THE DAWN OF AI DISRUPTION

Tape Will Become Key Enabler of Massive Data Retention

Security, Energy, Sustainability, Immutability, Durability, and TCO Highlight the Compelling Tape Value Proposition

Introduction

Data centers were confronted with several obstacles in recent years, including global inflation, US regional bank struggles, currency fluctuations, lingering supply shortages, increasing energy consumption, endless geo-political tensions and the aggressive arrival of AI. Even with these ongoing challenges, signs of recovery gradually began to emerge in 2024, renewing confidence and stability in traditional data storage markets. Growth projections for the amount of data stored worldwide continue to suggest a ~20% annual CAGR, a doubling of data stored approximately every four years.

The AI avalanche has taken off in earnest, ushering in the dawn of AI disruption. The unquenchable thirst of AI for resources such as compute, memory, storage, power, and chilled water has placed energy usage, carbon emissions and the overall environmental impact of data centers in the bullseye for most organizations. Without rich troves of high-quality data, the most sophisticated AI system has nothing to work with – they both need and enable each other. Fortunately to harness this explosive growth, tape remains the most economical and environmentally friendly data center storage solution available and will securely retain the input/output source data to support AI workflows.

Generative AI significantly impacts enterprise storage by increasing data volumes while adding complexity. Enterprises need to quickly adapt their storage strategies to accommodate these new demands. While tape usage is increasing, due to inertia and a lack of strategic planning, much of the world's lower activity unstructured data continues to reside on inefficient HDDs.

> ***AI will generate up to 20% of the data center workloads in the next four years.***
>
> – Henrique Cecci, Senior Director at Gartner.

Companies are demanding more capability and the ability to manage more workloads, and AI is evolving much faster than physical infrastructure.

Stored Data Volume Projections – 2025 and Beyond

Secondary storage is designed to keep important, less active data on more economical, secure mediums that don't need to be accessed as frequently as primary storage data. The importance and value of this data is increasing rapidly due to aggressive AI harvesting. TRENDFOCUS projects installed storage capacity across all enterprise data centers is expected to reach ~6.4 ZBs in 2025 with at least 80% (~5.12 ZBs) classified as archival or "cold" data making secondary storage by far the largest data storage market. By 2030, total installed capacity is projected to reach ~17.4 ZBs suggesting ~13.92 ZBs of secondary storage requirements. By the end of 2025, if nothing changes, approximately 80% of all data stored will reside on expensive and energy intensive HDDs. These projections indicate that most of the world's cold but valuable data will continue to reside on inefficient HDDs unless enterprises begin to take advantage of the benefits of modern tape technology. HDDs and SSDs continue to store far too much cold data using massive amounts of energy. This may be the single biggest storage management challenge with the greatest payback when economics, TCO, and energy consumption are considered.

Table: TRENDFOCUS Enterprise storage native exabyte shipments and installed capacity. April, 2024

	2020	2025	2030
Shipped Capacity EBs			
eSSD	87	148	336
Captive eSSD	18	31	222
Nearline HDD	635	1,277	3,855
Performance Enterprise HDD	16	11	6
Tape	52	89	178
Total Ent. EB shipped	**808**	**1,556**	**4,596**
Installed Capacity EBs			
eSSD Total EB	225	653	1,422
Captive eSSD Total EB	30	116	595
Hyperscale Nearline Total EB	1,234	3,419	11,854
OEM/Other Nearline HDD Total EB	822	1,682	2,640
Performance Enterprise HDD Total EB	131	95	59
Tape Total EB	302	483	853
Total Ent. EB Installed	**2,744**	**6,449**	**17,424**

Source: TRENFOCUS Enterprise storage shipments and installed capacity, exabytes

Clearly the opportunity for data centers to strategically optimize their storage infrastructure for the long haul with modern tape has never been greater.

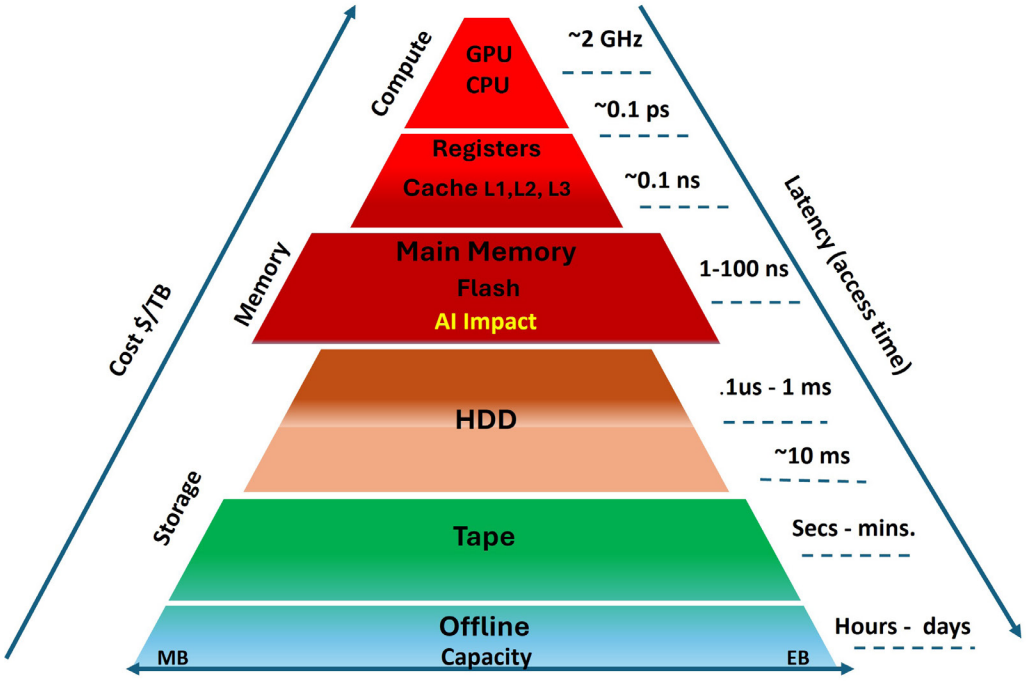
The Heavy Impact of AI on Compute, Memory, and Storage

The enormous universe of big data refers to data sets so large or complex that most traditional data management tools can't store or process them efficiently. Big data applications can generate data faster than it can be analyzed, significantly extending data retention timeframes and filling data lakes which have no size limits. AI is now squarely in the spotlight and is leading the race to harvest the massive troves of unstructured big data, much of which resides on secondary storage. The impact of AI on future storage demand has not been determined, but it will undoubtedly be huge.

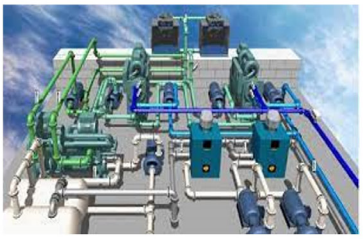
As AI fuels the dawn of disruption and big data stores, data lakes and muti-petabyte archives have become its primary input data source. It is estimated that ~97% of businesses are investing in AI and ML technology to mine big data. This bodes well for AI, which can feast on even larger data stores to build its complex training models.

AI Stressing all Technology Tiers

Intensive Compute, Memory and Storage Demands Reshape the Pyramid



AI Consumes Considerable Electricity and Chilled Water



Source: Horison Information Strategies, LLC

Barring any significant slowdown in AI deployment, AI will impact every technology tier with heaviest impact (see red section of pyramid above) on compute (GPUs), memory (DRAM) and flash SSD. HDD and tape will see demand increases to store, retrieve, archive and protect all AI output. AI also requires huge amounts of water and electricity to cool the red-hot running GPUs, further exacerbating the data center energy challenges to manage and reduce energy consumption. Estimates suggest that high-end GPUs are consuming as much electricity as several small countries and are responsible for huge portions of new electricity demand in the US. By 2027, AI servers could use between 85-134 TWh annually, similar to Argentina, the Netherlands or Sweden. This is clearly not a sustainable trend going forward.

Consider a simple Google text-based search can require ~0.5 MB of DRAM (Main Memory) compared to an AI chat model, which can require up to 1 TB to run a prompt significantly increasing memory requirements. Then consider the memory impact if a high percentage of today's Google searches are replaced by chat models! Typical ChatGPT models have ~1.8 trillion data points, but smaller models with only ~2.5 billion data points are emerging that can still provide enterprises with good results while cutting down energy consumption. AI training consists of a three-step process. The training step normally involves humans adding metadata to unstructured data which is fed into an algorithm to create predictions and evaluate their accuracy. The validation step evaluates how well the trained model performs on previously untouched data typically residing on secondary storage. Finally, testing is done to decide if the final model makes accurate predictions with new data that it has never seen before. These are very compute, storage and energy intensive processes.

By moving low activity or older inactive LLMs to modern tape storage, huge energy savings can be realized while freeing up HDD capacity for other applications. This will help offset the enormous energy demands of high-end GPUs.

New Hybrid Cloud Enabling Tape Libraries Emerge

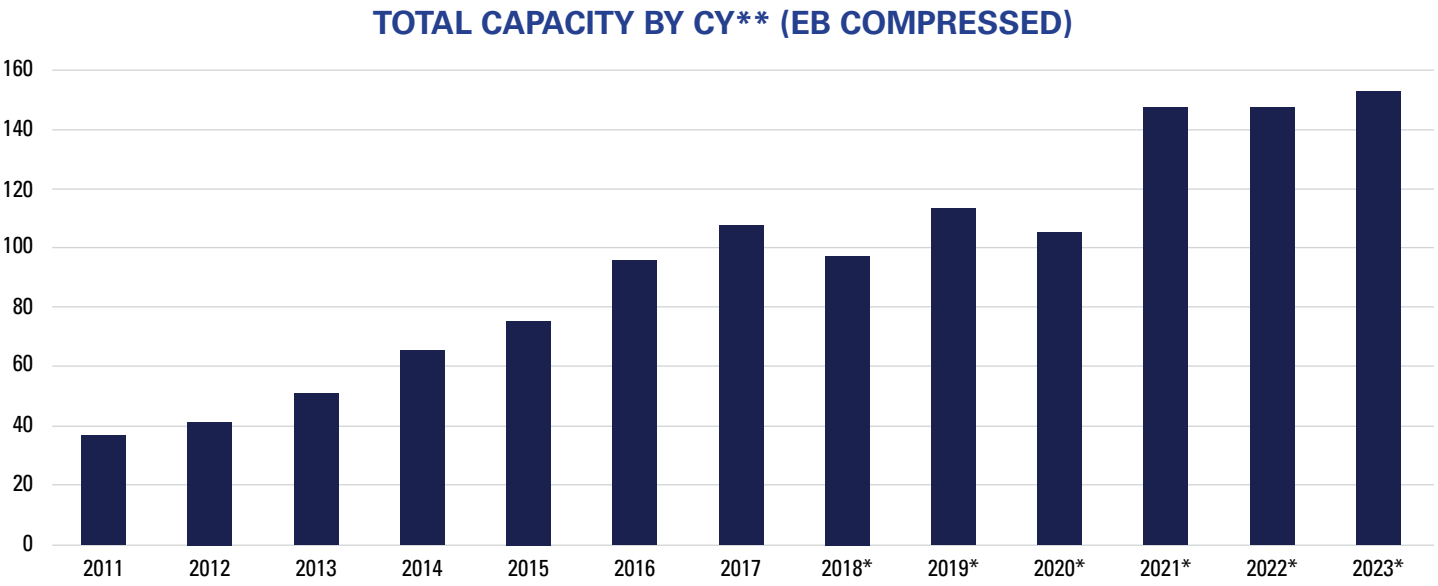
Cloud storage repatriation describes the shift away from putting everything in the cloud and back to an on-premise storage hybrid cloud infrastructure. A hybrid cloud is a mixed computing environment where applications are run in different environments – public clouds and private clouds, on-premise data centers or colocations, and "edge" locations. On-premise storage is usually managed by the organization, while the public cloud storage provider is responsible for the management and security of cloud data.

S3 does for objects and tape what LTFS does for files and tape. The standardized S3 Glacier™ interface is perfectly suited for integrating the new hybrid cloud, object-based tape libraries into the storage infrastructure. These new and highly advanced deep archive libraries from IBM (Diamondback), Spectra Logic (Cube), and recently from Quantum (Scalar i7 RAPTOR) easily integrate the S3 interface with glacier-class services. They deliver the highest available levels of tape density, reducing infrastructure costs, data center space, maintenance, power and cooling costs and can retain petabytes of long-term data in on-premise hybrid cloud, or cloud environments. These new hybrid cloud libraries enable enterprises to quickly set up a private cloud system in their own data centers or within colocations without any tape-specific skill sets required. With S3, applications can write directly to tape, creating a higher performance, on-premise deep archive storage solution. For example, starting data restoration from the AWS Glacier service can take anywhere from 4–48 hours, depending on the customer's service level. With on-premise tape systems, data restoration can begin within minutes, improving SLAs. Since data is stored both on-premise and in a cloud storage infrastructure, the effectiveness of the popular 3-2-1-1 data protection strategy is easy to implement.

Tape-as-a-Service Emerges Based on New Hybrid Cloud Tape Libraries

New Tape-as-a-Service (TaaS) offerings, such as those from Geyser Data, now deliver easy-to-consume, highly cost-effective object-based tape solutions to archive data at scale without the need for special skills, large capital investments or on-premise infrastructure. TaaS is a modern data storage category that utilizes advanced, modern tape technology in a cloud-based, as-a-service model, combining the benefits of traditional tape storage, such as high durability, low cost, and ultra low energy consumption, with the convenience and flexibility of cloud services. TaaS leverages S3-compatible object storage to create an object-based tape infrastructure that is fully compatible with any Amazon S3 or S3 Glacier application. TaaS delivers the air-gap security, reliability, and sustainability benefits of tape storage in a subscription-based model that can be instantly provisioned, is scalable on demand, and requires no specialized knowledge or skills to use. TaaS enables VARs, MSPs, and colocation service providers to deliver significant advantages in terms of cost, performance, and data sovereignty, compared to public cloud storage services.

LTO Tape Capacity Shipments Set New Record



* Aggregate capacities do not include LTO-7 Type M media | **Graph shows data from past 12 years only

Source: LTO.org

The LTO Program Technology Provider Companies (TPCs), Hewlett Packard Enterprise Company, IBM Corporation, and Quantum Corporation, released their latest tape media shipment report in May of 2024, detailing year-over-year shipments through the fourth quarter of 2023. The report revealed 152.9 Exabytes (EB) of total LTO tape capacity (compressed) shipped in 2023, a growth of 3.14% over the previous year. This result was driven by continued hyperscale, enterprise, and large data center investment, driven in part by increased infrastructure requirements of hyperscalers and enterprises.

The strong performance in shipments continues the growth trend following the previous record-breaking 114 EB capacity shipped in 2019, 105 EB of capacity shipped during the pandemic in 2020, and 148 EB shipped in 2022.

LTO Roadmap at 14 Generations Addresses Secondary Storage Eruption

The TPCs current LTO technology roadmap announced in Sept. 2022, extends the LTO Ultrium standard through 14 generations. The roadmap calls for tape capacities to double with each new generation, with LTO-14 delivering up to 1,440 TB or 1.44 PB compressed per cartridge. Once introduced, LTO-14 could surpass current LTO-9 cartridge capacity up to 32 times. At this point, no other storage technologies have revealed anything close to the multi-generational roadmap or the advantages of tape for cost-effective storage. In addition to full backward read and write compatibility with LTO-8 cartridges, LTO-9 specs include multi–layer security support with hardware–based encryption, immutable WORM functionality, and fast file access with oRAO, the Linear Tape File System (LTFS) and fast object access using the popular S3 interface. Expect next gen LTO-10 drives and media to be available by mid-2025.

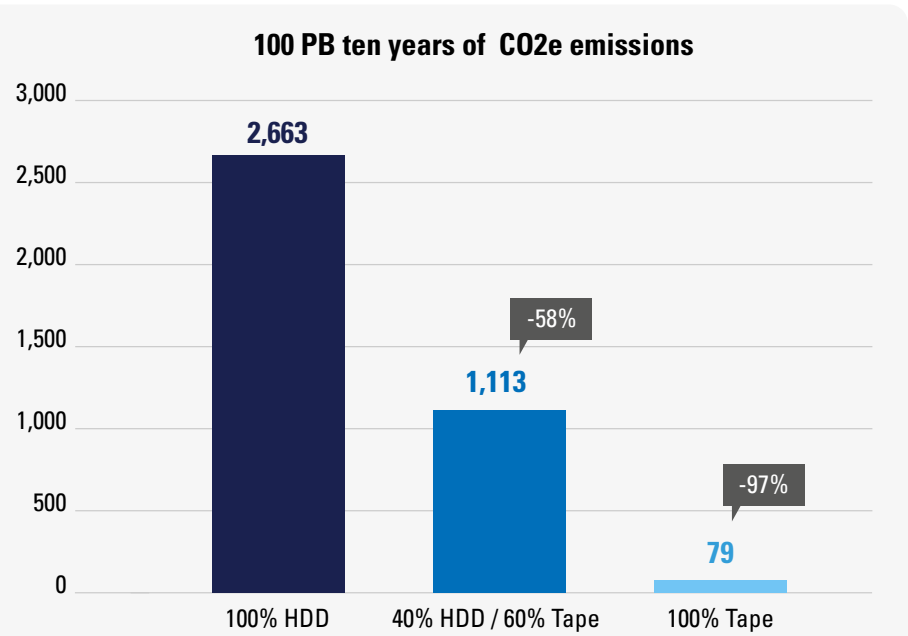
Since the introduction of LTO-1 in 2000 with a native capacity of 100 GB, the capacity of LTO cartridges has increased by 180 times and data rates have increased by 20 times. Over the same period, the specified uncorrectable Bit Error Rate (BER) of LTO cartridges has improved by a factor of 1000, a three orders of magnitude improvement. LTO-9 provides an industry-leading uncorrectable bit error rate of $1x10^{20}$ compared to the highest HDD BER at $1x10^{17}$. A BER of $1x10^{20}$ corresponds to one unrecoverable read error event for every 12.5 exabytes of data read. A tape drive may fail, but if the data on the cartridge can still be read back with another drive, then retrieval is successful. This is not necessarily the case for HDDs. Today's LTO and enterprise tape products are more reliable than any HDD, and can be migrated every 7 to 10 years compared to 3 to 5 years for HDDs.

Data Center Energy Challenges Mount – Tape Can be a Game Changer for Energy Consumption

The AI frenzy, the rollout of advanced faster GPUs, and cryptocurrency are contributing heavily to demand for power-intensive data centers. In addition, researchers are trying to estimate average server utilization rates over an entire year – taking downtime into account. The current assumption is 70% utilization, but the uncertainty factor ranges from 30–80%. AI makes modeling and prediction even harder, but regardless of the wide range of uncertainty, most everyone agrees that data center electricity consumption is expected to surge between 2025 and 2030. It is estimated that data centers are responsible for nearly 3% of global electricity consumption today and are projected to reach 4% by 2030. Servers and then HDDs are the two largest consumers of data center energy, with AI quickly becoming a heavy consumer. AI GPU power consumption will dwarf conventional server consumption. The overall environmental impact of reducing data center carbon emissions and e-waste is enormous and getting bigger every day. The advantage of tape in data center energy reduction will only become greater.

Tape Reduces CO2e by 97% Compared to an All-HDD Storage Strategy

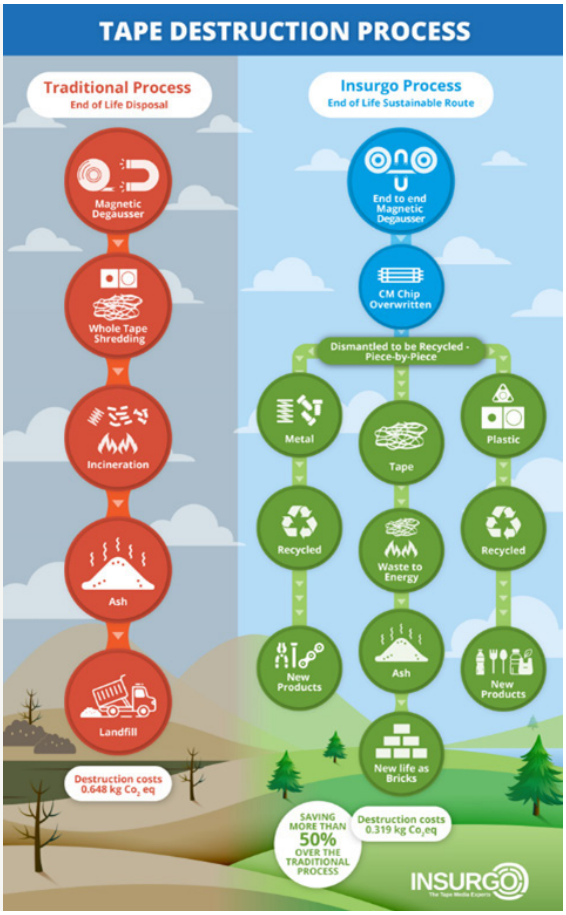
"Improving Information Technology Sustainability with Modern Tape Storage", a research paper issued by Brad John's Consulting, compared an all data on HDD solution to an all-tape solution and to an active archive that moved 60% of the HDD resident (low activity) data to tape. Moving 60% of HDD data to tape for 10 years reduced carbon emissions by 58%. The research paper also analyzed the CO2e generated due to energy consumption and emissions associated with the acquisition of raw materials, manufacturing, and the final disposal of storage media. Moving all 100 PB to tape reduced carbon equivalents (CO2e) by 97%! With insatiable secondary storage demand ahead, expect tape to play a pivotal role in data center sustainability initiatives as moving low activity data from HDDs to tape pays enormous dividends. Keep in mind - storing low activity and archival data on spinning HDDs is a strategy, just not a cost–effective or eco-friendly one.



Brad Johns Consulting, "Improving Information Technology Sustainability with Modern Tape Storage", August 2022

Tape End-of-Life Disposal Innovations Reduce CO2 Impact by more than 50%

Beyond energy savings in the usage phase, innovative new solutions for tape cartridge disposal at end-of-life are now available that further enhance the eco-friendly nature of tape. These innovations consist of more energy efficient methods of data eradication, including the cartridge memory chip, with full traceability of the cartridge through the disposal process. Once completely devoid of data, the cartridge enters into a material component recycling stream, resulting in a more than 50% reduction in CO2e compared to traditional degauss, shred, and incineration processes. As global warming and climate change continue to be of increasing concern among corporate stakeholders, sustainability best practices from cradle to grave will be demanded for all components of IT infrastructure.



Tape Air Gap and Data Security Strategies Boost Resiliency and Cybercrime Protection

To fight the increasing threat of cybercrime, organizations must defend themselves with smart data storage and security strategies. One such strategy that organizations are adopting is to store copies of data on electronically disconnected or air-gapped devices. Tape is the only true air-gapped data center storage technology. The "tape air gap" means there is no electronic connection to data stored on a removable tape cartridge without robotic or human intervention placing the cartridge into a drive, preventing a direct malware attack (hacking) of data on the tape. HDD and SSD systems are connected and online 24/7 are always vulnerable to a cybercrime attack, making tape the only viable data center air-gapped storage solution currently available, a key component of any data protection strategy. Cartridges located in robotic tape library slots or racks are always protected by an air gap.

Backup using tape was the original data protection strategy, beginning with the IBM 701 in 1952, but having just one backup copy is no longer sufficient. Today's most popular and genetically diverse 3-2-1-1 Backup Strategy states that enterprises should have three copies of backup data on two different media types, one copy offsite, and one air-gapped copy. Combining the air gap with encryption and WORM, tape strengthens any data center's cyber resiliency strategy. Recovery time for backup data on tape has been significantly improved with features such as oRAO with LTO-9 which can reduce the time needed for file access to recover backup files and archive data from tape by as much as 73%. Remember – backup is important, but recovery is everything.

Data Protection Strategies Tape Plays Key Role to Protect ALL Data in the Security Ecosystem			
The 3–2–1–1 Backup Strategy Backup, Recovery and DR for Primary (active) Storage			
3 **Copies of Data** Cyclic Proces	**2** **Different Media Types** **(SSD, HDD, Tape)** Technology Diversity	**1** **Copy Offsite... Cloud, Vault** **(SSD, HDD, Tape)** Geographic Redundancy	**1** **Air Gap Copy Offline Media** **(Tape)** No Electronic Connection
The 2–2–1 Archive Strategy Backup, Recovery and DR for Primary (archival) Storage			
2 **Copies of Data** Cyclic Proces	**2** **Geographic Locations** • On-Premise, Cloud, or Vault • Replicated or Erasure Coded • Synchronous or Asynchronous Geographic Redundancy		**1** **Air Gap Copy Offline Media** **(Tape)** No Electronic Connection

Source: Horison Information Strategies

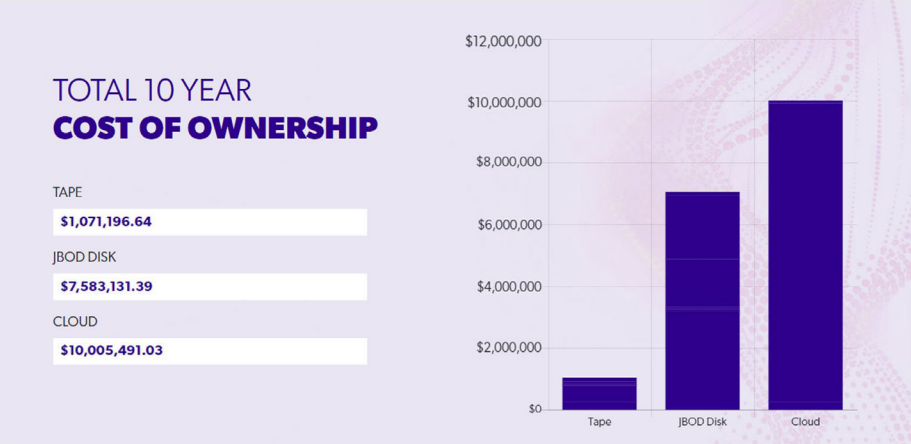
For many data centers, the archive copy is often the only copy of archival data exposing it in the case of a data loss event. Since the business value of untapped archival data is increasing, especially with the rapid rise of AI, creating a second, secure air-gapped copy in a different geographic location will soon become a standard data protection strategy. For easier access, the archive copy can be protected by implementing a 2-2-1 Archive Strategy, creating a second archival copy at a different physical location. (see chart above)

Ransomware Attacks on the Rise

2023 was the most devastating year yet for ransomware attacks, with businesses forking over a record $1.1 billion in ransom payments, for the first time ever and 2024 to 2025 is expected to be even worse. Beyond the payments, the average cost of each ransomware attack in 2023 rose to $5.13 million. Given these unprecedented numbers, ransomware attacks could become the largest, looming threat to businesses in 2025. Ransomware is malicious software that prevents access to computer files, systems, or networks, and demands payment of a ransom for their return.

Encryption is a powerful form of data security in which information is converted to ciphertext. Only authorized people who have the key can decipher the code and access the original plaintext information. In even simpler terms, encryption is a way to render data unreadable to an unauthorized party. Cybercriminals cannot read or utilize the stolen encrypted data. Enterprises can build an even stronger cyber defense by implementing the 3-2-1-1 backup strategy with encrypted, air-gapped tape and off-site backups. Using AI and automation combined with cybersecurity threat detection and response tools can help analysts detect new threats faster and more accurately than ever before.

TCO Calculations Underscore the Reason to Move Low Activity Data from HDDs to Tape

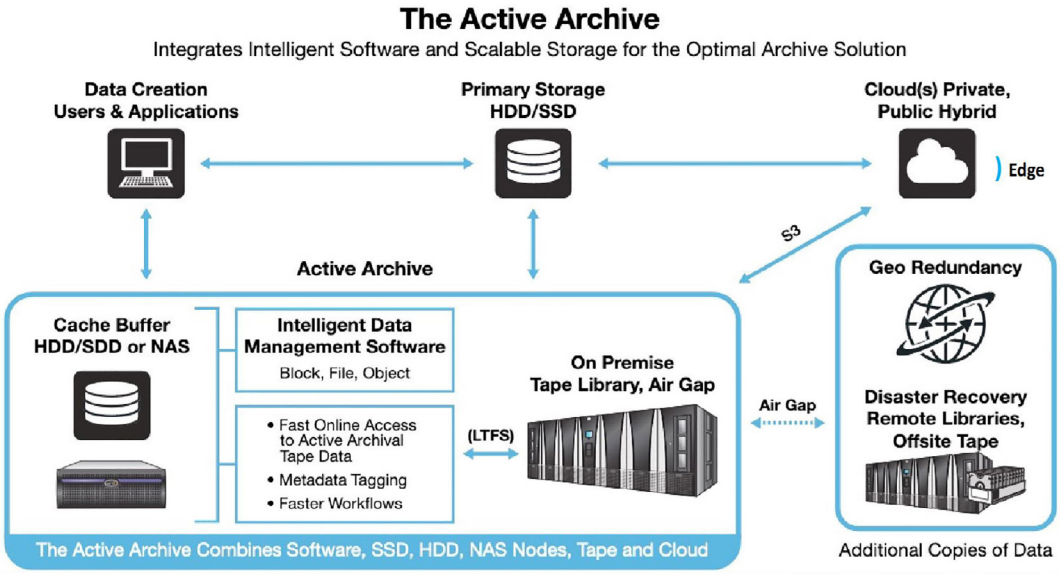


Source: LTO.org

Effectively addressing the storage optimization challenge of "getting the right data, in the right place, at the right time, and at the right cost" presents the single biggest total return for storage managers. To meet this challenge, the strengths of tiered storage combining intelligent software, SSDs, HDDs, and tape must be leveraged. As most data ages, access frequency drops off rapidly and data typically reaches archival status between 90–180 days, eventually becoming cold data. Much archival data continues to live on HDDs (too) long after it reaches archival status, a residence with expensive energy costs for such cold data. Using the highly versatile LTO Ultrium TCO Calculator, organizations can compare the TCO, energy, floorspace, and emissions to existing storage alternatives. The TCO for a HDD and cloud solution is compared to a tape solution using LTO-9 tape media and drives in the chart above. The calculator example indicates that the TCO of 20 PB of data growing at 25% per year would cost over $10 million if stored in the cloud, $7.5 million if stored on JBOD disk (on premise) and just $1.07 million if stored on tape. The compelling benefits of tape become obvious.

Clearly, the greatest economic benefits are realized when the tape tier is used. Intelligent data management software from a variety of suppliers that moves data from disk to tape is a key component to implement an optimized tiered storage infrastructure. Look for AI to play a more significant role in data management decisions going forward and to do the re-location of data to the optimal location for the user. Remember—adding disk is tactical and very costly, adding tape is strategic and much more cost-effective.

The Active Archive Provides Fast Access Times for Secondary Storage



Source: Active Archive Alliance, activearchive.com

Secondary storage receives a big performance and access time boost from an active archive architecture. An active archive integrates two or more storage technologies (SSD, HDD, tape, and cloud storage) behind file systems, providing a seamless means to manage less active archival data in a single virtualized storage pool. SSDs or HDDs serve as a cache buffer for archival data stored on tape libraries providing faster access to the first byte of data, higher IOPs, and random access for more interactive archival data. Combining the open tape file system LTFS or S3 for objects with tape partitioning, data mover software (HSM, etc.), an HDD array, or NAS in front of a tape library creates an active archive. Using an SSD for the cache creates an instant archive. The active archive is supported by the Active Archive Alliance. See the Active Archive conceptual view above.

Video Surveillance Creates Growing Storage Demand

With an ever-increasing threat landscape, video surveillance is becoming even more important than it was just a few years ago. To deter crime, organizations are installing cameras everywhere with higher resolution and frame rates and much longer retention periods. As a result, the amount of video surveillance content being stored is accelerating. Solutions will continue to emerge that combine high speed HDD storage with efficient LTO tape storage and add metadata to create a two-tiered active archive strategy that balances cost, speed, and long-term retention requirements. This ensures access to older video footage while relieving expensive and energy-intensive high speed storage in the active tier. Increasing retention periods have made storing older surveillance data on HDDs a costly choice. Coupled with AI, the value of historical video surveillance content is quickly increasing, leading to a demand for even longer retention times. Though most data reaches archival status in 90-180 days, surveillance data takes less than a week after creation. Surveillance data is an ideal candidate for an active archive implementation.

Tape Performance – Delivering Faster Access Times and Throughput

HDDs and SSDs can access the first byte of data much faster than tape. For large files, tape systems have faster access times to the last byte of data. Previously available for IBM enterprise tape drives, oRAO (Open Recommended Access Order) was made available with LTO-9 full-high tape drives. oRAO reduces initial file access time, serving as a data retrieval accelerator enabling applications to retrieve non-consecutive (random) files from tape by optimizing physical seek times between files. oRAO can improve random access time to data segments on tape by as much as 73%, when compared with retrievals of the same data segments linearly, while significantly reducing physical tape movement and drive wear by creating an optimally ordered list of files on a cartridge. In addition, LTO-9 increases drive data rate to 400 MBps making it ideal for data streaming and large file transfers. RAIT, analogous to HDD RAID, serves as a data rate multiplier enabling parallel data transfer from an array of tape drives.

Tape Performance Improvement Summary	
	Tape Access Time Improvements (Time to 1st Byte)
Active Archive	Active archive greatly improves access time to file and object tape data by using high-capacity HDDs or SSDs as a cache buffer in conjunction with a tape library.
oRAO	oRAO (Open Recommended Access Order) arrived with LTO-9 and produces an optimized list called "best access order" enabling applications to retrieve non-consecutive tape files by minimizing physical seek times (~73%) between files.
LTFS | S3	LTFS provides access to files directly without the application that wrote the data. S3 provides many of the LTFS services for object storage.
Faster Smarter Library Robotics	Intelligent robotics optimize robotic movements reducing mount and access times while improving reliability. Ransomware-free partitions boost security.
	Tape Throughput Improvements (Data Transfer Rate)
Fastest Data Rates	The LTO-9 and TS1170 enterprise drives each have a data transfer rate of 400 MBps. This compares to the 7,200 RPM HDDs ranging between 160 – 260 MBps.
RAIT	RAIT (Redundant Arrays of Independent Tape) stripes data across multiple tape drives in parallel significantly increasing throughput and provides parity for data reconstruction like RAID does for HDDs.
RAIL	RAIL (Redundant Arrays of Independent Libraries) stripes data across tape cartridges but in different libraries which may be in different geographic locations.

LTO Value Proposition: A Compelling Business Case for Tape

The current state of the tape industry is highlighted with continued development and investment in smart libraries, new drives, advanced media, and intelligent management software. The tape value proposition shown in the table below is compelling and addresses the relentless demand for higher reliability, higher capacity, better power efficiency, ease of use, and the lowest $/TB and TCO of any available storage solution.

Tape Function	Benefits Summary	Tape Re-enters Growth Phase
Price/TCO	Tape has the lowest acquisition price $/TB, and the lowest TCO.	
Energy, CO2 Sustainability	Tape uses much less energy and has much lower carbon footprint than HDDs (~97% lower).	
Performance and Throughput	See tape performance improvement summary above.	
Capacity	LTO-9 cartridge capacity @ 18 TB (45 TB compressed) with 400 MBps data rate. Smart zone, exabyte+ capacity libraries are available. Lab Demos reach 580 TBs per cartridge. Deep archive libraries emerge.	
Scalability	Tape easily scales capacity (PBs to EBs) by adding media/racks *without adding energy consumption*, HDDs scale capacity by *adding drives and adding energy consumption*.	
Portability	Tape media easily portable in case of disaster, HDDs more difficult to physically move.	
Cybersecurity	Air Gap, WORM, and encryption options protect against malware attacks, providing immutability.	
Durability/Media	LTO reliability BER ($1x10^{20}$) surpassed HDDs ($1x10^{17}$), media life >50 years for all modern tape.	
Recording Limits	HDDs face areal density and performance (IOPs) limits. Tape has a well-defined roadmap extending through LTO-14.	
Open Standards	LTO and LTFS provide open standard file interface, APIs. SW (S3 API) file support for tape object storage.	
Tape and Cloud Ecosystem	Tape interfaces seamlessly with clouds using industry standard API's. Native cloud applications can write to and read from tape. Hot and cold clouds.	

CONCLUSION:
The Dawn of AI Disruption has Arrived

As AI applications proliferate, demand for memory and storage solutions to manage the extensive data utilized in its inference engines is soaring. The arrival of AI signals a turning point, potentially altering the shape of the long-standing storage pyramid by applying pressure on DRAM, NAND flash, HDDs, modern data tape, and energy demand. As AI and related technologies increase storage requirements and associated costs, LTO makes the management of these new vast amounts of data even more cost-effective and sustainable. While momentum continues to build for a new secondary storage solution, any successful new technology must be easily scalable and require minimal remastering cycles as the home for the "golden copy," an immutable master copy of the most critical data. The optimal design will have a robust roadmap, minimal environmental/carbon footprint, realistic access times and a price point below all other competitive offerings. Other large-scale, potential secondary storage technologies remain under various stages of development including ceramics, glass media, and DNA. Some of these technologies have been under development for decades and a realistic timeframe for commercial availability remains unknown. For the foreseeable future, modern tape systems stand alone as the leading secure, cost-effective, energy efficient, pure long-term storage solution. Roadmaps indicate that the trend of steady tape technological innovation will steadily continue well into the future.

Tape is by far the greenest storage technology and can significantly reduce carbon emissions and e-waste from data center operations. Leading edge organizations determined to contain their infrastructure costs and improve sustainability metrics will be motivated to rethink existing data storage practices and take advantage of advanced magnetic tape. Combined with improved access times, faster data rates, a 50-year media life, the lowest TCO, the highest device reliability, and huge sustainability benefits, modern tape has the greatest potential to address the massive demands of AI and the zettabyte era. It's no coincidence that the rise of many new tape advancements corresponds with the rise in secondary storage demand. After carefully considering the alternatives for the foreseeable future—tape has clearly established its position as the primary secondary storage choice as we enter the age of AI disruption.

Additional Resources:

Proven Reliability of LTO-9 Tape Technology ESG Technical Review
https://www.lto.org/wp-content/uploads/2023/01/ESG-Technical-Review-LTO-9-Jan-2023.pdf

IBM TS1170 Hi-Density 50 TB Tape System
https://newsroom.ibm.com/2023-08-29-Fujifilm-and-IBM-Develop-50TB-Native-Tape-Storage-System,-Featuring-Worlds-Highest-Data-Storage-Tape-Capacity-1

INSIC 2024 Report: Global Trends, Applications and Use Csaes for Tape Adoption
Global-Trends-Applications-and-Use-Cases-for-Tape-Adoption-INSIC-2024.pdf (lto.org)

INSIC 2024 Magnetic Tape Storage Technology Roadmap
INSIC-International-Magnetic-Tape-Storage-Technology-Roadmap-2024.pdf (lto.org)

Active Archive Alliance Special Report: How Active Archives Support Modern AI Strategies
AAA-Annual-Report-2024-FINAL.pdf (activearchive.com)

Tape. New Game. New Rules.
https://asset.fujifilm.com/www/us/files/2024-03/1cb09f4968e7adf72ce54d2ecfe2853b/Horison-Tape-New-Game-update-2024.pdf

The Impacts of Generative AI on Enterprise Data
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