, electronic vaulting in the form of data mirroring or shadowing reduces the recovery time for mission critical applications. Shadowing and mirroring maintains an exact copy of the primary database at a remote site.

We've classified high end disaster recovery systems like this among vertical applications for DLTtape systems because these drives are often dedicated to this function and are not supporting routine file recovery tasks. An example of this advanced type of disaster recovery set-up can be found at KPMG, world-renowned professional services firm.

At KPMG's London operation, the company had a unique situation in which it needed to establish a parallel data center across the Thames river in order to avoid shutdowns in the city due to bomb threats, fires, or other emergencies. KPMG selected DLTtape system-based libraries to eliminate the risk of data loss due to tape or drive failures, and for the technology's speed and capacity.

The company established a 100 megabits per second fiber optic link between its London offices and its backup site across the river. Now, should the city be sealed off during an emergency, the company can resume operation across the river almost immediately using its DLTtape library systems.

KPMG's conversion from 4mm DAT backup to DLTtape libraries has also saved the company's network administrators 31 hours per week on backup administration. In addition, file restores, which used to take half a day or more, can now be accomplished in minutes.

Digital Publishing

The publishing industry is going digital as fast as it can. Digital presses, digital printing plate production, digital proofing, digital files, digital images...digital everything! Digital publishing reduces preparation time, saves on labor, reduces inventories, and, in the case of the Web and CD-ROM, can even eliminate paper altogether.

DLTtape systems are ideal for digital publishing applications. Companies involved in digital pre-press (the preparation stage prior to printing) typically require huge amounts of storage capacity. Digital pre-press often involves both a graphics service bureau and a printer. Many large printers perform all digital pre-press functions, including final preparation of desktop publishing files, color artwork scans, color correction, film output, color proofing and printing plate production. Each step in the pre-press process requires files to be stored and retrieved on numerous occasions.

Once a job is printed, the printer or service bureau typically stores the job in its archives for a specified period. These archived files are kept in anticipation of future reprints and as a service for customers. A single file for a mid-size color printing project may occupy many gigabytes of storage space. A large printer may have thousands of projects in its archives.

DLTtape cartridges are also used by printers, service bureaus and publishers to ship projects that are ready for production. Desktop publishing files for an annual report, for instance, can be prepared by a graphics design firm and shipped to a printer for final preparation and color proofing. The files are typically offloaded to the printer's computer workstation for color corrections and any other final adjustments or changes. DLTtape systems allow the printer's pre-press experts to work on several jobs at once, shuttling the hottest jobs on and off the workstation's hard disk as needed. Fast data transfer speeds make the DLTtape system ideal for this type of near on-line application.

Backup for “Road Warriors”

Today’s business “road warriors” succeed or fail based on the information they carry in their portable computers. A stolen or damaged laptop, or a lost file, can mean failure if the data is not backed up. Connected Corporation offers a solution: intelligent, hands-off, online data protection and real-time recovery for Windows-based PCs.

Every day, thousands of Windows NT 4.0, Windows 95, and Windows 98 computers automatically link to Connected’s Secure Data Centers via any IP connection. Before data leaves a user’s PC, it is encrypted and compressed. It is then transmitted to a Connected Secure Data Center where the data is written to RAID systems and copied to a second, physically separate, mirrored, and secure data center. Both data centers are state-of-the-art facilities, employing multiple levels of data redundancy and fault-tolerant operations. Both locations use Compaq ProLiant systems running under Windows NT. With such a heavy daily volume, it’s important to keep the RAID disks from filling up, so Connected’s proprietary Hierarchical Storage Management system transfers data to one of eight DLTtape drives. Installed in libraries with automatic cartridge loaders, these units can handle many terabytes of data.

Remote Backup for Medical Information

MeritCare Health System operates 37 healthcare facilities scattered across hundreds of miles on the Great Plains of Minnesota and North Dakota. For many of these sites, which are remote in every sense of the word, their computer network is literally a lifeline to critical health information stored at the system’s headquarters in Fargo, North Dakota – everything from payment records to X rays. A vital strand in the information lifeline is a network-wide remote backup and retrieval system that runs over high-speed telephone lines linking remote sites to DLTtape drives at the central site.

Eight Compaq tape libraries handle all server backup, including all remote sites, over high-speed T1 lines. Full server backups are done weekly; differential backups are performed nightly.

Law Firm Backs Up Time and Billing Data

Few things are more important to a law firm than the integrity of their time and billing records. The international law firm of Cozen and O'Connor has been in business for 20 years and is headquartered in Philadelphia, with 12 offices across the country. The firm uses DLTtape systems to make sure that time and billing information is safely backed up and easy to retrieve.

As the firm has migrated to a Windows NT network environment, they have acquired high-capacity DLTtape systems, built into their Compaq ProLiant servers. The data backed up via DLTtape systems is generated on Elite Information Systems' Financial, Case Management and Legal Time and Billing software, running on SCO/UNIX and accessed on the firm's TCP/IP network.

"We archive the entire accounting system database every day," says Amy Freese, Director of Information Services. "All of our accounting information has to be backed up daily and stored off-site. It's mission-critical, so it's absolutely essential for us to maintain the integrity of the database." Selecting the DLTtape system for backup was an easy choice, Freese points out. "The drive was recommended by Compaq for its ProLiant quad processor server," Freese says.

Multimedia

Multimedia developers use powerful computer workstations to blend many different elements into one unified presentation or product. Many multimedia presentations use music, sound effects, photographs, computer graphics, type, and animation to tell a story, engage the viewer, and convey a message.

One example of how the DLTtape system is being used in a multimedia application is at a developer and publisher of computer entertainment software. These games are intricate blends of music, sound effects, computer graphics, photographs, live action, dialogue, and other elements.

Each video game product represents many months of intense development effort. Game development cycles often overlap, so that several games may be in development simultaneously. Hundreds of gigabytes of storage are required to handle these multiple projects. Of course, backup for this irreplaceable information is a must. That's why developers rely on DLTtape library systems and DLTtape cartridges.

Some Time Travel Required

One of the key benefits of DLTtape library systems is that they enable developers to keep a game's many plot twists and turns in near-online storage. Should the plot lead down a dead end, developers need to be able to turn back the clock and pick up the plot from the point before they went astray.

An even more common occurrence is a situation in which a hardware malfunction corrupts a complex graphics rendering. The speed of a DLTtape library can allow a developer to quickly reload a corrupted file. That means a whole team of developers won't be sitting around for several hours waiting to recover the right backup.

Video Editing Applications

In a video editing application, the user – the editor – is usually working on several projects at once, each involving many gigabytes of storage. Instead of doing nightly incremental backups and weekly full backups, the video editor is actually in a process of constant

ongoing backup. Typically, the editor will work on one job for a period of time, perhaps several hours. When he or she finishes work on that project – completes a new scene, or completes a set of revisions, or simply needs to get on something with a hotter deadline – the editor doesn't simply close that file and open a new one. That won't work. The files, the individual projects, are usually so big that you can only have one active at a time. So the editor takes the whole file and off loads it from hard disk to tape. In some cases, the user may have two tape drives and two SCSI ports and make two copies on two separate tape cartridges at the same time. One is the primary copy and one is a backup. As soon as program A is off the hard disk, the editor finds the next program he wants to work on – stored on tape – and loads it to hard disk.

So, instead of scheduled backups, sheer content-driven size dictates an ongoing backup process. Another characteristic is the fact that video files usually consist of three distinct types of files: the video “footage” itself, various headers and footers that provide information about the program, and another set of project information – budgets, schedules, etc. This application requires a backup solution that includes high-capacity media (so you are sure you can get a whole program on one cartridge), high transfer rate (so you can catch the late drop off at FedEx, instead of having to wait until tomorrow because it takes so long to copy the tape), and durable media (so the program survives physical adversity).

Video On Demand

Someday soon, instead of going to a video rental store to rent a movie, you may be able to simply select the movie you want from your cable service. You'll have your pick of hundreds of titles, and the same service may even offer you on-line banking, games, and interactive shopping services. If you live in one of several areas of the country, you may even have access to this type of video on

demand (VOD) service right now on a test-market basis. VOD services use cable to provide homes with an array of services, including home shopping, interactive games, on-line banking, and video on demand.

The DLTtape system provides the high capacity, fast throughput and total reliability that are a must for video on demand applications. The DLTtape system can help the VOD service provider deliver much of the programming and promotional material that appears on the network. An entire day's output of editing can be delivered to the network operations center on a single DLTtape cartridge. Film studios and distributors can ship feature films to the VOD service on DLTtape cartridges. A single two-hour movie can occupy from four to 40GB of storage space. Special MPEG (Motion Picture Experts Group) encoders are used to compress movies and other programs.

Digital Nonlinear Editing

Film editors used to review every foot of film and manually cut and splice together the sections they wanted in the final version. Today, film editors are more likely to use a powerful computer workstation to review and edit their masterworks. These new digital editing systems feature huge amounts of RAM and a large disk drive for handling the "hot" project at hand. Just as importantly, these systems incorporate a powerful tape backup system to store completed work and works in process.

According to Avid Technology, the industry leader in digital nonlinear editing systems, the debate is not whether to use digital technology, but rather how best to implement it. Avid offers DLTtape systems with all of its digital editing systems. According to the company, DLTtape drives and media provide the "fastest, most cost-effective method to

back up digital media.” Avid lists a number of important reasons why its customers should consider DLTtape systems, including:

Protection from data loss. By backing up digital source footage, users can go back to the digitized media, modify projects, or access clips for new programs. In many Avid resolutions, it’s faster to restore from a DLTtape backup than to redigitize.

Archiving. Unlike many magnetic tapes, DLTtape media can be stored for years without fear of media degradation.

Fast project turnaround. Off-loading projects onto a DLTtape system frees the editing system’s hard drive for the next project. Project scheduling and coordination is also made easier.

Compact and inexpensive. DLTtape media occupies less space than traditional video cassettes or other removable magnetic media. It also provides an inexpensive way to transport projects and raw footage between facilities.

Next, we’ll compare DLTtape technology to competing tape storage systems.

DLTtape System Technology Compared

11

It would be easy to say there's no comparison to DLTtape system technology – it's the best! But, nothing is that simple. Sure, DLTtape products are fast, reliable, and offer industry-leading capacity and speed. Depending on your application, DLTtape technology may very well be your best choice in a tape backup system. However, to make the right choice, you need to know more about the leading backup options.

In this chapter, we will take a closer look at quarter-inch tape (QIC), 4mm DAT (digital audio tape), 8mm tape and optical disk. We'll compare these backup systems to the DLTtape system (see Figure 11-1) in order to help you select the system that best meets your needs.

Before You Go Shopping...

Remember, speeds and feeds (and price) are important, but they are not the only criteria you should use in evaluating backup systems. The number one step to take before setting out to investigate tape and other backup schemes is Know What You Need.

- How long is your backup window?
- How much data do you need to back up?
- How fast is your data growing? (It's alive!)
- Does your new backup solution need to be backward compatible with your old?

- How important is backup system reliability?
- What will media cost (cost per gigabyte)?
- Is the backup system supported by third-party software?
- Is there a clear growth path for my backup system?

These are just some of the factors you should consider as you embark on your quest for the perfect backup solution. If your data backup needs are great and/or growing, and your backup window is short or non-existent, as in many 7x24 operations, then an industry-leading solution like DLTtape drives, autoloaders, and libraries should be at the top of your research list.

DLTtape System Technology Details

To help you compare DLTtape half-inch tape technology to competing technologies, let's recap the features that make DLTtape drives unique. DLTtape drives use half-inch tape in a single-reel cartridge that eliminates wasted space. DLTtape media is drawn

	DLT 4000	DLT1	DLT 8000	SDLT 220	Exabyte Mammoth 2	Sony AIT2	DDS4
Native Capacity	20GB	40GB	40GB	110GB	60GB	50GB	20GB
Compressed Capacity (2:1)	40GB	80GB	80GB	220GB	120GB	100GB	40GB
Native Transfer Rate	1.5MB/s	3.0MB/s	6MB/s	11MB/s	12MB/s	6MB/s	2.5MB/s
Tape Life (years)	30	30	30	30	30	30	n/a
Media Passes	1 million	1 million	1 million	1 million	30,000	30,000	1,500

Figure 11-1 DLTtape and Super DLTtape Drives *are the performance and reliability targets for all others on the market today.*

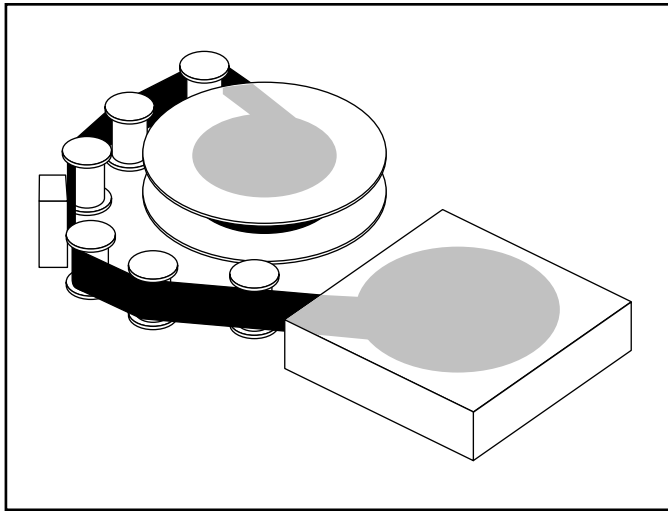


Figure 11-2 Tape Path Is a Key reason for DLTtape media's industry-leading reliability, long life, and accuracy. Six precision rollers guide tape to internal take-up reel; the Super DLTtape drive uses four rollers.

from the cartridge along a gently curving path (see Figure 11-2) past the write-read-write head to the take-up reel. Unlike helical scan drives, in which the tape recording surface makes contact with numerous rollers and guides (see Figure 11-3), the recording surface of the DLTtape media touches only the write/read head. This minimizes wear and abrasion.

DLTtape drives use a computer-controlled dual-motor system that precisely controls tape acceleration, deceleration, and write/read speed. One motor pulls the tape across the write/read head, while the second motor controls tape tension. This system eliminates tape stress and is one important reason DLTtape media can easily withstand a million passes.

Information is recorded on DLTtape media in a serpentine linear format. The DLTtape drive begins recording at the start of the tape

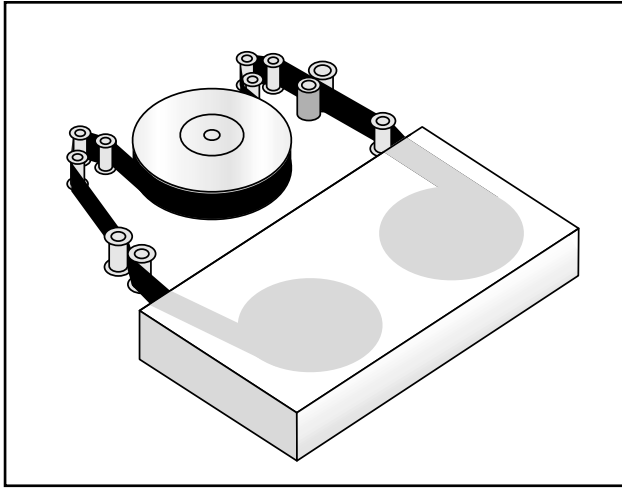


Figure 11-3 Typical Helical Scan Tape System *must pull tape out of the cartridge and around a spinning read/write head. Acute wrap angles and recording-side contact reduce tape life.*

and records to the end. The drive then steps the head to the next track, reverses direction and records back to the beginning of the tape, and so on. One of the main reasons DLTtape drives achieve such high data transfer rates is because data is written using multiple channels. DLT 4000 systems use two channels, DLT 7000 and DLT 8000 drives use four, while Super DLTtape drives use eight.

This Parallel Channel Architecture (PCA) gives DLTtape technology a major advantage over competing single channel systems in both speed and accuracy. Not only do multiple channels enable faster throughput, but they allow bad data blocks to be rewritten to an alternate channel. This fault-tolerance enhances data accuracy by allowing bad blocks to be rewritten on the next available channel.

Along with its channel-independent data scheme, DLTtape systems use multiple error detection and correction techniques to ensure

data accuracy. These include parity, multi-layer cyclical redundancy code (CRC), error detection code (EDC) and custom Reed-Solomon Error Correction Code (see Chapters 5 and 6 to learn more).

An additional advantage provided by the DLT 7000 and DLT 8000 drives is Symmetric Phase Recording (SPR). Using SPR technology, adjacent data tracks are recorded using alternating head angles. The resulting herringbone pattern eliminates cross-talk interference and the need for guard bands between tracks. This allows tracks to be packed tighter and is one important reason the DLTtape drives offer industry-leading capacity. SPR technology enabled us to increase track density from 256 tpi (tracks per inch) in the DLT 4000 drive to 416 tpi in the DLT 7000 and DLT 8000 drives.

DLT1

The DLT1 drive is successfully bringing DLTtape technology to new markets at the low end of the mid-range. The DLT1 shares many basic design characteristics with other DLTtape drives, and uses DLTtape IV media cartridges. The DLT1 drive provides native capacity of 40GB and native transfer rate of 3MB/sec.

Super DLTtape Technology Details

Super DLTtape technology is an extension of DLTtape technology; it retains all of the major features of DLTtape technology. At the same time, Super DLTtape technology incorporates a number of important technology innovations. The following paragraphs briefly outline the primary similarities and differences between the DLTtape and Super DLTtape technologies, and summarize the technology innovations incorporated in Super DLTtape technology.

Like DLTtape technology, Super DLTtape technology uses half-inch tape in a single-reel cartridge. It incorporates a modified Head Guide Assembly with four rollers instead of the six used in DLTtape technology. The resulting tape path is very similar to that

of the DLTtape drives, with even less contact between the tape media and the rollers. The dual motor system in Super DLTtape drives is very similar to that used in the DLTtape drives.

Super DLTtape drives record data in a serpentine linear format, just like DLTtape drives, but use eight-channel recording, versus four channels for the DLT 7000 and DLT 8000 drives.

Super DLTtape technology employs the same Parallel Channel Architecture as previous DLTtape drives. Super DLTtape drives record data using 448 data tracks, versus 208 for the DLT 7000 and DLT 8000 drives. They do not use the Symmetric Phase Recording (SPR) technique employed in the DLT 7000 and DLT 8000 drives, except when reading data previously recorded on a DLTtape drive using SPR.

Of course the big differences between Super DLTtape and DLTtape technology are in performance and capacity. Super DLTtape drives offer capacity of 110GB (uncompressed) and data transfer rates of 11MB/second. The key to these dramatic achievements is a series of technology innovations. These innovations are described in more detail in Chapter 17, *Super DLTtape: The Future of DLTtape Technology*. They are:

- Laser Guided Magnetic Recording (LGMR™) technology,
- Pivoting Optical Servo (POS),
- Magneto-Resistive Cluster (MRC) heads,
- Partial Response Maximum Likelihood (PRML) channel technology,
- Positive engagement tape leader buckling mechanism,
- Advanced Metal Powder (AMP) media,
- New, rugged media cartridge.

Helical Scan Systems

The next two backup systems we'll discuss are 4mm DAT (digital audio tape) and 8mm tape. Both of these systems are based on helical scan technology developed in the early days of television to store video images. This is virtually the same technology used in your home VCR. With QIC and DLTtape systems, the tape is drawn rapidly past a fixed read/write head. With helical scan systems, both the tape and head move.

The tape in a helical scan system is pulled from a two-reel cartridge and wrapped halfway (more in some systems) around a cylindrical drum containing the read/write heads. The read/write cylinder is tilted and spins at a rapid rate in one direction as the tape is drawn slowly past in the opposite direction. In this way, blocks of data are recorded diagonally across the tape.

By alternating the angle of the data from track to track, a helical system can actually overlap tracks. When reading from the tape, the head that matches the recorded data's angle reads the strongest signal. This technique enables helical scan systems to achieve very high data densities.

A serious drawback to the helical system design is the complicated tape path. Because the tape used in helical systems must be pulled from a cartridge and wrapped tightly around the spinning read/write cylinder, a great deal of stress is placed on the tape. It's interesting to note that the combination of slow moving tape and the rapidly spinning read/write head results in a relative tape speed that's actually greater than that in a DLTtape system. This fact results in even greater tape stress in helical scan systems. In addition, the recording surface of the tape is drawn over numerous rollers, resulting in additional wear and increasing the likelihood of errors.

Sony AIT-2

Sony's AIT-2 drive is a high-performance 8mm helical scan drive offering a native capacity of 50GB and a native transfer rate of 6MB/sec. Important features of the AIT-2 technology include its Memory In Cartridge (MIC) feature, which stores data on the contents and usage history of the cartridge in a chip that can be read by a library automation device. It is important to note that, while AIT-2 is an 8mm technology, it is not compatible with previous generations of 8mm drives.

Exabyte Mammoth-2

Mammoth-2 is an 8mm helical scan drive from Exabyte that offers a native capacity of 60GB and a native transfer rate of 12MB/second. Mammoth-2 drives offer backward compatibility with previous generations of Mammoth 8mm drives.

DDS-4

DDS-4 is a high-performance 4mm tape technology. It delivers significantly greater capacity (up to 20GB) and transfer rates (up to 2.4MB/s) than previous generations of 4mm drives. However, it is significantly less capable than larger format systems like DLTape systems. DDS-4 is, therefore, primarily used for PC backup. DDS-4 offers the important advantage of being compatible with previous generations of 4mm DDS technology.

Ultrium

Ultrium is a high-performance half-inch tape technology being developed by a consortium of leading data processing/data storage vendors. Ultrium is planned to offer native capacity of 100GB and native transfer rate of 20MB/sec. While its proposed specifications are impressive, it is important to note that the Ultrium technology faces a number of hurdles. First, it is a multi-partner development

effort. Such efforts can very easily get bogged down by conflict between the competing interests of the partners. Second, unlike Super DLTtape systems, Mammoth-2, or AIT-2, there is no installed base of Ultrium products. Therefore, any user who decides to move to the Ultrium technology must either maintain their previous technology in order to be able to access archived data, or go through the process of converting all their archived data to a new format, or simply abandon archived data.

Quarter-Inch Tape (QIC)

The quarter-inch tape cartridge (QIC) was first introduced in 1972 by the 3M Company as a means to store data from telecommunications and data acquisition applications. This was long before PCs came into being.

As time passed, QIC became an accepted data storage system offering compact, easy to use cartridges. QIC tapes come in two form factors: 3.5" minicartridges and 5.25" data cartridges. The minicartridge uses either quarter-inch or .315" (Travan) wide tape. Data cartridges use only quarter-inch wide tape.

QIC tape cartridges look much like audio tape cassettes, with two reels inside, one with tape and the other for takeup. The reels are driven by a belt built into the cartridge. A metal rod, known as a capstan, projects from the drive motor and pinches the tape against a rubber drive wheel. This capstan drive system is a major source of tape wear and contamination – dirt and other particles can be ground into the tape by the capstan pressure.

While QIC systems are generally a low-cost option, especially for single workstation backup, storage capacity is limited and QIC libraries are rare. Another drawback is incompatibility. Because of changing standards over the years, you must be careful to check

that any new QIC drive you buy is compatible with your existing tape cartridges. Incompatibility among QIC drives and tape formats is a real problem that must be considered when purchasing this type of system.

Like the DLTtape system, QIC systems use a serpentine recording method. Until recently, QIC systems used a single channel for read/writes. One vendor has introduced a multi-channel QIC system that offers a capacity of 13GB. High end QIC systems now compete directly with 4mm DAT for workstation and very small network backup applications.

One QIC version that is growing in popularity at the low end of the backup spectrum is 3M's Travan TR-4 format cartridges. Currently, Travan drives offer only 4GB of storage, but are priced below similar capacity QIC drives. Travan minicartridges use .315" wide tape. Many manufacturers are adopting the Travan format, which is good for QIC users who have suffered from an overabundance of "standards." There are currently no library systems available for QIC drives due primarily to the lack of demand for QIC systems in large-scale installations.

Optical Options

If access speed, portability and/or permanence figure prominently on your list of must haves, then optical disk may be an appropriate storage option for you. Optical disk drives fall somewhere in the middle between hard disks and tape backup systems. Optical drives do not have the storage capacity of high end tape systems, nor do they have the access speed of a hard disk. These drives do, however, offer some unique benefits that make them ideal for special applications such as long-term archiving, data distribution, and near on-line storage.

Write once, read many (WORM) drives have been available for many years and are most often used to provide a permanent record for critical information, or are used in optical jukeboxes in hierarchical storage management (HSM) systems. Law firms, for instance, often use WORM drives to store important documents and court records. WORM media has a shelf life of at least 30 years. A standard CD format version of the WORM drive is known as a CD-R for CD recordable. These systems store information in standard CD format with a standard density of 650MB and can be read by the CD drives found in most of today's PCs.

Standalone WORM drives have virtually disappeared from the market with the introduction of multi-function drives that can act as either a rewritable drive or a WORM drive. By using the correct media, you can create a WORM disk that offers a permanent record, or use rewritable media, and the same drive can write, read and overwrite.

The most popular multi-function drive is the phase-change dual (PD) drive. This drive uses a high intensity laser to change the crystalline structure on the surface of a 5.25" PD disk. The change in reflectivity caused by the laser represents either a zero or a one. A medium-intensity laser is then used to restore the crystalline structure so that it can be written to again. When a WORM disk is used in the same drive, the data written to it by the laser is permanent.

Because these drives adhere to the same format used in the CD drive found on most computers, they are limited to 650MB of storage. This limitation places them at the low end in terms of a standalone data backup solution. In addition, PD drives have very slow access times. One advantage to PD drives is that they can read standard CD-ROMs.

Magneto-optical (MO) drives use a combination laser/magnetic head to achieve higher storage capacities than PD drives. However, higher capacity comes at the expense of compatibility with standard CD drives. MO disks can only be read by other MO drives. The highest capacity MO drive on the market today offers 4.6GB of storage, hardly sufficient for serious storage applications. MO drives are slow during write operations because they must erase each disk sector before new data can be written.

In general, optical media is prohibitively expensive for large volume backup and archiving applications. In addition, optical's low data density means it would take numerous disks to equal one DLTtape cartridge. This extra administrative burden adds to labor costs and logistical headaches.

Next, we'll evaluate the obvious and hidden costs of owning and operating various data backup systems, including the DLTtape system.

Evaluating the Cost of a DLTtape Backup Solution

12

What does DLTtape system backup cost?

We could answer by showing you a price list, but that isn't really an answer at all. If you are considering using a DLTtape system for backup, then you are in the market for a serious backup system. Serious backup isn't just buying a box. It is a mission critical function. You need a systematic approach, and you need to make a significant and continuing investment in backup. The box is just the beginning. In this chapter we go into the details of the dollars and cents of backup. We start off, of course, with the most time honored answer to any cost question: "It depends." Then we follow up with another classic: "What's it worth to you?"

It Depends

First of all, do you really need the level of backup that the DLTtape system provides? The "it depends" answer is really not as evasive as it sounds. It should not be difficult to figure out what cost range you should consider. Cost is driven primarily by the underlying backup technology you choose, and that choice depends on your needs. It depends on how much data you need to back up, how often you need to back it up, how much time you have to do your backup, and how valuable the data is. It also depends on what you anticipate your future backup needs will be.

If you're dealing in megabytes, you probably do not need an industrial-strength solution. You are probably well covered by a desktop solution using 4mm DAT tape that costs a few hundred dollars. However, once your volume reaches gigabytes, you should consider a more robust solution, like a DLTtape system. If you must deal with tens or hundreds of gigabytes, or terabytes, you should consider a DLTtape library or autoloader.

If your backup need is "every once in a while" or "when you get around to it," then you don't really need DLTtape system backup. However, if you back up on a regular schedule – nightly incremental backups and weekly full backups – then you are beyond desktop-class backup solutions. If you need to back up on a tight schedule – for example, between midnight and 6 a.m. – you probably need an industrial strength backup solution, like a DLTtape-based system.

What's It Worth To You?

What if you have customer data on your system? What if your clients depend on the data on your system to do their job? In more and more situations, your data is really your business, and the cost to back it up is small compared to the potential loss if you do not back up. If that is the case, you should be using DLTtape system backup.

Look At All The Pieces

If you are doing desktop level backup, the process is quite simple. But if your business depends on availability of data you need to take a much more comprehensive view of your backup strategy and its total cost. Total cost includes the cost of the backup hardware, backup software, perhaps a more comprehensive storage management software package, and high-capacity media. In addition, you must consider the more complex (and bigger) cost of labor, downtime, risk, and future needs.

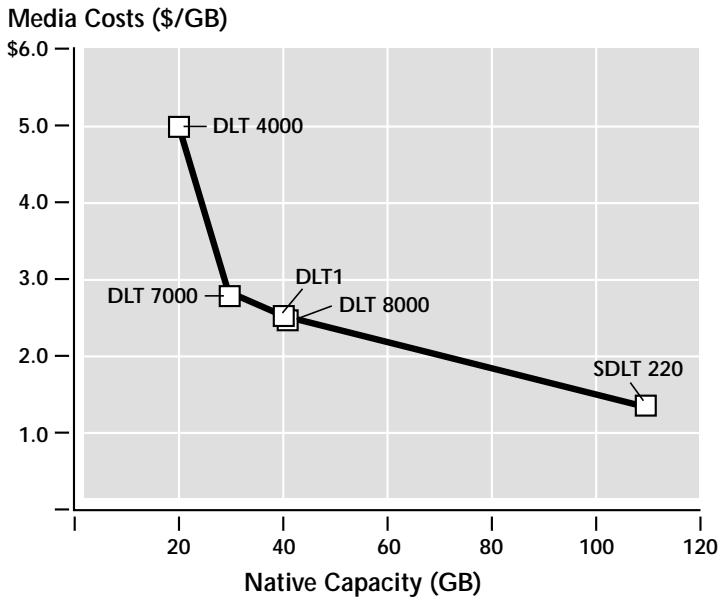


Figure 12-1 Cost per Gigabyte of Storage is a function of media capacity. High-capacity DLTtape IV and Super DLTtape I cartridges deliver the lowest dollars-per-gigabyte cost.

What Does Media Cost?

Media prices fluctuate. In general, however, smaller-capacity media tend to have a lower cost per cartridge, while larger capacity media (like DLTtape cartridges) tend to offer the lowest cost per gigabyte. (See Figure 12-1.) In these terms, DLTtape media is among the least expensive tape media on the market.

Overall media cost may also be determined by application and the specific backup routines used. How many tapes will you need? In a “typical” backup application, there would be incremental backups daily, and a weekly full backup. If you can put an incremental backup on a single DLTtape cartridge, and the full backup takes five cartridges, you’ll need ten cartridges for a complete one-week cycle of backups. In that kind of situation, many organizations elect to keep

last week's backups off-site, so that would mean a total of investment of 20 DLTtape cartridges.

Archiving data presents a very different need. When you are consuming tapes on an ongoing basis, rather than rotating the same tapes through the system, media costs are higher. This is another case in which the high capacity DLTtape cartridges are more economical than lower capacity cassettes.

In fact, the difference in cost over the long run can be dramatic. One customer who uses both 4mm and the DLTtape system describes going through as many as 100 4mm cartridges each week to keep up with an archiving requirement. Using DLTtape cartridges would require many fewer cartridges, and would also cost less, in spite of the big difference in unit cost.

Compatibility Can Save Money

When you are looking at media costs, you can't overlook the economic impact of media compatibility. Or, to put it another way, the high cost of incompatibility. As we discuss elsewhere in this handbook, media incompatibility is a significant problem for users of some tape technologies. You can't simply jump from one technology to another without a great deal of pain, and, even within what look like related technologies, there are often critical incompatibility issues from one generation to the next.

DLTtape technology is the notable exception. Over the years, Quantum has made a strong commitment to preserving its customers' investments in media and drives by maintaining a high level of compatibility across generations of DLTtape media and drives. One most compelling example is the DLTtape IV media cartridge. DLTtape IV cartridges run on the DLT1, DLT 4000, DLT 7000, and DLT 8000 drives, and are read-compatible with Super DLTtape drives. Thus, this single cartridge can be used in a very high percentage of all the

DLTtape drives in the world – and can deliver the maximum performance possible for every one of those drives. For users, that means they do not need to go to the great expense of transferring all their older tapes to new media just to make them readable. And it means that users with a mix of DLTtape drives can buy a single type of cartridge to support all their stand-alone and library drives, reducing acquisition, stocking, and administrative costs.

Labor Costs

Labor cost is usually the biggest part of the true cost of backup. It's also the factor that drives many organizations to make the move from other backup technologies to a DLTtape system-based backup. Labor costs can be difficult to control. An organization could have an adequate backup system, using a 4mm DAT or 8mm solution. This solution could work well for a long time, until the environment starts to change. New applications come on board. Some of them are critical to the success of the organization, and need to be updated on a frequent schedule. The new applications may also be larger and demand more backup space. At the same time, the available window of time for backups is shrinking. Unfortunately, the existing backup system has not kept pace. All of a sudden, it is not possible to complete a whole incremental backup in one shift. It takes more tapes to complete a backup. And, tape drive mechanisms originally designed with low duty-cycle consumer applications in mind are seriously compromised when faced with hour after hour of heavy-duty use.

In this situation, labor costs start going through the roof. Someone has to change tapes more and more frequently, be on hand to finish the backup that won't fit on one tape, and more and more frequently swap out a drive that has succumbed to the pressure. As one DLTtape system customer described his experience with DAT backup, he found himself "getting too many midnight calls" with his DAT system, prompting the move to DLTtape technology.

Another DLTtape system user described his experience with labor costs in an application that required maintaining archives of client data. Using a 4mm DAT system, he recalls, he had reached the point at which he was tying up two staff members for a total of about 35 hours per week, simply swapping tapes and replacing failed drives.

The lesson is clear: an inadequate, undersized, or insufficiently robust backup system can be a major expense, in terms of dollars and time, not to mention morale. By the same token, a reliable DLTtape backup system, running with proven software, can reduce labor costs to practically nothing. This is particularly important at a time when most IS departments are running with minimum staff, and IS managers want to use the people they have as productively as possible. Productivity certainly does not include loading and unloading backup tapes. In the past, many organizations could think of things like reduced management time as “soft savings,” and perhaps not even include labor in a cost analysis. But when you’re running on short staff and that backup window feels like it could close fast, those “soft” costs look very concrete.

What Does Down Time Cost?

“Down time” is another “soft” cost area. If the application goes down and is not backed up, what’s the cost? For many organizations the answer is, “we’re out of business!” What is a more reliable system worth? The answer is probably “everything!”

Another important “soft” cost area is restore time. How much does it cost to have a slow restore time? Or, what’s the value of a faster restoration. For some applications, restores are so infrequent that they really don’t register as a defined cost. For others, a restore is mission critical. For example, one of our customers develops video

games (see Chapter 10 for more detail). Building a video game is a large, complex development project, and it is not uncommon to have a system error or, more commonly, a human error that can blow up a file. In that situation, you don't want a whole team of developers sitting around for hours or even for many minutes waiting to restore the file from backup, so they can get on with their work. That's when the high speed of a DLTtape system backup unit delivers hard cost benefits. By contrast, a slower backup unit in the same situation simply delivers hard costs that are hard to swallow!

Next, we'll explore the world of DLTtape system platform connectivity and software compatibility issues.

Platform Connectivity & Software Compatibility

13

For the vast majority of DLTtape system users, any issues of connectivity and compatibility have been worked out long before they turn on their new systems. That's because most DLTtape systems are sold through OEMs such as Compaq, Dell, HP, IBM, and Sun. These platform vendors have already certified their systems to work with DLTtape drives through an in-depth qualification process described in this chapter. The same is true if you buy a DLTtape system-based automated library that claims compatibility with your computer platform. It too, has been qualified by the vendor to work with your system.

Similarly, the developers of software for backup, archiving, hierarchical storage management (HSM), and other storage-oriented applications go through the same kind of vigorous qualification process before they can claim to support DLTtape technology.

Getting Along With Others

Unlike tightly integrated components such as disk drives and RAM, peripherals such as tape drives require extra commands and connectivity protocol to work properly with a given platform or application. At Quantum Corporation, we devote tremendous technical resources to help original equipment manufacturers

(OEMs), value-added resellers (VARs), tape library makers, and independent software vendors (ISVs) achieve connectivity and compatibility with DLTtape systems and DLTtape libraries.

Our connectivity and compatibility support generally falls into the following categories:

- Platform Qualification Program and Web-based Platform Connectivity Matrix.
- Software Compatibility Program and Web-based Software Compatibility Matrix.
- Web-based Platform Solutions Guide and Application Notes.
- Web-based Matrix Of Software Compatible with DLTtape Libraries.

Our web-based Platform Connectivity Matrix, Software Compatibility Matrix, application notes, and Platform Solutions Guide are available at www.quantum.com or www.DLTtape.com.

The Platform Connectivity Matrix contains information on platform type (which operating system is used), hardware used to test connectivity, operating system revision, which DLTtape drives are supported, and comments about the level of support provided. Our Software Compatibility Matrix lists backup/archive, hierarchical storage management (HSM), and data interchange products which currently support or claim support for DLTtape drives. The listing is organized by company, product type, product name, current revision, platform, and current level of support.

The Platform Solutions Guide is a comprehensive collection of information on servers and desktop systems, and includes descriptions of native and ISV backup software applications that have been qualified and found to support DLTtape drives on each specific hardware plat-

form. This listing includes native applications such as tar backup, cpio, dd, Ftio and Fbackup. Examples of ISV partners include Computer Associates, Dantz, Legato, Seagate, Novastor, Microsoft, and many more.

Host Attachment

The first step to using a DLTtape drive or DLTtape-based tape library is to attach it to a host operating system by means of a tape driver. All of the major backup software packages (Examples: Backup Exec, ARCserve, NovaBack, NetWorker) and many of the lesser known systems include driver support for DLTtape drives for specific operating systems and specific applications. This is the easiest path to DLTtape connectivity on your hardware platform. Of course, if you purchase a DLTtape drive from your system supplier, the vendor will have already solved any connectivity issues. The same is true if you purchase a DLTtape-based tape library system that claims support for your particular platform.

Native Tools

Another option, often used by smaller installations, is to perform data backups using native operating system tools. While native OS tools are okay for basic backup and archive operations, they won't provide for automated backup, scheduling, and other more sophisticated backup management operations. Two types of native utilities are typically provided by most operating systems. The first are status commands that control drive functions such as rewind, density changes, and drive-ready warnings.

The second type of commands are the backup and archive instructions. In UNIX, some examples of generic backup commands include tar, dd, dump, cpio, and mt. Most flavors of UNIX come with some unique backup commands. For instance, Sun users are familiar with ufsdump and ufsrestore; Silicon Graphics users know

the BRU commands; and HP uses fbackup and frestore. The Windows NT operating system comes with a native backup utility.

Platform and Software Qualification Programs

Every platform partner or ISV that wishes to either sell DLTtape drives or claim compatibility with DLTtape drives, must first go through a qualification process to ensure that the DLTtape drive will work with the target platform and any applications that may be associated with it. Software vendors use the qualification process to verify that their DLTtape drivers work as expected and to specification.

Quantum and its platform partners work together to create a qualification plan designed to meet a market introduction target date. Quantum hardware and software specialists provide the partner with technical support at every stage of the qualification process. In the end, the customer must decide when the qualification process is complete. In the case of hardware vendors, once the customer is satisfied with the DLTtape drive qualification tests, we begin shipping them DLTtape systems in volume.

For OEMs and system integrators, most of the changes made to DLTtape drives during the qualification process are made in the system's firmware (see Chapter 15). This is where SCSI interface issues are resolved, including communication protocols, data blocking and deblocking, and special commands that may be unique to the customer's implementation of SCSI.

Reliability Qualification Testing (RQT)

RQT is an endurance test of the DLTtape systems, and is often run in parallel at Quantum or solely by Quantum for the customer. One of the reasons that Quantum frequently conducts some of the qualification testing for the customer is to reduce the customer's

time-to-market. By running some tests in parallel with Quantum, the customer saves time and expense. Up to 20 drives on several different types of host platforms are typically used during the RQT phase. RQT can last for up to ten weeks and is conducted late in the qualification cycle, after most issues have been resolved.

RQT includes interchange testing, where tapes are written on one DLTtape drive and taken to another DLTtape drive to be read. The test systems are kept under continuous operation for the entire RQT to make sure the drives do not produce any hard (unrecoverable) read or write errors.

For library manufacturers, a major part of RQT is how the DLTtape drive will stand up to countless load and unload cycles. Library makers will often test DLTtape drives up to 60,000 consecutive load and unload cycles during an RQT period.

Qualification Process Ensures Satisfaction

The DLTtape drive qualification process is an essential part of ensuring that the product shipped delivers the expected performance and reliability. The objective is to make it as easy as possible for the end user to set up and use the system. Plug and play, or as close to it as possible, is the goal in the qualification process. This process, which can take from one to several months, also helps build a partnership between Quantum, OEMs, library partners and integrators/resellers. In addition, the intensive nature of product qualification helps us build better products overall. Many of the enhancements we make during customer qualification find their way into the overall product.

Software Support

Just as important as qualification testing for new products and hardware platforms is the support Quantum provides for customers who are experiencing performance problems. Even when

using a platform or application that has been qualified to work with a DLTtape drive, occasionally a customer will experience a problem in achieving expected performance.

These types of cases are often the source for new application notes on our Web site. Quantum's customer support engineers will try to simulate the customer's problem in our test labs. The customer support engineer will pretend he or she is the customer unpacking the DLTtape drive for the first time and attempting to connect and operate it. In some cases, the solution is simple operator error and can be corrected easily. In other cases, a firmware change may be required and may result in a firmware update being issued to the installed base for that particular OEM's customers.

DLTtape Tools Available on Web Site

If you are a DLTtape system user, you can save time and optimize system performance by downloading the latest version of the DLTtape Tools utility system from the Quantum web site (www.quantum.com or www.DLTtape.com). This program gives you the ability to manage the internal workings of your DLTtape drive. It can be used to help you update your drive's firmware, run diagnostics, view or alter various parameters, edit mode pages, and view log pages. DLTtape Tools also includes an on-line help system.

Seeking Software

Almost every major backup, archive, and HSM software system on the market today supports DLTtape systems. These applications have either been qualified by the software vendor, and/or qualified by Quantum. We often test new applications for compatibility with our systems. Once an application has been qualified by us or the independent software vendor, we add them to our compatibility matrices on the Quantum Web site www.quantum.com or www.DLTtape.com.

We are continually working with major ISVs to ensure support for current and future DLTtape products. We check ISV solutions to identify functional deficiencies, provide the ISV with performance tips and tuning, provide quantitative and qualitative feedback, and provide the latest firmware updates. Once an ISV solution is qualified (either by Quantum or the ISV, or both) on DLTtape drives, we encourage the ISV to add us to their Certified Device List as soon as possible.

Next, we'll look at storage management software and what it means for DLTtape system users.

Storage Management Software

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Storage management software is a hot bed of evolutionary activity. A huge number of variables are in the mix, and new ones are popping every day. At the same time, the environment is changing very quickly, and the changing environment will have a lot to do with which variants emerge as successful species, and which disappear down evolutionary dead ends.

Evolving Storage Needs

The list of forces driving the demand for storage management solutions start with the growth of client/server computing. “Client/server” often means heterogeneous environments, disconnected islands of technology, inconsistent backup practices, ad hoc or non-existent storage management policies, and remote storage resources that are essentially unmanaged.

Meanwhile, new mission critical applications have emerged and must be up and running on a 7x24 basis. One category of new applications has moved into every possible niche in the environment: Internet, Intranet, and World Wide Web applications. These applications demand vast amounts of storage capacity and immediate access to all the data.

Finally, files are simply getting bigger. Not just the multimedia or imaging files, but even simple word processing files are getting larger and larger, adding layers of highlighting, tables, and mixed type fonts. Similarly, there was a time when an entire operating system would fit on a couple of floppy disks. Now, it takes a CD-ROM just to do a simple software upgrade.

These trends have created a tremendous need for integrated, consistent storage management. The pendulum has already swung from de-centralization to re-centralization. New expectations have emerged to put the pressure on for storage management solutions. Orderly, reliable backup is no longer good enough. For many organizations, the new criteria include nearly instant file restoration, total automation (even for remote sites), and complete visibility of all storage resources. (See Figure 14-1.)

What's in the Mix?

While nobody can say for sure what components will comprise a fully-evolved enterprise storage management system in the next few years, we know it will include more than backup, archiving, and file restoration. It will integrate a set of capabilities that might include instant file restoration, all-inclusive hierarchical storage management, total storage resources visibility, central console control, real-time backup, remote resource management, and integrated Web access.

To support this comprehensive functionality, the storage management system of the future will have its own dedicated resources, including high performance storage management servers, dedicated network bandwidth, complete hardware/software platform independence, and comprehensive Web access.

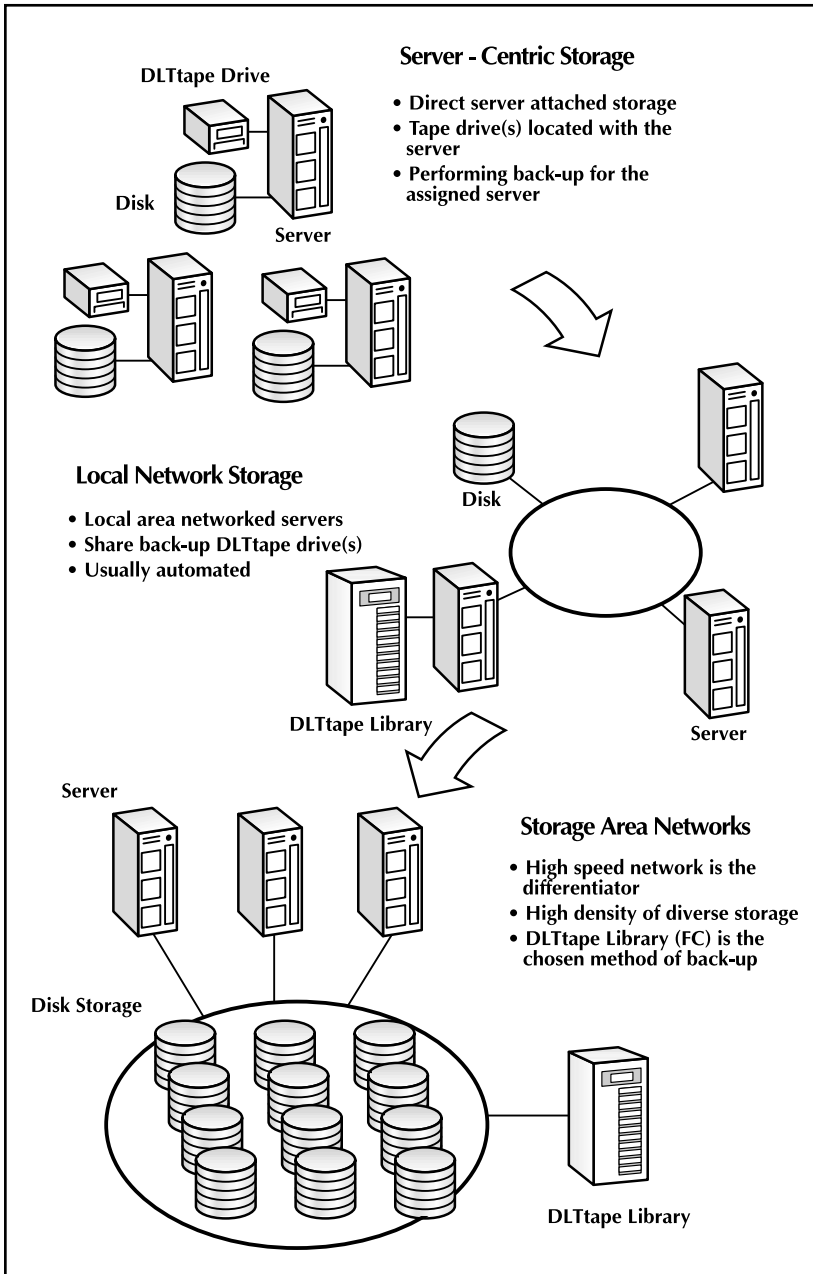


Figure 14-1 Evolution of Storage Management

DLTtape System Technology And Storage Management

As the shape of storage management software emerges, it's clear that the DLTtape system is a good fit. Here are some of the strengths that make DLTtape technology the right foundation for enterprise storage management solutions.

Capacity. The total size of the storage infrastructure in large organizations is growing at a tremendous pace. Storage capacity is absolutely essential, and the DLTtape system offers far more capacity than any other solution. An SDLT 220 drive can put 220GB (at 2:1 compression) on a single cartridge, far more than its nearest rivals.

Performance. In the storage management game, just as in sports, pure speed can solve lots of problems. With transfer rates up to 11MB/s (22MB/s at 2:1 compression), DLTtape systems have the native speed that gives developers of storage management systems the edge they need.

Scalability. No tape technology should even be considered if you don't know for sure that it can be scaled up. DLTtape technology has already proven its ability to scale from a few hundred MB to hundreds of terabytes.

Growth path. DLTtape technology is a proven, time-tested technology that still has a great deal of head-room in terms of growth in capacity and performance. We've barely scratched the surface in terms of tape coating technology, track density, and head technology. You can expect years of dramatic improvements in DLTtape technology, starting with the next generation Super DLTtape system. (See Chapter 17 for more details.)

Breadth of product line. Quantum is taking advantage of the success of DLTtape technology by building an extensive family of DLTtape system products. In an enterprise storage strategy, that means you have a choice among multiple compatible building blocks, all using the same basic technology, but which you can deploy in different situations, depending on the exact needs of each piece of the storage hierarchy. Quantum is committed to offering a broad family of competitively-priced tape drive products based on DLTtape and Super DLTtape technology and designed to address the individual storage needs of low-, mid-, and high-end system users in the mid-range data storage sphere.

Automation. Finally, automation will be an increasingly important part of enterprise storage management solutions. DLTtape systems demonstrated long ago that they are especially well suited to automated solutions.

Next, we'll look at the "brains" behind the scenes in the DLTtape system and almost every electronic device in use today – firmware.

Firmware is the “brains” behind the scenes in many of the products we take for granted. It's hard at work in your microwave oven, your calculator, your refrigerator, your digital watch, your kids' electronic toys, your cell phone, your treadmill, and your car.

Of course, firmware is also a crucial part of every piece of computer and telecommunications equipment in use today. Naturally, we're interested here in how firmware works in your Quantum DLTtape system.

Firmware is a computer program that's stored in a special non-volatile computer memory chip, where it won't disappear when the power is turned off. It is typically located on the device's main control board. Firmware is stored in permanent, non-erasable form on a PROM (programmable read only memory) chip or on an EEPROM (electronically erasable programmable read only memory). Firmware stored on a PROM can only be updated by physically replacing the chip containing the firmware. EEPROMs can be rewritten with new firmware, if the need arises. This is the type of chip used to store firmware in all DLTtape systems.

Firmware is part hardware, but mostly software. It occupies the middle ground between you and the device you're trying to use or con-

trol. In most cases, firmware interprets or translates commands from you, from applications, or from communication controllers and turns them into commands the machine or device can understand.

Firmware And Your DLTtape System

Every Quantum DLTtape system comes from the factory with firmware loaded in EEPROMs on the controller board mounted at the base of the drive. In the DLT 8000 drive, for example, there are approximately 400,000 lines of code written, primarily, in the C and C++ programming languages. That's a large program! Your microwave oven, for instance, requires a mere 1,000-3,000 lines of code in order to cook your frozen peas to perfection.

Firmware oversees the operation of the DLT 8000 drive's two microprocessors and, through them, various other electronic drive components. The personality of a DLTtape system is embodied in its firmware. Nearly every aspect of operation is controlled through firmware, including:

- SCSI bus communications.
- Data flow to and from the drive.
- Adaptive caching.
- Error detection/correction.
- Event and "bugcheck" logs.
- Head servo control.
- Tape speed and tension control.
- Read/write control.
- Data formatting.
- Data compression.
- Library interface.

SCSI Interface

SCSI (Small Computer System Interface) is at the heart of DLTtape drive control and communication. The SCSI interface is designed to be an industry standard for device control and communication.

Among the SCSI commands supported by DLTtape firmware are ERASE, LOAD-UNLOAD, LOCATE, WRITE, READ, READ POSITION, and REWIND. Supported SCSI messages, which are used to manage the physical path between the host and the DLTtape drive, include ABORT, BUS DEVICE RESET, CLEAR QUEUE, DISCONNECT, WIDE DATA TRANSFER REQUEST, and many others.

Like many “standards,” SCSI is interpreted by each system vendor in their own unique way. Often, these differences among versions of SCSI are subtle, yet they are significant enough to adversely effect drive operation if not recognized.

One of the biggest jobs performed by DLTtape system firmware is implementation of the SCSI protocol, including commands, messages, and options. Firmware customization is the primary means used to ensure that end users, no matter which host system they may be using, enjoy all of the benefits offered by DLTtape technology. Identifying and resolving differences among vendor implementations of SCSI occurs during Vendor Qualification.

Firmware Speeds Vendor Qualification

Although all DLTtape drives are manufactured by Quantum Corporation (or under license by Tandberg Data), the vast majority of DLTtape drives are resold by system OEMs such as Compaq, Dell, HP, IBM, and Sun, as well as tape library manufacturers. These drives are typically sold as part of complete computer systems or incorporated into tape library systems.

The flexibility provided by firmware enables Quantum to adapt DLTtape systems to meet almost any operating system or vendor requirements. In addition, when compared to hardware modifications, firmware changes usually take less development time and are less expensive to implement. It's important to note that nearly 99 percent of DLTtape firmware remains the same from system to system.

Different Firmware For Libraries

Most DLTtape drives headed to library vendors include a different firmware to enable the drive to communicate using SCSI protocol over the system's RS422 serial port, rather than through the SCSI interface. In cases where multiple DLTtape drives are used in a library, the firmware enables the library developer to control multiple drives from a centralized library controller.

Firmware provides the flexibility library makers need to incorporate DLTtape drives in their systems. For instance, library versions of DLTtape firmware allow library makers to adjust tape cartridge unloading resistance. The motor that determines the rate of speed at which a DLTtape cartridge will pop out of the drive during the UNLOAD process is controlled via firmware. The amount of exposed cartridge required for grasping by library robotics varies from maker to maker. Library makers can select the firmware that offers the right unload speed for their tape handling system.

Field Upgrades Offer New Features/Fixes

Because DLTtape system firmware is stored in re-writable EEPROM chips, it can be easily upgraded in the field by an end user or technician. In fact, the very first DLTtape drive, the Digital TF85 (2.6GB native capacity; introduced in 1989), was one of the first drives on the market to store its firmware in EEPROM memory (see Chapter 3 for more on DLTtape history).

This innovative feature enables Quantum and its resellers to develop and issue new versions of drive firmware that enhance operation and product value. For instance, firmware is sometimes upgraded in the field to introduce an improved compression algorithm or to refine a particular SCSI command. In other cases, firmware upgrades may be required to help certain types of backup software to work with DLTtape drives.

Two Ways To Upgrade

There are two ways to perform a field upgrade of DLTtape system firmware: by tape or from your host system using the utilities found in DLTtape Tools. Firmware upgrades are issued by either your system vendor or direct from Quantum. You should refer to your DLTtape drive Product Manual for complete instructions on updating your firmware.

Performing a firmware upgrade using tape is easy. After placing your DLTtape drive in firmware update mode, you simply insert the Firmware Update Cartridge (available from your system vendor or direct from Quantum) in your drive. That's it! Your DLTtape drive will do the rest.

During the firmware update, the DLTtape drive verifies that the cartridge you've inserted actually contains firmware. The system then erases the old firmware "image" from the EEPROM and replaces it with the new version. The drive then resets itself and goes through a Power-On Self-Test to ensure everything's working fine.

You can also upgrade DLTtape system firmware from your host system using the utilities found in DLTtools along with the SCSI WRITE BUFFER command. This procedure is described in your DLTtape Product Manual. The appropriate firmware image is

downloaded to the host from Quantum's bulletin board or corporate Web site.

Looking Back While Moving Forward

One of the key benefits of the DLTtape system is investment protection. Each new generation of DLTtape system has been compatible with previous generations. This means that your closet full of DLTtape IV cartridges recorded at 20GB on DLT 4000 drives or in DLTtape drive-equipped libraries are readable in the DLT 8000 and Super DLTtape drives.

Again, this is possible thanks to firmware. Because DLTtape drive servos and read/write channels are controlled by the drive's firmware, the drive is able to replicate older formats and densities. Of course, this level of compatibility comes with a price tag. Each new generation of DLTtape system firmware carries with it the heritage of its ancestors. Subsequently, the firmware used in the DLT 8000 drive is substantially larger than that found in the DLT 4000 drive. In fact, a DLT 8000 drive can read tapes recorded on even the earliest DLTtape drives, the DLT 260, 600, 2000, and 2000XT.

While Quantum no longer sells DLT 260, 600, 2000, or 2000XT systems, we have continued to maintain compatibility with them in new generations of DLTtape systems. This level of commitment and product adaptability cannot be found in any other line of tape drive on the market today.

Firmware is the unseen hero of our electronic age. Firmware is at the heart of the DLTtape system and is a key reason DLTtape systems are the most reliable, highest performance systems in the mid-range market today. And, firmware will play a crucial role in

helping to implement these advanced features in future generations of DLTtape drives.

Next, we'll look at learning how to use your DLTtape system.

Using the DLTtape System

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The DLTtape family of systems offers the highest reliability, capacity, and performance in the mid-range market today. For example, the DLT 8000 drive is rated at an MTBF (Mean Time Between Failures) of 250,000 hours – that’s over 28 years. DLT 8000 drive heads are self-cleaning and rated to last approximately 5.7 years at 100 percent duty-cycle. Our tapes are good for one million passes. Of course, like any high performance computer peripheral, DLTtape drives require proper care and use to achieve optimal performance and reliability.

Read The Directions

The number one rule to follow in order to use your DLTtape system properly is to read the directions. All DLTtape systems ship with detailed installation and usage information.

Another excellent source of operational information, including the latest application notes for system integrators, can be found on Quantum’s World Wide Web site; www.quantum.com or at www.DLTtape.com. Along with application notes, you’ll find user success stories, white papers, technical specifications, software and hardware compatibility charts, and announcements of new products and options for your DLTtape system or DLTtape library. Below are some helpful tips to guide you in using and troubleshoot-

ing your DLTtape drive and media. These tips cover our standalone DLTtape systems. For operational information on other DLTtape automation systems and backup software, you should consult your system vendor directly or visit their Web site.

DLTtape Media Do's & Don'ts

As the importance and volume of information continues to increase year after year, the need for reliable, long-term data storage grows with it. The DLTtape half-inch cartridge provides one of the most efficient and durable ways to store information. A DLTtape cartridge is just over four inches square and one inch thick. Yet, thanks to its single-reel design, a DLTtape cartridge packs 10,000 square inches of high-grade tape inside its case. Competing technologies provide just a fraction of that storage space.

When stored properly, a DLTtape cartridge has an archive life of at least 30 years with just a five percent loss in magnetic strength. So, what should you do and not do when it comes to your DLTtape cartridges?

Don't Drop Cartridges. It goes without saying that you shouldn't drop your DLTtape cartridges. However, if you do drop one, don't panic. The DLTtape cartridge, in its protective outer box, has been designed to withstand a fall from table height (approximately three feet) without damage. If your cartridge should sustain a fall like this, you'll want to check it anyway by examining the casing for cracks and bulges. You should also shake the cartridge to make sure nothing has broken inside. Any rattling sounds indicate internal damage. If a cartridge appears or sounds damaged in any way, it should not be used. If you drop a cartridge from a height greater than three feet, say a closet shelf, we recommend you not use that

tape. To reduce the chance of dropping cartridges, you should store them on their sides in their protective cases.

Data Recovery. If a damaged tape contains important data, we recommend sending the tape to a qualified data recovery service, such as Ovation Data Services of Houston, Texas (www.ovationdata.com). Other recovery services can be found by searching the Internet.

Stow Loose Labels. Every new DLTape cartridge comes with a sheet of labels in its storage box. These are non-adhesive labels and are designed to slide into the label slot on the front of the cartridge. Never use adhesive-based labels on your cartridges, and never put a label anywhere but in the front label slot. It is possible for the sheet of labels to cling to the cartridge by static or humidity and find its way into your DLTape drive. If this occurs, it can block the cartridge drive gear. **Solution:** store extra labels separately from your cartridges.

Ink Only. Don't use a pencil, grease pen, or other debris-producing writing instrument to mark your DLTape cartridge labels. This debris can find its way into your tape cartridges and into your drive. In addition, don't erase your labels and reuse; use a new label if you need to make corrections.

Hands Off. Never handle the leader or the tape in your DLTape cartridge. The oil from your hands may be carried by the tape or leader into the drive and be deposited on the read/write head. This could cause a Failure To Calibrate or Hard Read/Write Error. This condition will cause the Use Cleaning Tape light to come on. This problem can usually be corrected by using the DLTape cleaning cartridge.

Storage Requirements. As noted above, DLTtape media is ideal for long-term archiving, with a storage life of 30 years or more. To achieve its maximum shelf life, a DLTtape cartridge must be stored in its protective case on its side and kept within a reasonable temperature and humidity range. The ideal archival environment for storing DLTtape cartridges is at a temperature range of 64°F to 79°F and relative humidity of 40 to 60 percent.

Avoid Temperature Extremes. DLTtape cartridges should be acclimated to your operating environment before use. A good rule of thumb is to allow tape to adjust to room temperature for approximately as long as it was exposed to extreme temperatures. Even though the temperature of the cartridge housing may feel normal, the tape inside takes much longer to acclimatize. So, for instance, if you left a tape in your car overnight and the temperature dropped below freezing, you should let the tape warm up for the same amount of time it was left outside.

When To Retire Your DLTtape Cartridges. As noted above, DLTtape cartridges last a very long time. DLTtape media is pre-burnished at the factory to provide a smooth, debris-free recording surface. In addition, our tape goes through stringent quality control and testing during manufacturing. No media is perfect, but half-inch DLTtape cartridges come close, especially when combined with the multi-level error detection and correction systems built into every DLTtape drive. *Note:* if your Use Cleaning Tape light comes on repeatedly, it may be time to retire a tape. A weak signal from a damaged tape can cause this light to come on. It should also be noted that the Use Cleaning Tape light may also come on from time to time during the drive's initial break-in period.

DLTtape Drives Do's and Don'ts

You should treat your DLTtape drive like you do any piece of high performance computer equipment. Your DLTtape drive contains

its own sophisticated computer system, including RAM, microprocessors, controllers, firmware, and data cache. Install your DLTtape drive in a clean area with an industrial-quality surge-protected power source. Be aware that many factors contribute to the overall performance you'll experience with your DLTtape drive. Host processor speed, host adapter performance, bus configuration, host software, backup software, disk drive characteristics, and the characteristics of the data you're backing up are all considerations. Below are some Do's and Don'ts that will help keep your DLTtape drive working properly.

Self-Cleaning Design. DLTtape drives are designed to be self cleaning. There is no specified cleaning schedule for DLTtape drives. Simply clean as needed, which should be very infrequently. The DLTtape drive read/write head is equipped with outriggers that help to align the tape with the contoured head and help remove any debris from the tape. We often hear of users who run their DLTtape drives for months, even years, without ever having to clean their drive. The cleaning tape for DLTtape drives is a CleaningTape III cartridge. This is actually a 1,200 foot DLTtape III cartridge that has not been burnished during manufacturing, as other DLTtape products are. This unburnished cleaning tape is slightly "rougher" than a burnished tape and therefore tends to wipe the heads clean of debris. A CleaningTape III is good for 20 cleanings. *Note:* if you get a Use Cleaning Tape light, before you use the cleaning tape, you should try loading a fresh data tape. The movement of any tape across the head may clean it.

Hold The Dust. While DLTtape drives are self cleaning, reasonable care should be taken in keeping them clean. You don't want to overload the self-cleaning mechanism. For instance, don't locate your tape drive near line printers, near exit doors, in busy storage areas, or anywhere else that may be excessively dusty.

What's The Hold-up? What if you install a DLTtape drive and you don't get the performance you expect? Here are a few things to check. First, make sure your DLTtape drive is properly defined for the host system. It is common for a SCSI host to disable (Unbuffered Mode) the adaptive cache on the drive if it doesn't recognize the product identification string returned by an inquiry command. This cache enables the drive to adapt to the data rate of your host system and keep your drive streaming at peak performance. See your DLTtape drive documentation for more details on this.

Second, be sure your disk is de-fragmented on a regular basis. Fragmented disks and files take much longer to back up. Third, check your host's record size. DLT 8000 drives, for instance, support record sizes up to 64MB each. In general, the larger the record size, the better the throughput. Many software applications will default to 512-byte records, often resulting in poor performance. Check with your ISV (independent software vendor) to see if their software supports greater record sizes. Finally, check to make sure you're using the correct DLTtape media for highest performance. In the SDLT 220 drive, for example, only Super DLTtape I media is capable of recording data at the drive's 110GB native capacity. If you attempt this with a DLTtape IV cartridge, the system will automatically default to the tape's maximum capacity of 40GB native and 80GB compressed.

To Compress Or Not To Compress? Successful compression can increase your DLTtape system's data transfer rate. All DLTtape systems use the LZ1 (Lempel-Ziv) compression algorithm, which was selected over other algorithms for its superior versatility and efficiency. Although Quantum and most other tape drive manufacturers use a 2:1 compression ratio as an average, actual compression can be highly variable depending on your input data. Compression algorithms "look" for repeatable data patterns that can be compact-

ed. Image files from a graphical program like Paint may compress at 4.5:1 or more, while binary files may compress at just 1.5:1. Data that has already been compressed or random data (such as encrypted data) may actually expand by about five percent if you attempt to compress it further. This can actually reduce drive throughput.

Mixing Density. Your DLTtape system can easily mix compression ratios on a single tape. Compression will change on the fly depending on the input data. If the tape was used previously at another density setting, you can overwrite data at a different density (if the tape supports it) at any time with the Density Override button on the drive's front panel.

Backwards, Not Forwards. We have been very careful in developing each generation of DLTtape system to ensure backward compatibility with previous generations. For example, the SDLT 220 Super DLTtape drive can read files on DLTtape IV cartridges at 20, 35, or 40GB native capacity. The DLT 8000 drive can read and write files on DLTtape III, DLTtape IIIXT, or DLTtape IV cartridges at 10, 15, 20, 35, and 40GB native capacity. This provides you with excellent investment protection in both media and drive technology. It should be noted that the reverse is not necessarily true. For instance, a DLT 260 drive (the first DLTtape drive) with a maximum native capacity of 2.6GB can only read DLTtape media recorded at 2.6GB. In other words, a DLTtape drive cannot read a tape recorded at a density higher than it is capable of recording at. A DLT 2000 drive, for instance, has a maximum native capacity of 10GB, so it can read DLTtape cartridges written at 10, 6, and 2.6GB, but nothing higher.

Resources For You

We hope these tidbits of DLTtape drive wisdom will come in handy some day. Remember, you can always call the Quantum Service Center at (408) 894-4000, visit the Quantum Web site at

www.quantum.com or **www.DLTtape.com**, or call your independent system vendor with any questions you may have about using your DLTtape drive, DLTtape-based tape automation system, or DLTtape cartridges.

Next, we'll look at the future of DLTtape system products – Super DLTtape technology.

Super DLTtape: The Future of DLTtape Technology

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Current Trends

One reliable way to discern where IS and data storage management might be headed is to project present trends. Every current trend has a built-in momentum that will carry it forward. Some of the IS trends we see today that will continue to have an impact on the growth in popularity of DLTtape technology in the future include:

- Growing network storage demands (some say total storage capacity is doubling every 12 to 18 months).
- Shrinking backup windows.
- Expanding applications and databases.
- Reliance on information as a strategic asset (only those who manage and massage it best stand a chance to win).
- Faster, bigger, “smarter” storage automation systems.
- Centralization in backup and information storage management.

All the data backup trends evident in IS today point to a bright future for DLTtape technology. For instance, as the backup window continues to close, it will become even more critical that tape drives be fast and reliable, and provide the highest data density possible. DLTtape systems are already leading the way in these important areas. As more organizations move to tape automation

to solve the backup crisis, the DLTtape system will continue to be the system of choice for library vendors and end users alike.

Big Iron In Server Clothing

One trend that promises to continue for the foreseeable future is re-centralization. In the past – before the personal computer – information management was handled by the “data processing” crew in the glass room with the raised floor. They handled data backup, application development, and access to information. Then the PC changed everything. Before we knew it, PCs had spread to every corner of the organization. Now, we have vast heterogeneous networks that include PCs, servers, workstations, and mainframes. With data distributed far and wide, few organizations have adequate systems in place to back up everything that’s critical.

However, the computing industry is starting to look a little like the fashion world – let enough time pass and what once was old is new again. Experts said the rise of the PC LAN and client/server computing would kill the mainframe. Now, the mainframe is re-emerging as big servers. And, IS departments are beginning to use these mainframe class servers to bring order to network chaos through centralized file and backup control. These big systems need big tape drives for backup, and the DLTtape system is and will continue to be the system of choice for these organizations.

Library Trends

Users of low to mid-range systems are beginning to exceed the capacity of standalone tape drives, and are migrating to automated storage management solutions. Library vendors will continue to incorporate DLTtape systems in their products. DLTtape technology offers library vendors and their users scalability in the same footprint, low cost-per-gigabyte, and built-in market acceptance.

At the high end of the library market, modular systems that can be expanded with additional drives and tape slots will continue to offer cost-effective and scalable solutions. The fundamental features of the DLTtape system will continue to attract library makers. These manufacturers know that the very nature of library operation requires a drive that can withstand constant operation and countless loads and unloads without failing. That's the kind of proven performance library makers and their customers demand, and only the DLTtape system can deliver.

DLTtape System Products For Every Market

The introduction of the Super DLTtape drives has created a clear stratification of the DLTtape system product line-up. DLTtape systems now form distinct product lines, differentiated by capacity, performance and price, with Super DLTtape products at the higher end of the DLTtape family, and the DLT 4000, DLT 8000, and DLT1 drives evolving into entry-level systems, offering very high value at lower price points.

With DLTtape technology leading the mid-range market in capacity, performance and reliability, other tape technologies such as 8mm have been pushed down on top of low end drives on their way up. DDS4 DAT drives and advanced QIC drives are competing directly with 8mm in certain markets. The value line DLTtape systems, the DLT 4000, DLT1, and DLT 8000, are well-positioned to provide library vendors, workstation makers, and network integrators with high performance, budget-minded solutions that provides scalability and compatibility with higher performance DLTtape system products.

Our competitors know they have an uphill battle to match or beat DLTtape technology for high performance backup. Through several generations of DLTtape systems, we have been able to achieve market-leading performance while maintaining compatibility with previous products.

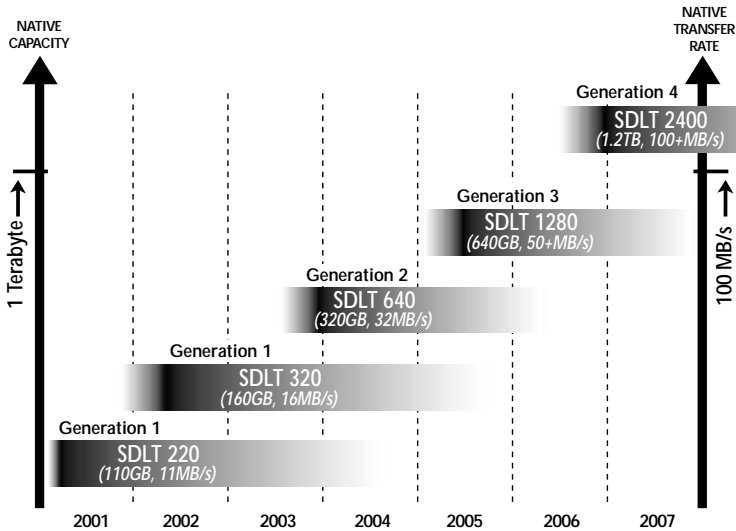


Figure 17-1 Super DLTtape, the Next Generation of DLTtape Technology, supports the development of multiple generations of systems, extending per-cartridge capacity to over a terabyte, and transfer rate to over 100MB/s. For roadmap updates, visit www.DLTtape.com.

Raising The Bar

The DLTtape system can continue to improve in performance and capacity well into the future. A DLTtape cartridge has over 10,000 square inches of recording area, several times the recording area offered by helical scan technologies. There are two reasons for this. First, the DLTtape system uses half-inch tape, which is wider than the tape used by helical scan technologies. Second, helical scan tape cassettes contain two reels, so they are only half full of usable tape. As a result, DLTtape technology has far greater potential for continued capacity improvement.

Super DLTtape Technology

Early in 1998, Quantum announced the next-generation Super DLTtape technology. Initial shipments of Super DLTtape technology products started in 2000 (see Figure 17-1), with volume produc-

tion starting in Q1, 2001. We believe this new Super DLTtape technology will become even more dominant than the DLTtape system is today. While today's DLTtape technology is expanding its market share, the next-generation Super DLTtape products leapfrog all current and proposed competitive technologies.

Our product development road map offers a path for customers to follow with confidence. Follow-on generations of Super DLTtape system products have specifications offering even greater capacity and transfer speeds than offered today.

We believe that there are compelling business and technology reasons why DLTtape and Super DLTtape technology will continue to be number one in tape technology for mid-range systems and will actually become even more dominant than it is today.

Why Super DLTtape Will Win: Business Reasons.

DLTtape systems are clearly today's dominant technology in the fast growing mid-range system market. We have shipped 1.5 million DLTtape drives. More important, there are 55 million DLTtape media cartridges out there. Every major computer systems manufacturer offers DLTtape systems as standard equipment. Every major manufacturer of automated tape libraries is committed to DLTtape technology.

While competing technologies get ready to hit the market, the dominance of DLTtape technology won't change. Nobody is going to stop buying servers for the next year, and nobody is going to stop backing up while they wait for new technology. Given the superiority of current DLTtape systems, and the innovative technology offered by Super DLTtape, there is every reason to believe that Quantum DLTtape technology will continue to be the market leader.

Seamless Transition

DLTtape products, current and future, offer backward compatibility to the large and growing installed base of DLTtape systems. If you are running an IT operation, you will probably consider updating your backup strategy to take advantage of the dramatic increases in capacity and speed proposed for the next-generation technologies. However, your first question will probably be, “Can we do this without disruption.” If you are using DLTtape technology, and if you switch to a non-DLTtape technology, there will be disruption. And you will not be able to use the new technology to read existing DLTtape media. Even if you are not using DLTtape technology, you may suffer disruption if you move to the competing next generation technologies, because in many situations they are not compatible with current technology.

But if you move from DLTtape to Super DLTtape technology, you continue to handle your backup, disaster recovery, and other storage management functions exactly as you do today. More importantly, you are able to read existing DLTtape IV cartridges on your new Super DLTtape drives.

DLTtape IV is the media that we ship today on all our DLT 4000, DLT1, DLT 7000, and DLT 8000 drives; it accounts for the great majority of current DLTtape media shipments. Because of the extraordinarily rapid growth of DLTtape technology, the DLTtape IV media, which was only introduced in 1998, already represents a large part of the total installed world population of DLTtape media. Thus, Super DLTtape drives are able to read a very large percentage of the data written to the large and growing installed base of DLTtape media. Therefore, users can take advantage of the dramatic advances of Super DLTtape technology without diminishing or disrupting access to existing data.

Ubiquity

The definition of “open standards” is up for debate. UNIX is considered an open standard. Yet, there have been literally dozens of

flavors of standard UNIX over the years. Which has not prevented UNIX from working as an open system.

On the other hand, Windows is proprietary. Yet, because it is also ubiquitous, Windows is clearly an industry standard. We believe that DLTtape technology, by virtue of its ubiquity, provides the advantages of an open industry standard:

- It does not impose limits on the choices open to users. You can use the operating system, the hardware platform, and the applications, and utility software of your choice. Virtually all are compatible with DLTtape systems.
- It is open to competition. Every system manufacturer and every library builder and dozens of VARs and distributors offer DLTtape systems. There is plenty of competition.
- It is open to input from the outside world. Our customers are the world's leading system builders and library manufacturers. We listen to them, we maintain an ongoing dialogue aimed at making sure DLTtape technology meets their goals. And we work with literally dozens of software developers whose goal is to maximize DLTtape system performance.
- We have second-source manufacturing from Tandberg.

Why Super DLTtape Technology Will Win: Innovation

The strong business arguments in favor of DLTtape technology would be less important if other technologies offered substantial performance advantages. Why would you switch from DLTtape technology unless something else had a compelling advantage? In fact, it is Super DLTtape technology that offers the compelling advantage. The Super DLTtape technology road map lays out landmarks that call for native capacity starting at 110GB in the first generation, advancing to over 1 terabyte (uncompressed) over multiple product generations. This is the most compelling road map in the industry. It meets or substantially exceeds every published competitive spec.

LGMR Technology

The cornerstone of the Super DLTtape technology platform is its use of Laser Guided Magnetic Recording (LGMR). This unique technology application will produce an advanced scalable platform designed to meet an extraordinary range of storage requirements, and to support multiple generations of products.

LGMR ensures higher cartridge capacities by allowing for the substantial increase in the number of recording tracks and recording density on the data surface of the media by servoing from optical targets on the media's back side.

In the development of Super DLTtape technology, design engineers aimed to advance the capabilities of many of the critical attributes of magnetic recording. By using enhancements in tape formulations, head designs, and recording channel technologies, they were able to achieve increased recording densities and a substantial increase in the number of tracks available for recording. However, by increasing the number of tracks, more advanced servo techniques were required to ensure efficiency. It was clear that all traditional magnetic tape servo methods had a fundamental problem: they all used a portion of the recording surface to store the servo track information. The engineers created a design breakthrough: they designed and developed technology to take advantage of the previously unused backside of the media by laser-etching optically read servo tracks on a specially formulated back coating. This design innovation – the placing of magnetic data tracks on one side of the tape and indelible optical guidance tracks on the other – provides increased storage space on the magnetic side of the media. By introducing these Quantum-refined optical tracking technologies, the servo tracking capabilities of traditional magnetic systems have been greatly improved. The result is the foundation of LGMR. (See Figure 17-2.)

Four key technologies contribute to the revolutionary capacity and performance LGMR brings to Super DLTtape technology. Those Quantum-patented technologies are:

- Pivoting Optical Servo (POS)
- Magneto-Resistive Cluster Heads (MRC)
- A new, High-Efficiency PRML Channel
- Advanced Metal Powder Media (AMP).

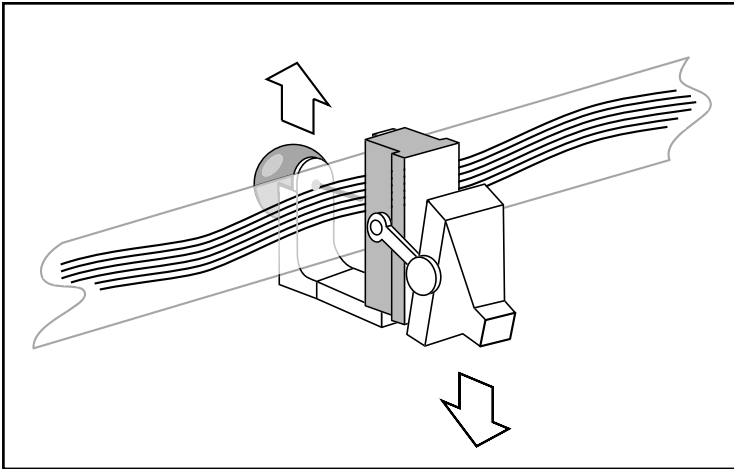


Figure 17-2 LGMR Technology Increases Tape Capacity by increasing the number of recording tracks on the data-bearing side of the tape and servoing optically on the back side.

Pivoting Optical Servo (POS)

The Pivoting Optical Servo is at the core of LGMR technology. It offers a combination of the best of optical and magnetic technologies. POS is an optically assisted servo system, which combines high-density magnetic read/write data recording with laser servo guiding. Designed for high duty cycle applications, the POS has a much lower

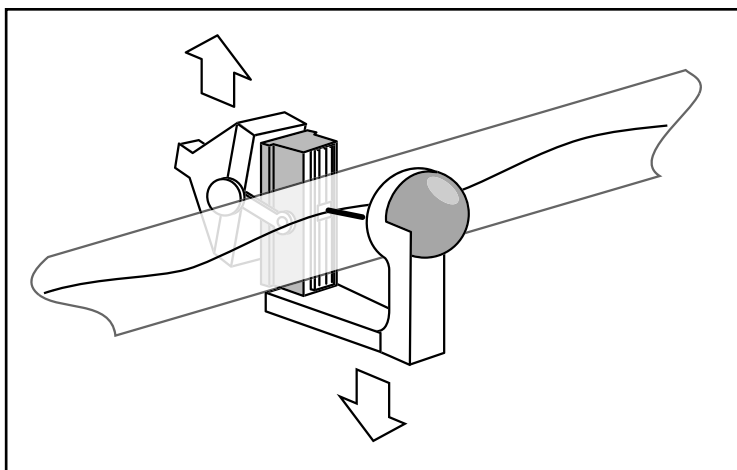


Figure 17-3 POS Technology Implements *an optical servo on the unused back side of the media, allowing 100% of the data-bearing side to be used for data recording.*

sensitivity to outside influences, which allows the Super DLTtape system to achieve a track count with an order of magnitude increase over current DLTtape products. (See Figure 17-3.)

Magneto-Resistive Cluster Heads (MRC)

Quantum has evolved the Magneto-Resistive Cluster heads to a new level as they are integrated into the POS as an LGMR-enabling technology. MRC heads are small magneto resistive heads densely packed together to form a “cluster.” These clustered heads are joined together through the use of advanced thin film processing technology. MRC provides higher data transfer rates and capacity than traditional MR heads of equal size. MRC heads also provide high wafer usage efficiency for low head costs. They offer higher track density and capacity through greater resistance to environmental considerations like temperature and humidity, and they increase transfer rates and performance with multiple heads. (See Figure 17-4.)

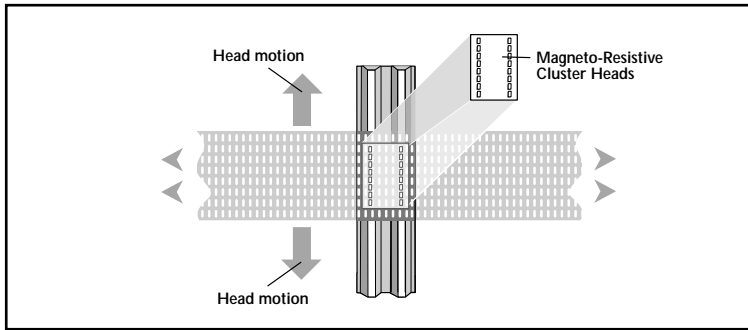


Figure 17-4 Super DLTtape Read/Write Head features 8 channels. Very small Magneto-Resistive Cluster (MRC) Heads yield data transfer rates as high as 11MBs.

New High-Efficiency PRML Channel

A newer PRML channel improves on traditional PRML disk drive technology by bringing new levels of performance and capacity to LGMR technology and high-performance tape drives. The advanced, high-efficiency PRML channel used in LGMR was developed jointly by Quantum and Lucent Technologies. It provides high encoding efficiency recording densities (97 percent efficient) for greater capacity and performance, which enables Super DLTtape technology to substantially increase its transfer rates and capacities over current DLTtape products and other linear tape technologies.

Advanced Metal Powder Media (AMP)

The Advanced Metal Powder media is a vital component of the foundation of Super DLTtape technology. The state-of-the-art AMP media increases the native capacity of the media to at least 110GB per cartridge, offering ease-of-use and lower total cost of ownership. AMP media uses durable metal powder technology to store very high densities of data and contain embedded information for the POS system. Neither magnetic servo writing nor media magnetic pre-formatting are required for the Super DLTtape system. (See Figure 17-5.)

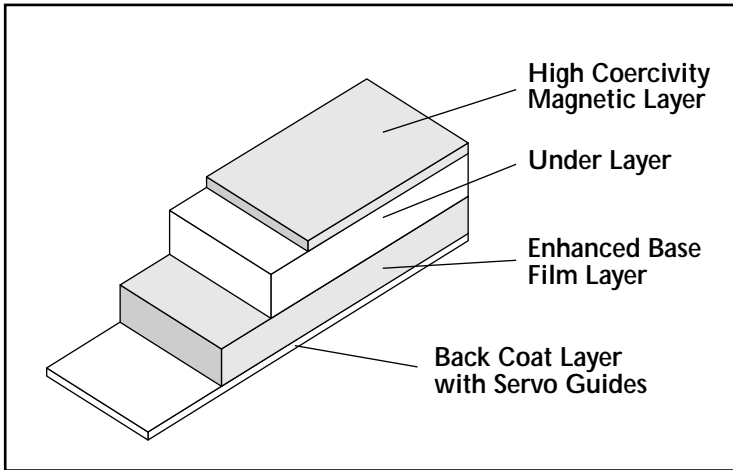


Figure 17-5 Advanced Metal Powder (AMP) Media supports high density data storage and embedded information for the Pivoting Optical Servo.

Positive Engagement Tape Leader Buckling Mechanism

Super DLTtape Systems feature a newly designed Positive Engagement Tape Leader Buckling Mechanism – a robust buckling system that increases cartridge life and supports the heavy duty cycle environments found in high-end and automated environments. (See Figure 17-6.)

This unique new buckling mechanism engages the tape leaders upon cartridge load and disengages them upon cartridge unload. It uses a solid metal pin that is attached to the drive leader to link with molded clips attached to the tape leader inside the cartridge. The Positive Leader Link design makes the buckling of Super DLTtape I media a highly reliable mechanical process. In addition to supporting Super DLTtape I media cartridges, the buckling mechanism also supports existing DLTtape IV data cartridges to ensure backward-read compatibility.

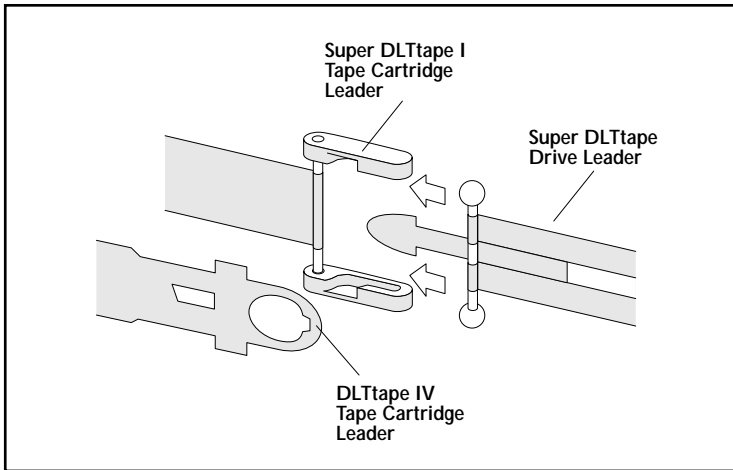


Figure 17-6 Positive Engagement Tape Leader Buckling Mechanism *increases cartridge life and supports heavy duty-cycle, 7x24 environments, along with compatibility with DLTtape IV media.*

New, Rugged Media Cartridge

The Super DLTtape I cartridge has a new, more rugged design for greater durability. (See Figure 17-7.) The Super DLTtape I cartridge features a thicker internal circular wall surrounding the media and more structural ribbing to increase overall cartridge resiliency and reduce potential damage resulting from a drop. New, wear-resistant materials reduce the potential for debris generation and increase the life of the cartridge.

Modular Design

Quantum engineers have built the Super DLTtape System in five distinct modules:

- TCM - Tape Control Module
- DCM - Data Control Module
- FPM - Front Panel Module
- EIM - Electronics and Interface Module
- CTM - Cartridge Tape Module

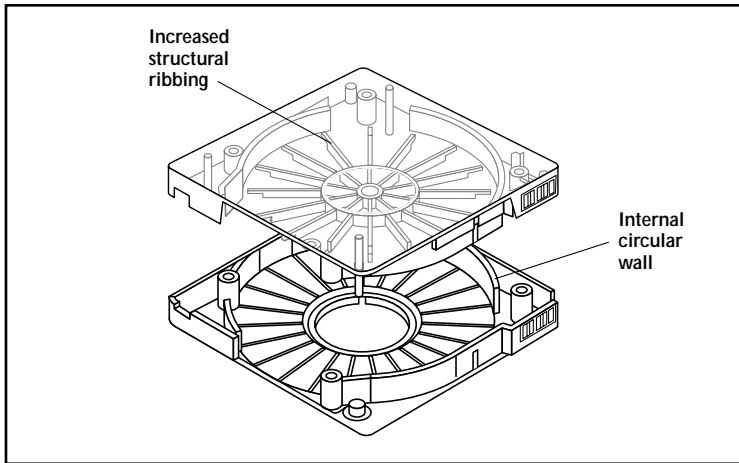


Figure 17-7 New, rugged cartridge design *reduces the potential for damage, and wear resistant materials reduce debris generation.*

The modules include the best features of current DLTtape technology design and the breakthrough technologies that allow the Super DLTtape system to achieve its exceptional performance. Each module is optimized to perform a specific set of functions and is designed to interface with the other modules in a prescribed manner. (See Figure 17-8.) Customers reap important economic benefits from the Super DLTtape system's modular design, such as decreased time-to-market and manufacture, and improved support and services.

Managing Technology Risk

We are introducing the new Super DLTtape technologies within a proven technology framework, minimizing technology risk. Within that framework, we have developed a clean, no-compromise architecture that provides enormous technology headroom across multiple product generations. Thus, Super DLTtape technology provides the basis for both dramatic short-term increases in speed and capacity, and for long-term advances that enable the continued

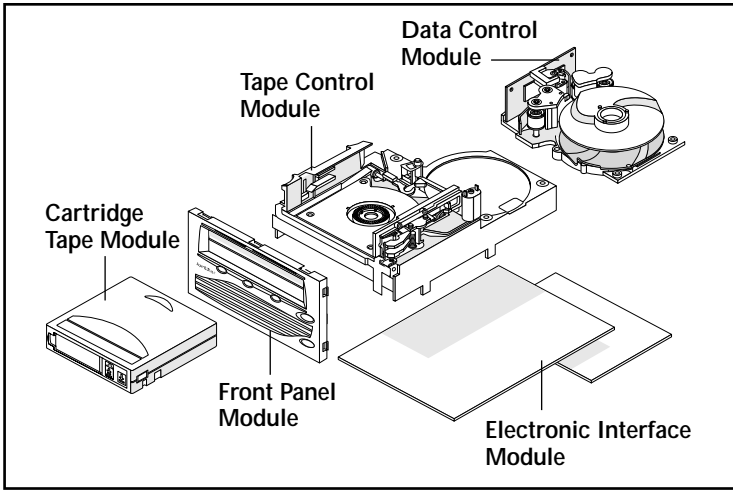


Figure 17-8 The Modular Design of the Super DLTtape drives makes them easier to design, manufacture, and upgrade.

central role of DLTtape technology in our customers' storage strategies.

We hope you've enjoyed this look into DLTtape technology. One thing is certain, the DLTtape system is the system to beat for a long time to come. If industry-leading capacity, reliability, and speed sound good to you, then you owe it to yourself and your organization to explore the DLTtape system with Quantum or one of the many qualified DLTtape system vendors or tape automation system providers.

Appendix A

Super DLTtape System

Products: SDLT 220 Drive



SDLT 220

For the mid-range server market, the SDLT 220 drive offers storage capacity of 110GB and data transfer rate of 11MB/sec. This model is designed to provide excellent data backup and archiving storage for mid-range UNIX and NT systems for use in larger corporate departments operating in networked or stand-alone application environments. The mid-range library automation market will also benefit from the higher performance and backward read compatibility with DLT 4000, DLT1, DLT 7000, and DLT 8000 drives.

	SDLT 220
Formatted Capacity (GB)	110 Native
Form Factor	5.25
Sustained Transfer Rate (MB/sec) Synchronous	11
Peak Transfer Rate (MB/sec)	22
Recording Format	448 Track Serial, Serpentine Variable Block
Recording Format (bpi)	131,000
Track Density (tpi)	896
Drive MTBF (hrs)	250,000
Head Life (hrs)	50,000
Typical Power Consumption (W)	25
Warranty (years)	3

DLTtape System Products: DLT 8000 Drive



DLT 8000

The Quantum DLT 8000 half-inch cartridge tape drive provides leadership in data storage and retrieval for demanding data backup, archiving, and near on-line storage applications for mid range systems. The tape drive features a native transfer rate of 6MB/s, with a native capacity of 40GB. Building on the traditional strengths of DLTtape system technology, the DLT 8000 tape drive provides significant advantages in performance and capacity over others in its class.

	DLT 8000
Formatted Capacity (GB)	40 Native
Form Factor (inches)	5.25
Sustained Transfer Rate (MB/sec) Synchronous	6.0
Peak Transfer Rate (MB/sec)	12
Recording Format	208 Track Serial Serpentine, Variable Block
Recording Format (bpi)	98,000
Track Density (tpi)	416
Drive MTBF (hrs)	250,000
Head Life (hrs)	50,000
Typical Power Consumption (W)	28
Warranty (years)	3

DLT1 Drive



DLT1

The Quantum DLT1 half-inch tape drive is designed to provide high-capacity backup for small- to medium-size storage servers and workstations in cost-sensitive applications. The DLT1 tape drive offers a combination of 40GB native capacity per cartridge and a native transfer rate of 3MB/s.

	DLT1
Formatted Capacity (GB)	40 Native
Form Factor (inches)	5.25
Sustained Transfer Rate (MB/sec) Synchronous	3.0
Peak Transfer Rate (MB/sec)	20
Recording Format	168 Track Serial Serpentine, Variable Block
Recording Format (bpi)	123,000
Track Density (tpi)	336
Drive MTBF (hrs)	200,000
Head Life (hrs)	30,000
Typical Power Consumption (W)	15
Warranty (years)	3

DLT 4000 Drive



DLT 4000

The Quantum DLT 4000 half-inch tape drive is designed for heavy duty-cycle computer applications in the lower to middle level of the tape drive market for mid-range systems. The DLT 4000 tape drive offers a combination of 20GB native capacity per cartridge and a native transfer rate of 1.5MB/s.

	DLT 4000
Formatted Capacity (GB)	20 Native
Form Factor (Inches)	5.25
Sustained Transfer Rate (MB/sec) Synchronous	1.5
Peak Transfer Rate (MB/sec)	10
Recording Format	128 Track Serial Serpentine, Variable Block
Recording Format (bpi)	82,000
Track Density (tpi)	256
Drive MTBF (hrs)	200,000
Head Life (hrs)	10,000
Typical Power Consumption (W)	25
Warranty (years)	3

DLTtape Cartridges



DLTtape III

DLTtape IIIXT

DLTtape IV

Super DLTtape I

The Quantum DLTtape family of half-inch cartridges, approved for use in all DLTtape system drives and autoloaders, delivers the highest capacity of any 5.25-inch cartridge – up to 220GB in compressed mode. To ensure accuracy, a patented tape leader ensures consistent tape motion, while a unique tape/reel locking mechanism prevents tape slack. The tape itself features a special high-grade Metal Particle (MP; DLTtape III, DLTtape IIIXT and DLTtape IV), or Advanced Metal Powder (AMP; Super DLTtape I) formula that reduces tape and head wear. The result is tape that delivers a proven one million passes with a negligible impact on soft error rates and a 30-year archival life.

DLTtape	III	IIIXT	IV	Super DLTtape I
Formatted Capacity (GB)				
DLT 4000	10	15	20	20
DLT1	NA	NA	40	NA
DLT 8000	10	15	40	40
SDLT 220	NA	NA	40	110
Tape Life				
Archival Storage (yrs) (with <5% loss in demagnetization, at 20°C & 40% non-condensing humidity)	>20	>30	>30	>30
Durability (average head passes in typical office/computer environment)	.5 million	1 million	1 million	1 million
Tape Characteristics				
Tape Type	MP	MP	MP	AMP
Overall Length (ft.)	1,200	1,828	1,828	1,828
Color	Gray	White	Black	Black
Warranty	Limited Lifetime Warranty			

Glossary

A

Access. (v) Read, write, or update information on a storage medium, such as tape. (n) The operation of reading, writing, or updating stored information.

Access time. The interval between the time a request for data is made by the system and the time the data is available from the drive.

Advanced Metal Evaporated (AME). A type of tape media created by depositing a thin layer of magnetic material onto a base by means of evaporation. AME's pure magnetic layer allows for high data density.

Advanced Metal Powder (AMP). A state-of-the-art media designed for Super DLTtape. It incorporates durable metal powder technology for high-density data storage and embedded non-magnetic information for head tracking.

Advanced Servo Positioning (ASP). This closed-loop positioning system allows increased data density by continually adjusting the position of the tape drive's read/write head to achieve the strongest signal strength.

Allocation. The process of assigning particular areas of the media to particular data or instructions.

Archiving. The removal of data from the computer system on to secondary storage media that is safely stored away. The DLTape system is an excellent choice for archiving due to its 30-year shelf life.

Automation. Refers to tape stackers, autoloaders, libraries used in data backup, archiving, hierarchical storage management, and near on-line storage. A system that generally has storage for multiple tape cartridges, a robotic cartridge-handling system, an electronic control system, software, and one or more tape drives.

Autoloader. A system that uses a robotic mechanism to automatically load and unload tape cartridges into a single tape drive. Used to provide unattended data backup and file restoration.

Average Seek Time. The average time it takes for the read/write head to move to a specific location. To compute the average seek time, divide the time it takes to complete a large number of random seeks by the number of seeks performed.

B

BOT. Acronym for beginning of tape. Indicated on a DLTape cartridge by a small hole in the leader portion of the tape.

BPI. Acronym for bits per inch. A measure of how densely information is packed on a storage medium.

Backup. A copy of a file, directory, or volume on a separate storage device from the original, for the purpose of retrieval in case the original is accidentally erased, damaged, or destroyed.

Backup Window. The period of time used to back up critical databases and other information. With an increasing number of companies running 7x24 applications, the backup window in many cases is either shrinking or closed.

Backward Compatibility. The capability of all DLTtape drives to read tapes written on previous generations of DLTtape drives. Preserves the end users' investment in DLTtape media and drives.

Bad Data Block. A block that cannot reliably hold data because of a media flaw or damaged format markings.

Bar Code Reader. A scanning system used in many large tape libraries to inventory tape cartridges and identify cartridge content by recognizing assigned codes.

Bezel. (Also known as the faceplate.) A plastic panel that extends the face of a drive so that it covers a computer's drive bay opening. The bezel usually contains a drive-activity LED.

Bit. Abbreviation for binary digit. A binary digit may have one of two values: 1 or 0. This contrasts with a decimal digit, which may have a value from 0 to 9. A bit is one of the logic 1 or logic 0 binary settings that make up a byte of data. See also byte.

Block. A sector or group of sectors. By default, a sector of data consists of 512 bytes.

Buffer. An area of RAM reserved for temporary storage of data that is waiting to be sent to a device. The data is usually on its way to or from the hard disk drive or some other peripheral device.

Bus. The part of a chip, circuit board, or interface designed to send and receive data.

Byte. The basic unit of computer memory, large enough to hold one character of alphanumeric data. Comprised of eight bits. See also bit.

C

CPU. Acronym for central processing unit. The microprocessor chip or group of chips that perform the bulk of data processing in a computer.

CRC. Acronym for cyclic redundancy check. An error detection code that is recorded within each sector and is used to see whether parts of a string of data are missing or erroneous.

Cache. Specialized RAM used to optimize data transfers between system elements with different performance characteristics, e.g., disk to main memory or main memory to CPU.

Cache Buffering. A technique used in DLTtape drives to reduce stops, starts, and repositioning delays due to a difference between the host data rate and that of the DLTtape drive.

Capacity. The amount of information that can be stored on a tape drive. The data is stored in bytes, and capacity is usually expressed in megabytes or gigabytes.

Closed-Loop Servo Control. See Advanced Servo Positioning.

Coercivity. The measure of magnetic strength required to change the magnetic orientation of a data bit stored on tape media.

Compression. Encoding data to take up less storage space on magnetic tape. Compression is carried out in the host (software compression) or in the drive itself (hardware compression). Software compression speed is dependent on host processor power, whereas hardware compression gives optimum performance and is transparent to the user. Data transfer speed and total tape capacity are affected by the data compression achieved.

Compression Algorithm. A mathematical technique used to find patterns in data and thereby save space through encoding. Achievable compression is dependent on the type of data being compressed. All DLTtape drives use the LZ1 compression algorithm (See Lempel-Ziv).

Controller. The chip or circuit that translates computer data and commands into a form suitable for use by the hard drive. Also known as the disk controller.

Corrupted File. A data file that has been rendered unreadable due to a variety of causes, including tampering, accidental alterations, physical damage, and data loss. Corrupted files are one important reason why companies need to back up on a data regular basis.

Cpio. A UNIX operating system command that stands for “copy file archives in and out.”

Cyclic Redundancy Check (CRC). See CRC.

D

DMA. Acronym for direct memory access. A process by which data moves directly between a drive (or other device) and system memory without passing through the CPU, thus allowing the system to continue processing other tasks while the new data is being retrieved.

Data Cartridge. The enclosed media cassette that is used to hold recording/restoral media.

Data Compression. A process generated by either hardware or software that reduces the amount of storage space required to hold a particular block of data. Typical compression rates are 2:1 or 3:1 and allow approximately double and triple the data storage respectively.

Data Integrity. The level of error-free storage of data. It is a key factor in the reliability of any technology.

Data Interchange. The capability of moving data from one tape drive to another without intermediate processing.

Data Mining. The identification of trends and other patterns in very large databases of consumer and other information. DLTtape drives are often used to back up and/or provide near on-line access to large databases used in data mining.

Data Mirroring. Capability provided by multi-drive tape libraries or RAIT (Redundant Array of Independent Tape drives) systems whereby two copies of the same data are written simultaneously. Provides copy of data for off-site archiving and disaster recovery protection.

Density. The amount of data stored in a particular section of media. The higher the density the more data stored in the same space.

Duty Cycle. A measure of the percentage of time a tape drive is actually used during a given period. Most tape drive manufacturers provide reliability figures based on 20 percent or less duty cycle. DLTtape drive figures are based on 100 percent duty cycle.

E

ECC. Acronym for Error Correction Code. The incorporation of extra parity bits in transmitted data in order to detect errors that can be corrected by the controller.

EDC. Acronym for Error Detection Code. DLTtape drives include a 16-bit EDC with every 4KB of user data. The EDC helps the drive detect and recover any errors that may occur.

EEPROM. Acronym for electronically-erasable programmable read only memory. An integrated circuit memory chip that can store programs and data in a non-volatile state. These devices, which are used to store firmware in DLTtape drives, can be erased and reprogrammed with new data.

Encoding. The protocol by which particular data patterns are changed prior to being written on the tape surface as a pattern of On and Off or 1 and 0 signals.

External Drive. A drive mounted in an enclosure, separate from the computer system enclosure, with its own power supply and fan, and connected to the system by a cable.

Extranet. The connection of two or more Intranets over the Internet. This allows the privacy of an Intranet with the global connectivity of the Internet.

Erase. The removal of data from a piece of media.

Error. A message that occurs when there is a loss of ability to interpret recorded data. Usually due to magnetic issues or defects in or on the media.

Error Correction Code. See ECC.

Error Detection Code. See EDC.

F

FCI. Acronym for flux changes per inch. See also BPI.

Faceplate. See bezel.

Files. A distinct group of data blocks.

File-by-File Backup. A recording method that records data a single file at a time as opposed to mirroring a tape or block of data.

Firmware. Permanent or semi-permanent instructions and data programmed directly into the circuitry of programmable read-only memory or electronically-erasable programmable read-only memory chips. Used for controlling the operation of the computer or tape drive. Distinct from software, which is stored in random access memory and can be altered with ease.

Format. A magnetic track pattern that specifies the locations of the tracks and sectors. This information must exist on a tape before it can store any user data. Formatting erases any previously stored data.

Formatted Capacity. The amount of room left to store data on a tape after writing the sector headers, boundary definitions, and timing information during a format operation.

Form Factor1. The industry standard that defines the physical, external dimensions of a particular device.

Form Factor2. The general geometric dimensions of a drive or width of a piece of tape media.

Full Height. Dimensions of a drive that meet standard height requirements (usually 3.25 inches for a tape or disk drive product).

G

Gigabyte (GB). A unit of measure consisting of one billion bytes (one thousand megabytes).

H

Half Height. Standard drive size equivalent to half the vertical space of a 5.25-inch drive.

Hard Error. A data error that persists when the tape is reread, usually caused by defects in the physical surface.

Head. The tiny electromagnetic coil and metal pole used to create and read back the magnetic patterns on the tape. Also known as the read/write head.

Head Life. The length of time a tape drive head will function without replacement or repair, usually measured in hours of use.

Helical Scan. Helical Scan technology drives employ a recording style in which data tracks are written at an angle relative to the edge of the tape rather than in a linear serpentine style of DLTtape.

Hierarchical Storage Management (HSM). A storage system that migrates the least-accessed data to secondary storage. The primary purpose is to ease the management of data while reducing over-all cost by storing this data on more cost-effective media like DLTtape cartridges.

I

ISV. Acronym for independent software vendor.

Image Backup. A backup option that takes a “snapshot” of an entire system by writing a volume image to tape sector-by-sector, rather than file-by-file. This method of backup is very fast and allows companies to backup critical information in a limited backup window.

Interface. A hardware or software protocol, contained in the electronics of the tape controller and tape drive, that manages the exchange of data between the drive and computer. The most common interfaces for small computer systems are AT (IDE) and SCSI.

Internal Drive. A drive mounted inside one of a computer’s drive bays.

Internet. A worldwide network of computer servers originally developed by the federal government as a communication system in the event of nuclear war or other wide-scale disaster.

Intranet. A private version of the Internet that provides a cost-effective way to publish critical information and provide an interactive communication path for heterogeneous systems.

J

Jumper. A tiny connector box that slips over two pins that protrude from a circuit board. The jumper can be moved to change electrical connectors. When in place, the jumper connects the pins electrically. Some board manufacturers use dual in-line package (DIP) switches instead of jumpers.

K

Kilobyte (KB). A unit of measure consisting of 1,024 bytes.

L

Lempel-Ziv Algorithm. A data compression technique used in all DLTtape drives. Named after Abraham Lempel and Jacob Ziv.

Laser Guided Magnetic Recording (LGMR). The Super DLTtape data recording system. It employs a precision optical head mechanism (Pivoting Optical Servo) for accurate head tracking, along with magnetic heads for reading and writing data.

Library System. A system that uses a robotic mechanism to automatically load and unload tape cartridges into one or more tape drives. Distinguishable from stackers and autoloaders in their ability to provide random access to tape cartridges.

Linear Recording. Recording technology in which data is written in tracks that run the length of the tape media. Contrast with helical scan technology which records data diagonally across the tape.

M

MB. See megabyte.

MHz. See megahertz.

MRC Heads. Magnetic Resistive Cluster heads, the read/write heads for Super DLTtape. A cluster of small, cost effective magneto resistive tape heads that can deliver higher data transfer rates and capacity than traditional MR heads of equal size.

MTBF. Acronym for Mean Time Between Failures. Reliability rating indicating the expected failure rate of a product in power on hours (POH). Since manufacturers differ in the ways they determine the MTBF, comparisons of products should always take into account the MTBF calculation method.

MTTR. Acronym for mean time to repair. The average time it takes to repair a drive that has failed for some reason. This only takes into consideration the changing of the major subassemblies such as the circuit board or sealed housing. Component-level repair is not included in this number as this type of repair cannot be performed in the field.

Media. The material or device used to store information in a storage subsystem, such as a tape or disk drive. DLTtape media is a high-grade metal particle (MP) formulation that takes advantage of the latest advances in binder chemistry. By combining both solid and liquid lubricants in the tape binder system, tape and head wear are reduced while repelling airborne particles that could affect read/write head performance. In addition, by using a uniform particle shape, a dense binding system, a smooth coating surface, and a specially selected base film, DLTtape half-inch cartridge tapes take advantage of shorter wavelength recording schemes to ensure read compatibility with future generations of DLTtape drives.

Megabyte (MB). A unit of measurement equal to 1 million bytes.

Megahertz (MHz). A measurement of frequency in millions of cycles per second.

Metal Particle (MP) tape. A magnetic recording media in which a flexible base is coated with a mixture of magnetic particles and a bonding agent. See also Media.

Microprocessor. The integrated circuit chip that performs the bulk of data processing and controls the operation of all of the parts of the system.

Microsecond (μ s). One millionth of a second (.000001 sec.).

Millisecond (ms). One thousandth of a second (.001 sec.).

Minicomputer. A somewhat out-of-date term used to describe a class of multi-user computer that was one notch below a mainframe system. Minicomputer popularity fell with the rise in popularity of the networked PC. Today's server systems perform many of the functions that were once the domain of mini-computers.

Mission Critical. Applications that are vital to a company or organization's well-being.

N

Native Mode. Refers to the uncompressed storage capacity of a tape or disk subsystem. For instance, a DLT 8000 tape drive can store 40GB in native mode and 80GB with 2:1 compression.

Near On-Line Storage. The use of secondary storage as a primary storage device. Data that is directly accessible is stored on this media and can be accessed as if it were in primary storage. The only difference is that it will take longer to access, thus the term near online.

Network Attached Storage (NAS). In a Network Attached Storage configuration, storage resources are attached as nodes on the network, making available expanded storage resources with minimal management overhead.

O

OEM. Acronym for Original Equipment Manufacturer.

Overhead. Command overhead refers to the processing time required by the controller, host adapter, or drive prior to the execution of a command. Lower command overhead yields higher drive performance.

Overwrite. To write data on top of existing data thus erasing the original data.

P

POH. Acronym for Power On Hours. The unit of measurement for Mean Time Between Failures (MTBF), expressed as the number of hours that the drive is powered on. See MTBF.

PRML. See partial response, maximum likelihood.

Parallel Channel Architecture. Allows DLTtape drives to read/write multiple channels simultaneously, providing a data transfer rate of 6MB/s for the DLT 8000 drive. With this architecture, data blocks are not required to be located on any particular track or in consecutive order. This channel-independent block structure provides a powerful write-error handling system that allows bad blocks to be rewritten on the next available channel.

Partial Response, Maximum Likelihood (PRML). A technology that allows a disk or tape drive's read channel to pack more data in the same amount of space on magnetic media. Super DLTtape technology incorporates a new, high-efficiency PRML channel.

Peak Transfer Rate. The maximum speed with which information moves inside a tape drive or between drive and host. Usually measured in megabytes per second.

Performance. A measure of the speed of the drive during normal operation. Factors affecting performance are seek times, transfer rate, and command overhead.

Peripheral. A device added to a system as a complement to the basic CPU, such as a disk drive, tape drive, or printer.

Petabyte. A unit of measure consisting of one quadrillion bytes (one billion megabytes).

Pivoting Optical Servo (POS). An optically-assisted servo system designed for Super DLTtape for high-duty-cycle applications.

Q

QIC. Acronym for quarter inch cartridge. A tape storage subsystem that uses .25-inch-wide media.

R

RAM. Acronym for random access memory. An integrated circuit memory chip that allows information to be stored and retrieved by a microprocessor or controller. The information can be stored or accessed in any order, and all storage locations are equally accessible.

RAIT. Acronym for redundant array of independent tape drives.

ROM. Acronym for read only memory. Integrated circuit chip containing programs and data that can be accessed and read but cannot be modified.

Random Access. The ability to directly locate any piece of data without having to read everything in memory or on disk.

Read After Write. A mode of operation that has the computer read back each data block immediately after it is written on the tape, checking that the data read back is the same as recorded.

Read/Write Head. The mechanism by which data is recorded on to magnetic media in a tape or disk drive system. See Read After Write.

Reed-Solomon Error Correction. An error correction technique based on research done by Irving Reed and Gustave Solomon at MIT's Lincoln Laboratory in the 1960's. First used to check the accuracy of data received from the Voyager spacecraft.

Restore. To replace data on the hard drive from another media device.

S

SAN. See Storage Area Network

SCSI. Acronym for small computer system interface. An American National Standards Institute (ANSI) interface between the computer and peripheral controllers. Apple Macintosh systems and many UNIX operating system workstations use the SCSI interface.

Scalability. Refers to the capability provided by the DLTtape system family to read tapes from previous generations of DLTtape systems. Allows users to upgrade to a faster, higher capacity DLTtape system, yet still be able to read tape recorded on an older system. The ability to add additional devices or cartridges to a tape library, thus allowing the library to grow as needs grow. The term also refers to the ability of DLTtape library systems to be upgraded with a higher performance DLTtape drive and thus provide more capacity and performance in the same footprint. See backward compatibility.

Seek. The movement of a read/write head to a specific data track.

Self Cleaning Head. Found in all DLTtape drives. Tiny ridges on either side of the DLTtape drive read/write head continuously wipe the tape clean as it passes over the head. This is why there is no periodic cleaning prescribed for DLTtape drives.

Server. A powerful computer system with a large hard disk drive that serves the information access and communication needs of multiple users. Often servers are dedicated to a particular function such as Internet access, printing, file management, backup, and network communications.

Servo Data. Magnetic markings written on the media that guide the read/write heads to the proper position.

Shelf Life. The length of time that a tape can be stored without losing its magnetic strength. For DLTtape media, this period is 30 years or more.

Shock Rating. A rating (expressed in Gs, which stands for multiples of gravity) of how much shock a tape drive can sustain without damage. Operating and non-operating shock levels are usually specified separately.

Soft Error. A faulty data reading that does not recur if the same data is reread from the disk or corrected by ECC. Usually caused by power fluctuations or noise spikes.

Stacker. A tape automation system that sequentially loads and unloads tape cartridges. Does not provide random access to cartridges or the data stored on them.

Stepper. A type of motor that moves in discrete amounts with each electrical pulse.

Storage Area Networks (SAN). Storage Area Networks give users anywhere on the network access to a large, centralized pool of storage resources located on a dedicated high-speed network, and usually backed up by DLTtape libraries.

Super DLTtape. The next-generation DLTtape family of products.

Supply Reel. The reel of tape contained within the DLTtape cartridge. DLTtape IV, for example, contains 1,800 feet of tape.

Surface. The side of the tape that is coated with the magnetic material for recording data.

Sustained Transfer Rate. The data transfer rate of a tape drive in native mode. For instance, the DLT 8000 has a sustained transfer rate of 6MB/s in native mode, and up to 12MB/s at 2:1 compression.

Symmetric Phase Recording (SPR). A recording technique used by the DLT 8000 drive that writes data at alternating angles in a herringbone pattern thereby eliminating the need for guard bands between data tracks, and providing higher data density.

System Manufacturers. Makers of computer systems and tape library systems.

T

TPI. Acronym for tracks per inch. A DLT 8000 drive, for instance, writes data a density of 416 tpi, or 208 tracks across the width of the half-inch DLTtape media.

Take-Up Reel. The reel inside every DLTtape drive onto which DLTtape media is wound. The in-the-drive take-up reel enables DLTtape systems to operate using a single-reel cartridge and thereby pack more tape and data into every cartridge.

Tape Path. The path through which tape moves from the cartridge, past the read/write head, and onto the take-up reel. The patented DLTtape drive head guide assembly provides a gentle and solid path that ensures tracking accuracy and long tape life.

Tar. A UNIX operating system command that stands for “create tape archives” and/or extract files.

Terabyte (TB). A unit of measure consisting of one trillion bytes (one thousand gigabytes).

Thin Film. A type of coating allowing very thin layers of magnetic material used on tape drive read/write heads. Media with thin film surfaces can store greater amounts of data.

Track. A linear or angled pattern of data written on a tape surface. DLTtape drives write information on multiple tracks simultaneously.

Track-To-Track Seek Time. The time required for the read/write heads to move to an adjacent track.

Transfer Rate. The rate at which the drive sends and receives data from the controller. Usually measured in megabytes per second. A DLT 8000 drive, for instance, has a native transfer rate of 6MB/s.

U

Unformatted Capacity. The total number of usable bytes on the media, including the space that will be required later to record location, boundary definitions, and timing information. See also formatted capacity.

V

Volume. The quantity of information written on a piece of media. Typically measured in megabytes or gigabytes.

W

Write Once, Read Many (WORM). An optical disk technology that allows the drive to store and read back data but prevents the drive from erasing information once it has been written.

X, Y, Z

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