SAIT - A Tape Technology for the 21st Century

White Paper
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Executive Summary

This white paper examines the future role and requirements of tape technology in high-performance, high-capacity storage applications and provides a comparative assessment of storage trends and the resultant needs for tape to maintain a competitive advantage within the storage hierarchy. Sony's introduction of its new, high-capacity SAIT technology represents a leap in capability, compared to current tape technologies, and effectively addresses the expected convergence in the cost per gigabyte of tape versus low-cost, high-capacity disk products.

Storage – A Critical Component in Today's Complex Business Environment

Companies worldwide today face a tremendous explosion of data produced at every level of the organization, from email, databases, the Internet, and e-commerce to image-based applications that produce video and audio files. Booming trends in the audio-visual market, including digital cameras and camcorder products, are expected to produce 700 petabytes of data per year, dwarfing the amount of data produced in traditional IT applications. Movies will be produced and distributed digitally. Concepts like Steven Spielberg's Shoah Foundation project may be extended to family genealogy preservation. Even broadband and new cell phone applications will contribute to significant, near-term storage growth.

With the accelerated use of content-rich systems, the need to store, manage and protect the important data produced is more important than ever. Storage systems will race to increase capacities and performance, and tape storage will play an important role. Already today, many systems, such as video and digital imaging systems, use tape for primary storage. Today's companies use tape in archival and near-line storage applications, and new tape array products are shrinking required backup windows. Tape systems are also often integrated with disk storage in network attached storage and storage area network configurations. Furthermore, tape is still the primary backup medium and is integral to most disaster recovery applications.

High-capacity, high-performance requirements are driving the way companies look at data production and data protection. Leading industry analyst firms such as Gartner Dataquest have focused on the requirements for storage in these kinds of environments when they state, "As disk capacities continue to grow with the explosion of digital content and mission-critical data warehouses, the tape storage segment has a bigger opportunity to close the gap between disk and tape roadmaps. For a tape product to be successful, capacity, performance and automation support are key."[1]

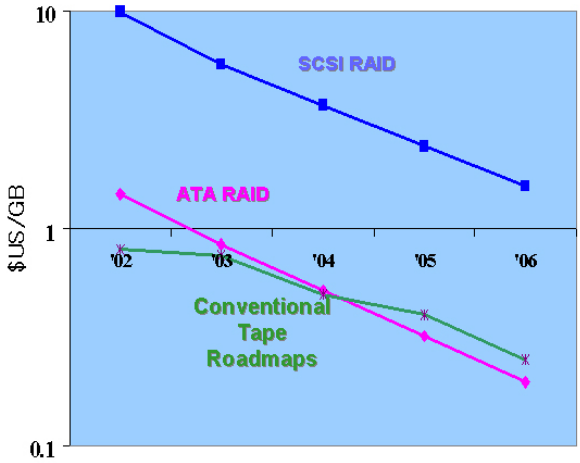
[1] "Sony Debuts SAIT Technology Platform," November 2, 2001 Sony Press Release

End users want to increase tape capacities in order to match the ever-increasing server capacities. Many companies already believe that the incorporation of cost-effective automated data recovery in their operations is crucial to the viability of their business. These companies are in the forefront of an ongoing trend to automated tape storage systems that have the ability to incorporate the highest capacity tapes available in the market.

A high-capacity, high-performance tape system today has significant advantages in backup, restoration and archival of critical corporate data, saving time and money. But can tape continue to play a cost-effective role in these demanding storage applications in the future?

The Future of Tape – A Tape Industry Roadmap

Today's single tape cartridges can easily store 100GB of information and are moving to 200GB per cartridge. However, disk capacities are on a steeper rise. For tape to remain cost-effective as a storage alternative, its capacity must track disk capacity growth while retaining its effective cost benefits. Will tape be able to keep up? Current tape technology roadmaps show that tape will continue to lose its competitive advantage to low-cost disk arrays and may, in fact, intersect with the disk trend line by as early as 2004.



Current tape vs. disk cost trends

To address this key issue, over 40 researchers representing large tape drive manufacturers, tape media suppliers and many of the leading research universities, collaborated, as part of the Information Storage Industry Consortium (INSIC), to analyze enterprise tape market requirements. The result was the development in 2001 of a ten-year projection for the future of magnetic tape storage[2]. INSIC's work indicates that to remain an economically viable storage solution when compared to disk, tape capacity must grow at a rate comparable to future disk capacity growth on a cost per gigabyte basis.

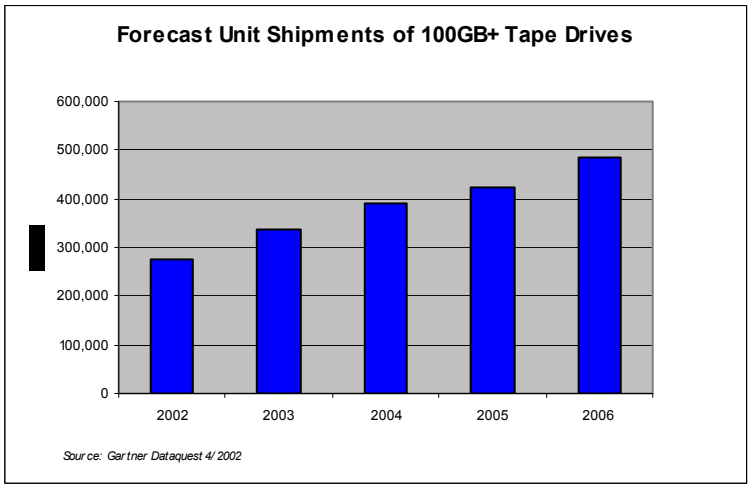
[2] INSIC tape roadmap – http://www.insic.org

Although disk densities are continuing to rise, the rate of growth is expected to slow as disk recording nears a super-paramagnetic limitation. Due to a much lower areal recording density and much greater recording area, tape technology has the potential to grow at a faster rate and as a result improve its cost per gigabyte trends compared to disk.

Therefore, when combined with disk in the enterprise storage environment, the tape industry roadmap currently maintains that tape capacity on a single cartridge must achieve 10 terabytes (TBs) (uncompressed) per cartridge by 2011, and must reach 1TB (uncompressed) on a single cartridge by 2006 on its way to reaching the 10 year goal.

Is a New Tape Platform Needed?

Analysts are also predicting that users soon will need much more than 200GB on a tape cartridge. Gartner Dataquest forecasts shipments of 100GB+ tape drives to reach over 450,000 units by 2006.



Both high-capacity linear and helical-scan tape products are currently available. Linear tape products utilize Metal Particle (MP)-based media. Today, native storage capacities of MP media designed for high capacity applications are in the 100GB to 200GB per cartridge range. MP roadmap advances are projected to follow the tape industry roadmap discussed above. Although the capacity per cartridge of linear devices is projected to increase in the future, it is not expected to reach the more aggressive industry roadmap goals without major new technology breakthroughs in media formulation and new mechanism designs. In fact, the current linear tape formats are not expected to break the 1Gbit per square inch areal recording density frontier until the end of the decade. At that rate, the capacity per cartridge will barely exceed an uncompressed capacity of 1TB.

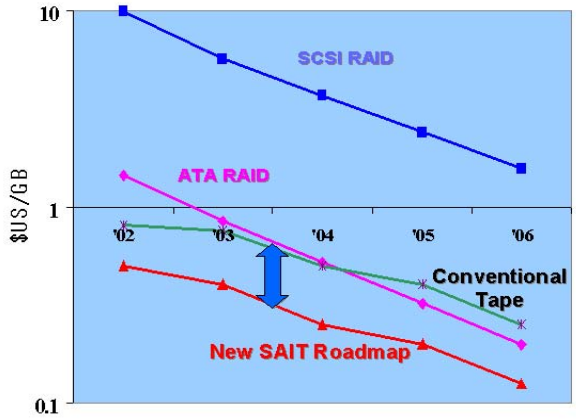
Therefore, it would seem that a new class of tape technology is needed; one that would leapfrog current technology limitations to deliver capacities and performance well above the capabilities of current tape formats. This new technology platform would then be able to keep pace with hard disk drive advances, and meet the roadmap goals.

Sony Corporation, manufacturer of Advanced Intelligent Tape™ (AIT), has committed to meeting the demand of 1TB of uncompressed capacity per cartridge before 2006 with a solution based on using AIT recording density but delivered in a single-reel, half-inch cartridge. Since AIT's helical-scan tape technology has more than a 4-fold areal density advantage over linear tape technologies, an 8-mm tape cartridge can hold as much data on 230 meters of tape as a half-inch linear tape can hold on 600 meters.

Leveraging AIT's superior areal density, Sony concluded that using a longer and wider AIT media in a single-reel configuration, five times the capacity could be achieved for any given AIT areal density design point. Thus, the SAIT family concept was born with a starting point of 500GB of uncompressed capacity per cartridge, deliverable to the market in early 2003. Using the published AIT areal recording density roadmap, a family of four SAIT members was also immediately identified.

SAIT – Changing The Paradigm for Tape Products

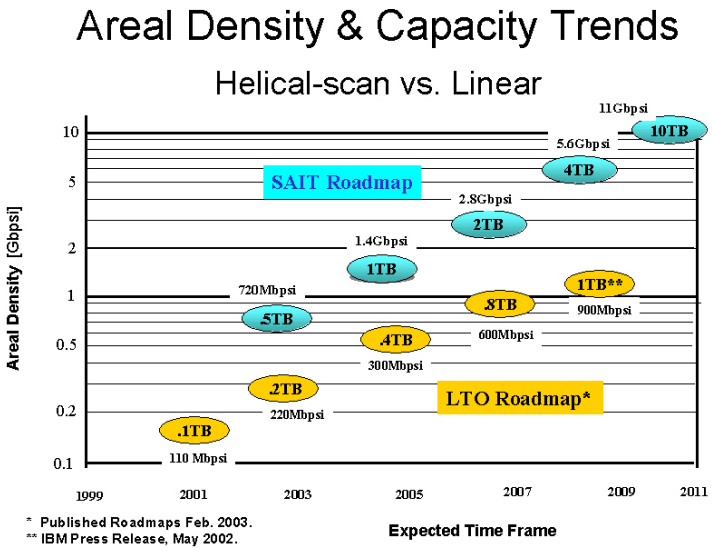
This new SAIT tape technology platform delivers high capacity and high performance using a half-inch, single-reel tape and a 5.25-inch full-height mechanism design, dramatically improving the value proposition between conventional tape roadmaps and future hard disk drive capacity trends. As a new class of tape solution, SAIT technology leapfrogs conventional linear solutions, offering significant advantages in capacity, performance, reliability and scalability.



Tape and disk costs trends, showing the projected impact of SAIT

Meeting the Capacity Challenge

Enterprise applications are demanding higher and higher storage capacities. The first generation of SAIT, to be shipped in Q1 2003, will offer 500GB of capacity on a single reel half-inch cartridge with a transfer rate of 30MB/second. This astonishing capacity easily surpasses any linear technology available today, and is achievable with the same AIT-3 recording density and technology that has been in production since 2001. The following chart illustrates the differences between helical-scan and linear tape recording densities and projected future capacity points.



All future products are based on technology projections

Performance – Key to Success

SAIT's data transfer rate starts at 30Mbytes per second for the first generation and is expected to double with each subsequent generation. The high SAIT data rate is achievable through multiple, independent read and write heads together with an effective high head-to-tape velocity derived from the spinning drum. These higher data transfer speeds, together with fast media load and fast search capability are needed to provide a total performance solution needed in today's enterprise applications.

The incorporation of a Memory-in-Cassette (MIC) flash memory chip embedded in all SAIT media allows the local storage of key media information and statistics. These include such parameters as media type and serial number, media usage and error recovery information together with a search-map to provide high-speed access to any file on tape. The stored "search map" for SAIT media allows the mechanism to unload the tape from the drum and perform tape positioning commands at much higher speeds and with a much shorter tape path than would otherwise be possible. Linear mechanisms implement tape positioning commands by speeding up the velocity of the tape over the same tape path as reading and writing.

In addition, SAIT optimizes application performance over a wide range of host data rates by incorporating a very short re-positioning time. This is due to the increased drive data buffering but more importantly, through the very low tape velocity, compared to linear recording. If there is an overall data rate mismatch between the tape mechanism and the host, linear mechanisms, due to their much higher tape velocities, must go through large media deceleration and acceleration cycles. This can result in a significant degradation of performance. The short re-cycle time of helical scan recording, on the other hand, allows the SAIT to outperform its linear technology competitors in repositioning performance.

Drive and Media Design – Setting a New Standard for Reliability& Data Integrity

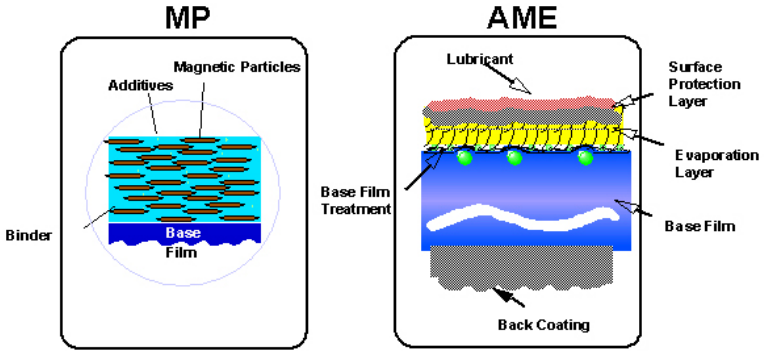
The ability to run with little to no downtime is needed by today's demanding storage environments. SAIT's media loading, data read/write and media unloading process is smooth and uncomplicated, ideal for the 24x7x365 operations of today's high duty cycle

automation solutions. SAIT drive reliability is rated at greater than 300,000 hours at a 100% duty cycle, exceeding the specifications of competing linear formats. SAIT drives, like AIT, are based on helical scan recording, which is characterized by a very stable rotating drum/head platform, low tape tension and single pass operation, to permit accurate and reliable data recording and read-back, at much higher recording densities.

SAIT is manufactured with a sealed deck design to improve reliability by protecting the mechanics from possible airborne contamination. Airflow under the deck provides effective cooling of the electronics and drum motor. The SAIT mechanism utilizes a dual-mode tape path delivering smooth operation and minimal tape friction under various operating conditions. Only during read, write and low-speed tape positioning operations is the tape wrapped around the drum. Even then, the tape is cushioned by an air bearing (except for the small head-to-tape contact area) to limit tape and drum wear. During high-speed searches the SAIT tape path is kept very short and simple, and utilizes the contents of the MIC to provide reliable positioning information.

With linear serpentine recording, on the other hand, the tape undergoes much greater stresses as it travels at very high speeds over the large stationary heads and requires many back and forth traverses to complete a full recording of tape. This high speed back-and-forth recording process (known as serpentine recording), together with the much larger head-to-tape contact area, results in more wear of the media and recording heads, and also produces significantly more tape media and mechanism stress in order to stop and reverse tape motion at those high speeds.

AME tape used by SAIT, can record at very high densities yet has enough energy to read a strong signal off the tape. Part of the ability to read the signal comes from the use of pure cobalt magnetic material together with low-noise read heads and drum-mounted signal amplifiers. Also, Sony uses a top-coating during the AME media manufacturing process called Diamond-Like Carbon (DLC). In the DLC coating process, the metal magnetic layer is protected with a very thin, flexible yet extremely durable, crystallized carbon layer. This DLC layer is about 20 times harder than metal oxides and when deposited upon the smooth metal layer, makes this surface even smoother and more durable.



This combination of media wear resistance and smoothness is ideal for the long-term recording of the tape; it resists wear and shedding, making the tapes and heads last longer, and requiring less frequent head and mechanism cleaning. As a result, the tapes give superb durability and archival stability while ensuring the highest levels of data integrity. SAIT was designed to achieve the maximum benefit of AME's exceptional qualities.

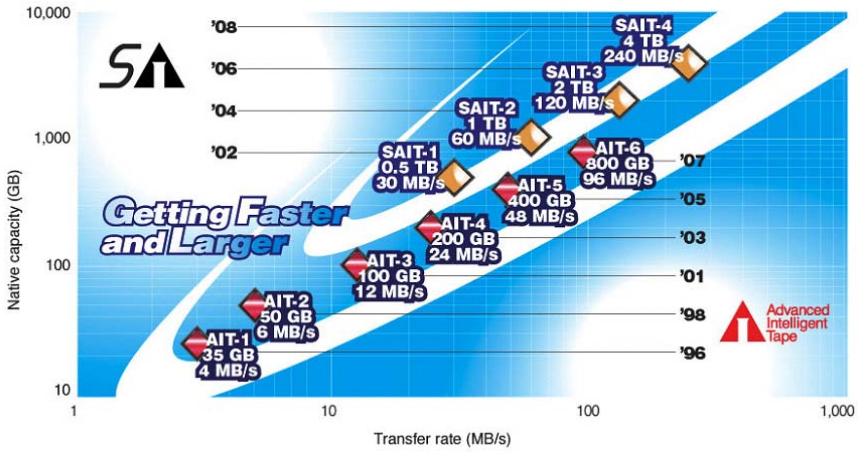
WORM Recording – Key to Media Integrity and Data Permanence

In the future, SAIT drives and media will implement multi-function capabilities to provide both conventional, erasable recording as well as Write-Once, Read-Many (WORM). This unique capability is made possible through the use of the MIC chip technology together with special drive firmware that prevents data overwrite on media that is designated and created as WORM media. This provides users with the ability to meet certain governmental regulations regarding data permanence, as well as providing other applications the capability to archive data that cannot be inadvertently overwritten. WORM media can be used concurrently with conventional, erasable media to provide applications the ultimate in flexibility and investment protection. As a result, Sony's SAIT technology is leading the way in providing users with cost-effective solutions to meet their requirements for the ultimate in data protection.

A Roadmap Emphasizing Scalability

While having tape capacity to meet today's storage needs is important, end-users must also plan for applications that need more data storage every day. Choosing a tape storage system that can and will grow over the years is even more imperative. This has been clearly pointed out by Gartner Dataquest when they state that ". . .a forward-looking roadmap is essential for companies that are looking to make an investment in a tape storage technology. Users always want the reassurance that their investment will be protected as their storage needs expand."[3]

As illustrated by the chart, Sony's current roadmap for SAIT exceeds the storage industry roadmap. SAIT's current roadmap calls out four generations that extend to 4TB in native cartridge capacity with a 240MB/second native transfer rate.



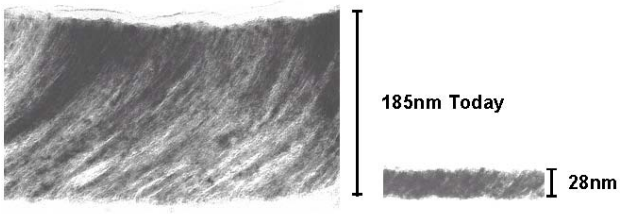
All future products are based on technology projections

Sony's confidence in its future SAIT roadmap is based on research done in its corporate laboratories. In April 2002, Sony R&D demonstrated the storage of more than 11 billion bits of data on one square inch (11.5Gbit/inch^2) of AME tape. This breakthrough, made possible through advancements in read/write heads, encoding techniques and metal evaporated media technology, nearly doubled the previous tape storage areal density

[3] "Sony Shatters Areal Density Record for Tape Storage" May 1, 2002 Sony press release

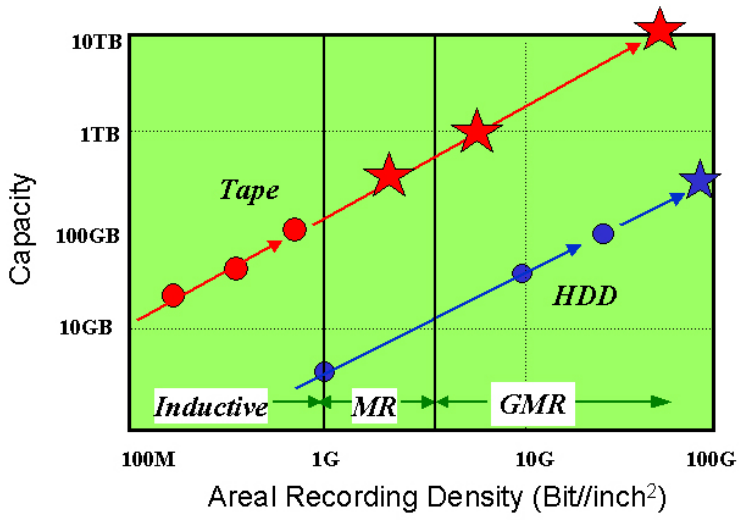
record of 6.5 Gb/inch^2, set by Sony. This achievement will become the foundation for a projected cartridge capacity of up to 10TB before 2011 - again exceeding the tape storage industry roadmap. The following chart illustrates the core technologies that contributed to this R&D achievement.

High-Output AME Media and GMR Head



Metal Evaporated Tape	GMR-2
Magnetic Layer	Cobalt-Cobalt Oxide
Thickness of Magnetic Layer (t)	28nm
GMR Head	
Type	Shield-Spin Valve GMR Head
Head Width	0.45 μm
Other	
Signal-to-Noise Ratio	18dB

Based on the above research results, Sony expects to implement its future SAIT roadmap utilizing MR and GMR read head technology together with changes in AME media formulation, as shown. The application of these key head and media technologies for SAIT follows that of disk drives, but its implementation yields significantly higher capacities than that projected for disks, and thereby provides an extremely competitive and scalable product family. The chart below illustrates the anticipated technology application trends.



Investment Protection – Minimizing Cost Through Flexibility

Investment protection is often identified as a key purchase criteria of tape technology. Although SAIT is designed to offer read-and-write backward compatibility to its prior product generation, as a new design, SAIT does not provide compatibility with any legacy technology, much the same as Ultrium® LTO and DLTtape™ at the time of their market introduction. Format compatibility with conventional or legacy tape technology would severely limit the ability of SAIT to leapfrog current products and deliver leadership
capacity and performance. At the same time, Sony recognized the need to provide as much total solution investment protection as possible and therefore chose the 5.25-inch drive dimension and a standard half-inch media cartridge size for SAIT.

Experts believe that the future direction of tape in enterprise-class applications will be in automation, and that mixing "enterprise-designed" drives and media will be the norm. SAIT's use of industry standard drive and media form-factors makes SAIT ideal for integration into multi-technology automation system solutions. In this way, SAIT will seamlessly complement the capacity and performance of an automation solution and consolidate other linear, half-inch tape formats into a single SAIT-based technology solution. With its multi-function WORM capability, SAIT drives further enhance an end-user's investment by incorporating more value and meeting new market requirements, at no additional cost.

Automation – Meeting Key Market Demands

SAIT solutions are ideal for the kinds of applications where automation shines: high capacity, multiple cartridge archival and direct storage of large files, such as document or medical images, large databases, seismic and aerospace data, and digital audio/video files. Delivering higher capacity on fewer cartridges than competitive solutions, first generation SAIT technology can provide uncompressed capacities ranging from 10TB in a 20 cartridge, space-efficient configuration to more than 500TB in a 1,000 cartridge freestanding library.

SAIT cartridges are designed to provide compatibility with most current half-inch tape automation solutions offered by a variety of vendors. SAIT will enable automation manufacturers and integrators to capitalize on this storage demand by delivering a new level of capacity and performance. By offering the highest capacity in a half-inch cartridge, SAIT solutions can provide more terabytes of capacity per customer dollar spent, thereby delivering more value to the market.

Freeman Reports recently stated, "As digital content continues to expand unabated and needs to be stored and managed, the SAIT format offers a compelling combination of capacity and performance for the automation market."[4] In fact, leading tape library manufacturers have expressed their intention to support the integration of SAIT drives and media into half-inch tape automation solutions.

[4] "Sony Debuts SAIT Technology Platform" November 2, 2001 Sony press release

The Benefit of Multiple Sources

Sony has teamed with Matsushita Kotobuki Electronics Industries, Ltd. (MKE), and Matsushita Electric Industrial Co., Ltd. (MEI), known for Panasonic-brand products, to jointly bring SAIT drives and media to market. With Sony as the primary supplier, MKE will serve as an alternative manufacturing source for SAIT drives, and MEI will serve as an alternative manufacturing source for SAIT media.

This type of partnership is supported by Gartner Dataquest, who believe that ". . .as with any new technology introduction, the collaboration of companies is always a powerful combination for success. The tape storage market and the customers of tape products can only benefit from big partnerships." [5]

SAIT – The Solution for the 21st Century

A paradigm shift in tape drive design will be required to meet the future market need to store ever increasing amounts of data and meet the industry roadmap goals for tape capacities of 1TB by 2006 and 10TB by 2011. In addition, a tape technology must combine capacity, performance, and reliability with an achievable forward looking roadmap and multiple sources of supply, to fully meet customer needs and industry acceptance, and thus assure the future of tape within the storage hierarchy.

SAIT tape technology is designed to address all of these requirements and the release of the first generation of SAIT is a demonstration of Sony's commitment and unique capability to meet industry roadmap requirements. In fact, Sony holds the distinction of being one of the only tape drive manufacturers to demonstrate, develop, and internally source all critical components of its tape technology. With the potential to scale up to 10TB of native capacity on a single cartridge, SAIT will target high-capacity, high-performance storage demands, and thereby maintain tape's competitive advantage against disk technology. The release of the SAIT family complements Sony's existing AIT product line and positions Sony to serve backup and archival storage markets from desktop to the largest enterprise applications. SAIT provides a feature-rich product line derived from Sony's 50-year innovation and leadership in tape recording technology.

[5] "Sony and Matsushita Collaborate to Bring New High-Density, SAIT Tape to Market" November 2, 2001 Sony press release

Technology Features Comparison			
	SAIT-1	**SDLT320**	**Ultrium LTO (Generation 2)**
Capacity (Native)	***500GB***	160GB	200GB
Capacity (Compressed)	***1,300 GB (1.3 TB)***	320 GB	400GB
Transfer Rate (Native)	***30 MB/second***	16MB/second	30-35MB/second
Transfer Rate (Compressed)	***72MB/second***	32 MB/second	60-70 MB/second
Mean Time Between Failure (MTBF) at 100% duty cycle	***>300,000 hours***	250,000 hours	250,000 hours
Media Formulation	***AME***	MP	MP
Media Form-factor	***Single reel, half-inch Cartridge***	Single reel, half-inch Cartridge	Single reel, half-inch Cartridge
Media Length	***600m***	600m	600m
File Access Time	***70 seconds***	70 seconds	52 seconds
Media Load Time	***23 seconds***	40 seconds	15 seconds
Memory in Cassette	***Yes***	No	Yes
WORM (Write Once Read Many) Capable	***Yes***	No	No
Published Roadmap # of Generations	***4***	4	4
Roadmap Maximum Capacity (Native)	***10,000 GB (10 TB)***	1,200 GB (1.2 TB)	1,600 GB (1.6TB)
Roadmap Maximum Performance (Native)	***240 MB/second***	100 MB/second	160 MB/second
Multiple Manufacturing Sources for Drives and Media	***Yes***	No	Yes

SONY