SONY

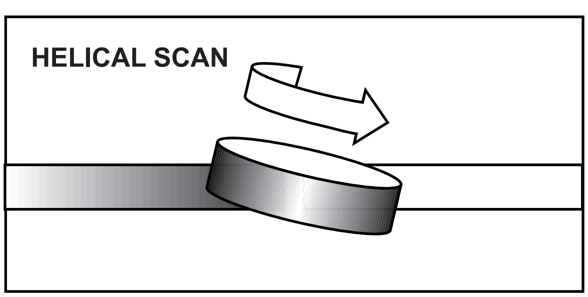
A COMPARATIVE ANALYSIS OF TAPE TECHNOLOGIES FOR MID-RANGE SYSTEMS AND SERVER APPLICATIONS

Emerging Markets - Characteristics and Requirments

Today's emerging digital applications, such as image document and digital content, have joined more traditional data protection and archival storage applications in driving the need for higher capacity, faster, and more durable tape-based solutions. Customers want solutions that maximize the available space, minimize power consumption and other operating costs, shorten recording times, run without manual intervention, and offer the highest levels of reliability. For automation applications, where tape is used because of its lowest cost per terabyte of storage, customers need solutions that permit fast "time-to-data" to their vast amount of stored information, as well as the confidence in the ability to access and retrieve the information later.

This paper highlights the requirements of digital applications and describes the essential tape technology characteristics needed to satisfy these needs in mid-range systems and servers.

Midrange platforms utilize one of two tape technologies, characterized by the method in which they record information: helical-scan or linear serpentine. Helical-scan recording technologies used for data storage were originally developed by Sony Corporation because they could realize both high capacity, as well as space-efficient solutions. These tape technologies are characterized by an efficient packing density, low tape tension, and low tape speeds with a rotating drum/head to achieve an effective head/tape velocity needed to record data accurately. Linear serpentine recording technologies, on the other hand, are characterized by low recording densities requiring large quantities of media, large mechanisms, and greater power consumption to achieve a competitive tape capacity. Linear technologies also require many back-and-forth transversals of the tape ("serpentine recording") to completely record the contents of the media cartridge. In addition and because of the large amount of media required to store data at a competitive capacity point to helical-scan, linear technologies require large, single-reel tape cartridges, resulting in longer media load and unload times, as well as complex and potentially problematic media threading and unthreading operation.



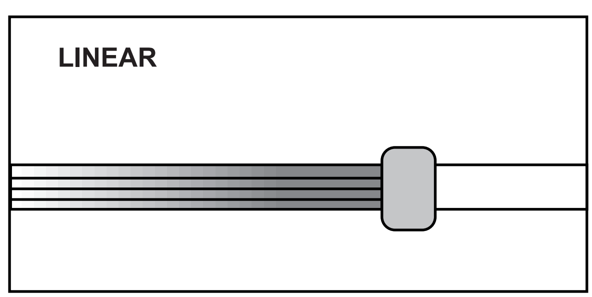


Figure 1: Helical Scan and Linear Recording Methods

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Selection Criteria

Organizations choosing tape products for mid-range systems and servers have to consider capacity, performance, durability, and cost of ownership, and prioritize these for specific applications.

Total cost of ownership, which is derived from these characteristics together with overall space and power needs, is a key criteria across all applications because it directly impacts the cost of doing business.

Tape Recording Density and Capacity

In unattended backup, image/data storage, and archival applications, large amounts of data are written once and read infrequently. In this typically automated environment, total stored capacity is a critical solution characteristic, providing both functional and cost benefits. Small sized, high capacity tapes can hold more data, reducing the total number of automation units required, as well as the physical space and power needed to support them. Higher capacity also allows more data to be “online” for a given number of drives and, in many cases, tape data density and capacity can determine whether additional tape libraries are required for the application, impacting tight floor space, power usage demands, and overall support costs.

Helical-scan technology is uniquely qualified to meet the space and power limitations being experienced today at many customer sites. For example, Sony’s four-cartridge autoloader incorporating AIT-2 drives holds five times more capacity than competing linear tape products in the equivalent 5.25-inch form-factor. Compared to the leading 100GB linear serpentine product available today, Sony’s AIT-2 helical product can provide over 20 percent more effective capacity when used in a comparable automation application. This margin of capacity advantage will increase dramatically with the planned introduction of the next generation, AIT-3, which will hold over four times the data density of the nearest linear tape competitor while occupying less that one half of the drive and media size.

Model Name	AIT-1	AIT-2	M2	DLT8000	LTO	SDLT
Technology	Helical	Helical	Helical	Linear	Linear	Linear
Linear Recording Density	116 Kbpi	167 Kbpi	165 Kbpi	98 Kbpi	131 Kbpi (approx)	113
Areal Density Mbits/Sq. inch	268	385	342	40	100	119

Table 1: Relative Density of Helical Scan vs. Linear Products

Helical-scan product capacities result from a much larger track density (up to 5 times greater) and constitute more efficient recording of the media, than linear serpentine recorded tapes. It is the recording density and space-efficient design that allows helical-scan products to be much smaller than typical linear technlogies at a given capacity point.

Model Name	AIT-1	AIT-2	M2	DLT8000	LTO	SDLT
Technology	Helical	Helical	Helical	Linear	Linear	Linear
Form Factor	3.5"	3.5"	5.25" HH	5.25" FH	5.25" HH/FH	5.25" FH
Media Dimensions (mm) LxWxH	95x62.5x15	65x62.5x15	95x62x15	105.3x105.6x25.4	105x102x21	102.5x102.5x25

Table 2: Comparison of Media and Drive Form Factor

Performance

Many sophisticated data management software packages transparently migrate data between fixed media such as disk drives to "nearline" removeable media, based on application and user file access frequency. Overall tape sub-system performance is crucial in this write once, read many times environment. Unlike typical, sequential backup or archival applications, these "nearline" software solutions frequently access stored data on tape and access performance is a key competitive metric.

Higher data transfer rates, together with fast media load and file search speeds, are needed to provide a total performance solution - a critical need for corporations as they commit more and more information to automated systems. Improved "time-to-data" also enables faster response to data restore requests and could cut hours off the restore times of customer files, when compared to linear technologies. Helical-scan recording is inherently a high performance technology due to its much shorter media length requirements and sequential (non-serpentine) recording. As a result, helical recording can easily outperform the competing linear products in "total access" to data by a margin of two to one or more.

In addition to minimizing "total time to data," helical-scan frequently provides higher data transfer rates due to better "head-to-tape velocity" achieved through the use of a spinning drum or "scanner" element. This element houses the various read and write "heads" and can easily be configured with more head elements to further improve the data transfer rates necessary for today's applications. Although linear serpentine products can also add more recording head elements, this type of configuration becomes more mechanically complex and costly than helical-scan techniques.

Memory-In-Cassette

In addition to the inherent data access benefits of helical-scan recording, Sony's AIT technology has incorporated an innovative semiconductor memory element (Memory-in-Cassette, or MIC) within its tape media cartridge to further improve this important metric. The MIC architecture allows AIT to load media faster and double the file search performance over standard approaches. This further expands the overall margin of advantage in access performance over linear recording techniques.

The AIT approach records format information and file search parameters within the innovative MIC system rather than using "on-tape" index files or requiring the time-consuming media load and tape threading process characteristic of the linear technologies. This feature effectively cuts the data access time in half, regardless of tape drive speed and recording density.

Memory-In-Cassette (continued)

In addition, helical-scan optimizes application performance over a wide range of host data rates by incorporating a very short “streaming re-cycle” time due to the slow tape motion, compared to linear serpentine. Linear technologies have a large mass of media in high-speed motion that needs to be slowed down, then reversed and slowed down to await data. The short re-cycle time of helical-scan, together with its “one-pass” recording nature, allows for a much faster access to customer data. Linear technologies need to “serpentine” back and forth for some portion of their file search, since data is recorded on tape with hundreds of tracks in a “back and forth” motion, rather than a single forward pass.
In addition, if there is an overall data rate mismatch, linear mechanisms must go through a tremendous deceleration and aceleration of the high-speed tape motion. The time required to stop and re-synch can degrade performance noticeably in a random access environment, such as with automation applications. Helical-scan re-positioning time is much faster because of the much lower tape speed and quantity of media, and can outperform a higher data-rate linear drive in this environment.

Over time, demands for increased performance will be just as strong as those for tape capacity. Helical-scan products will meet those demands by continuing to expand the number of data channels written to tape simultaneously. Sony’s next-generation AIT product, the AIT-3, will deliver significantly higher data transfer rates by recording and reading four channels simultaneously. In fact, the highest data transfer rate products on the market today are helical-scan, such as Sony’s DIR-1000 and DTF families.

Durability and Reliability

In the past, when tape was used primarily for backup and archiving, tape drives were busy "reading" and "writing" only about 10 percent to 20 percent of the time they were powered on. Early linear and helical-scan drives and costs reflected this low duty-cycle environment. Today's high duty-cycle automation solutions, which are far more complex than these traditional single drive applications, place a much heavier demand on drives and media. In a fully configured tape automation system, it is not unusual for tape drive utilization to approach 100 percent.

To support this very high utilization, significantly more durable tape drive designs are essential. The characteristics of helical-scan, with its gentle tape motion, air bearing tape wrap and very low tension, together with the exceptional durability of Advanced Metal Evaporated (A-ME) media used in helical-scan drives, make it ideal for this technology to achieve the durability standards required in high duty cycle applications. The unique geometry of the recording head design allows for a very gradual wear profile that promotes exceptional head life and media life.

With linear serpentine recording, on the other hand, the tape undergoes much greater tension, travels at very high speeds over the stationary heads and requires several hundred back-and-forth traverses to complete a full recording of tape. This high-speed “shoe shining” process results in considerable wear of the media and recording heads, and also requires significantly more power dissipation to move, stop and reverse tape motion at those high speeds. In addition, during the serpentine reversal cycle at the end of each of several hundred passes, the linear mechanism introduces several seconds of data transfer delay, further impacting overall performance in a high demand environment. Helical-scan, on the other hand, has no such delay since it is continously moving tape in a single direction.

Cost of Ownership Benefits - Power Consumtion

Helical-scan's more cost-effective design, lower power consumption, smaller form-factor, and durable recording heads and media life translate directly into cost of ownership benefits. Within a 5.25-inch full height form-factor typical of the current linear products, a helical-scan mechanism, such as an AIT autoloader, can provide over four times the capacity, minimal down-time, and perform at levels exceeding that of comparable linear products.

Power consumption is another important attribute to consider in choosing a tape technology in today's limited and more costly power environment. Helical-scan products typically consume one-half to one-third the power required for linear technologies, and can thereby not only save subtantial operating costs, but can also more easily meet todays' power conservation requirements. This is particularly important when considering multi-drive automation solutions that can contain anywhere from 6 to over 20 drives per library.

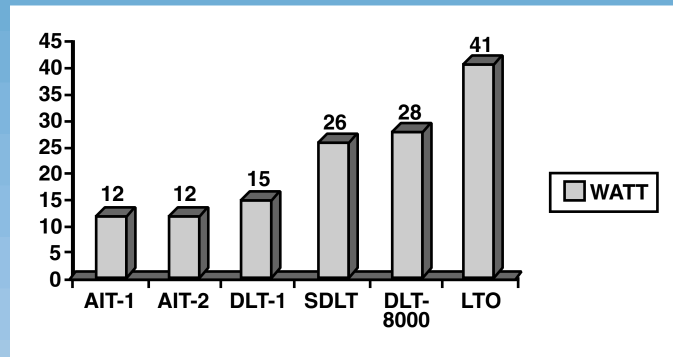
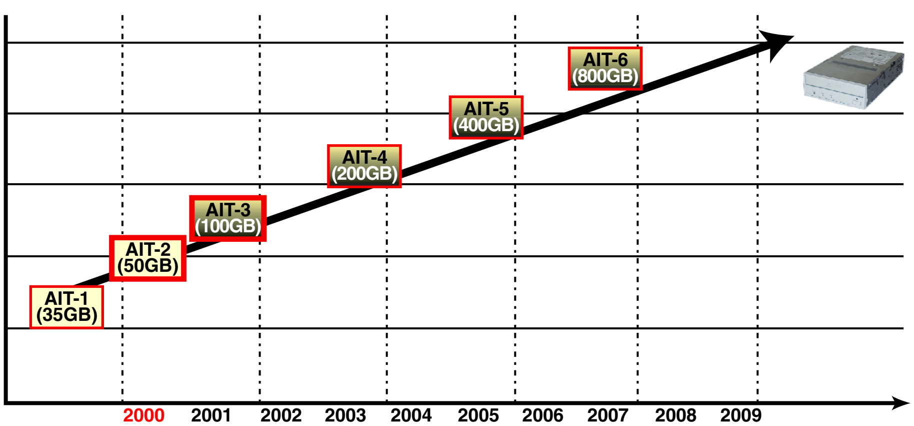


Figure 2: Power Consumption Comparison of Linear vs. Helical-Scan Library Automation Solutions

This multiplication factor is even more compelling for projects requiring multiple libraries, as illustrated in Figure 2.
The total cost savings of helical-scan products, including purchase price, as well as power consumption, and reduced system downtime, make helical-scan a good business decision in all applications, and particularly essential in high duty cycle applications, such as tape automation.

Summary

Inherent data density, access, data transfer performance, as well as reliability and durability characteristics, ideally position helical-scan tape technology to satisfy the current and future demands of backup and restore, image storage and retrieval, and other emerging removable data storage applications. Helical-scan recording provides very high data density and capacity today and offers the potential for significant improvements in future products to meet projected market needs. Helical-scan products, with their typical "dual-reel" cartridge designs, also provide unmatched "time-to-data" to meet high duty cycle tape automation environments. All of these factors contribute to a cost of ownership advantage that lowers the cost of doing business for resource constrained customers that must deal with limited space and power availability.



Sony is committed to maintaining this technology leadership with new and enhanced AIT products. The roadmap of current and future AIT products, shown in Figure 3, demonstrates this commitment. With these compatible AIT drives, OEM library, and other stand-alone drive solutions, organizations can grow their tape capabilities as needed. With AIT, they have the highest capacity, most reliable and cost effective solutions available which address real-world constraints of space and power, as well as minimize the cost of ownership of the total solution.