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## IBM LTO 10 Tape Drive Full Height Model Performance Position Paper

**Authors:**

*Tsuyoshi Miyamura (miyamu@jp.ibm.com)  
Tape Storage Development  
Tokyo, Japan*

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### Introduction

The purpose of this position paper is to examine the performance of the IBM LTO 10 Tape Drive (LTO 10 tape drive) Full Height Model in an open systems environment.

### LTO 10 Tape Drive Overview

The tenth generation IBM LTO 10 tape drive offers a great storage capacity and an excellent performance using technology designed for the mid-range open systems environment that include IBM Power Systems™; selected Oracle and Hewlett Packard servers and Intel servers running supported versions of Microsoft Windows or Linux.

There are 2 interfaces available for the LTO 10 tape drive:

- 32 Gbps Fibre Channel
- 12 Gbps SAS

The Fibre Channel interface and the SAS interface are available on full height models.

The IBM LTO 10 tape drive full height model offers a native data rate of up to 400 MB/s as same as the previous IBM LTO 9 tape drive full height model.

The IBM LTO 10 tape drive supports a new generation of data cartridge (gen10 media) that offers a native capacity of 30 TB (75 TB with 2.5:1 compression) 1.67x the capacity of the previous gen9 tape cartridge generation.

The IBM LTO 10 tape drive will support the Linear Tape File System (LTFS) format in IBM Spectrum Archive™ that presents the tape storage as a file-based storage system.

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### Performance Overview

The key features of the IBM LTO 10 tape drive full height mode are designed to improve performance and capabilities when compared to IBM LTO 9, IBM LTO 8 and other vendors tape drives, some of the highlights are:

- Native data rate of up to 400 MB/s
- Native data physical capacity of 30 TB
- Hardware data compression using the same algorithm since LTO 6.
- Support for 32 Gb FC and 12 Gb SAS connectivity
- SkipSync Function to provide small file backhitchless flush capability
- Cache buffer: 4096 MB

The LTO 10 tape drive features hardware encryption of data and two interface options. The data rate is the same as the previous generation, but its supported FC connectivity has improved to 32 Gb. The tape capacity also increases 1.67x from the previous generation 9.

This position paper examines the performance benchmarks of the IBM LTO 10 tape drive full height model and associated features.

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### Performance Evaluation

All the performance benchmarks were run on one or more of the following systems:

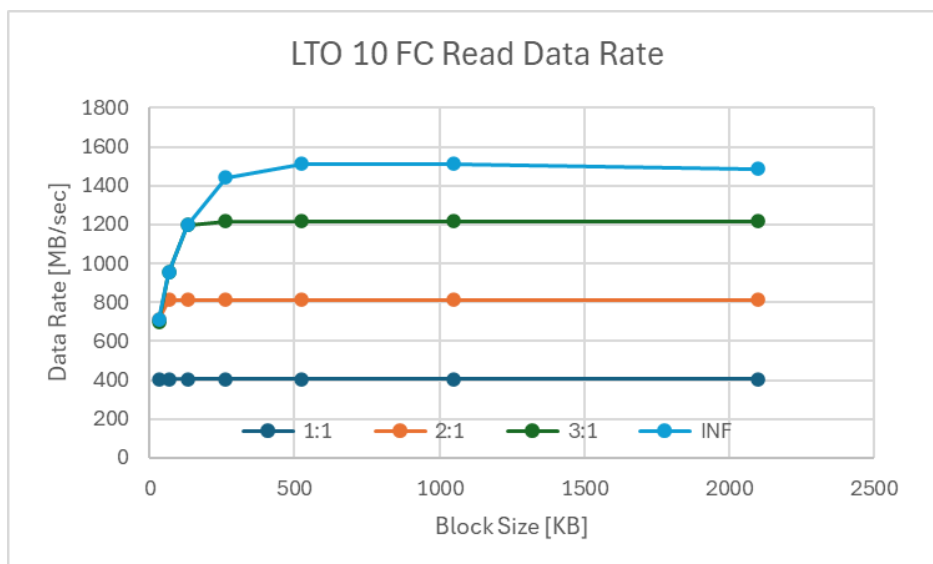
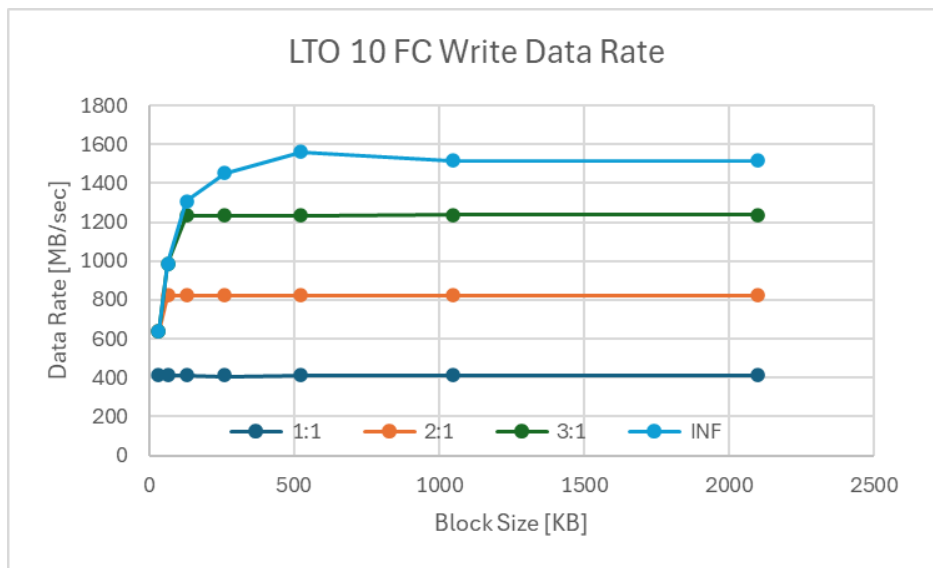
- Dell PowerEdge R750 servers running RHEL 9.5 with QLogic 2772 Dual Port 32Gb Fibre Channel HBA and Emulex LPE 35002 Dual Port 32Gb Fibre Channel HBA.
- Dell PowerEdge R740 servers running RHEL 9.5 with Broadcom 9300-8e.

The performance benchmarks used for the tests are a toolbox of in-house C-based performance measurement tools designed to fully exercise the host interface and tape drive with the least amount of overhead. As such, the primary goal of the benchmarks was to provide a picture of the maximum capabilities of the LTO 10 tape drive. All data rates/capacity reflect a decimal basis where KB = 1,000 bytes, MB = 1,000 KB, GB=1,000 MB and TB=1,000 GB. Actual tape drive data rate and cartridge capacity might vary depending on factors such as data compression, server and disk performance variables.

There are several factors that impact performance, especially data rate at high compression ratios and large block sizes. Server hardware performance, server slot and operating system/device driver performance are important factors. Another source of variability in the data rate performance tests could be due to the firmware used for the Fibre Channel and SAS connections.

### Fibre Channel Data Rate Performance

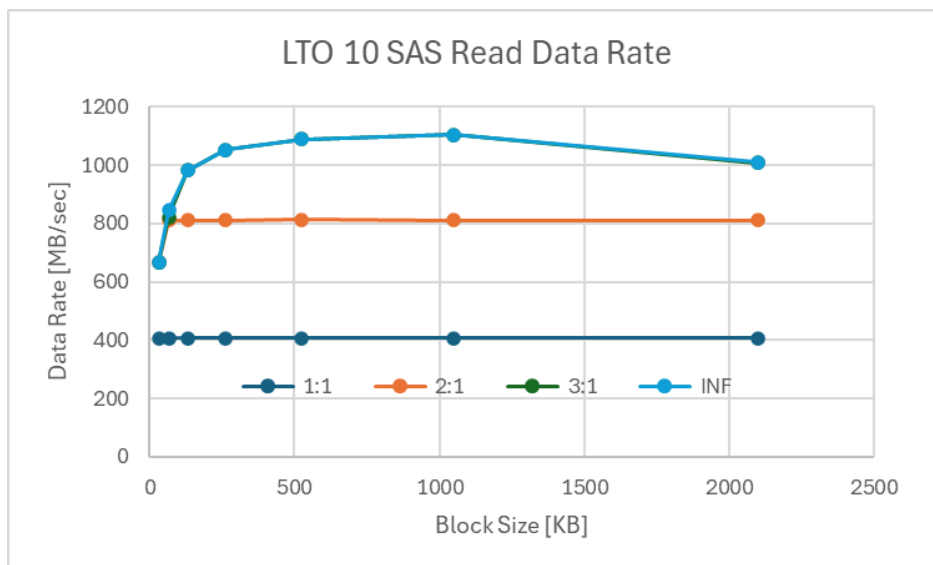
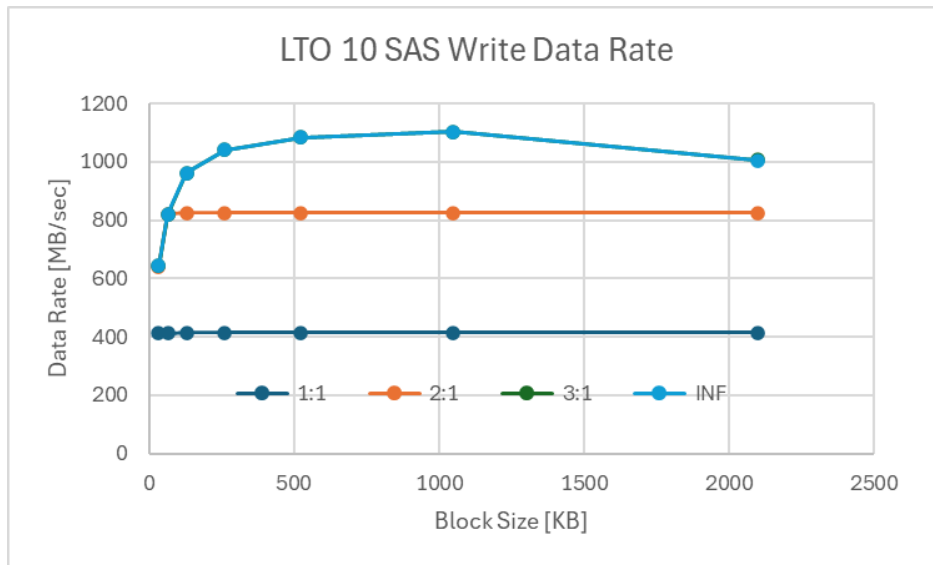
The data rate performance of the IBM LTO 10 Fibre Channel full height tape drive is described by the following set of charts that show how the drive behaves when writing or reading data that compresses uniformly at ratios 1:1, 2:1, 3:1 and maximum (80:1) using differing block sizes and LTO gen10 media.



The IBM LTO 10 tape drive achieves a native data rate of 400 MB/s with LTO Gen 10 media. Higher rates are reached with compressible data. LTO 10 uses the same compression engine as LTO 9 but supports 32Gb FC. The faster host interface improves compressible data performance from prior generations by nearly 2x.

### SAS Data Rate Performance

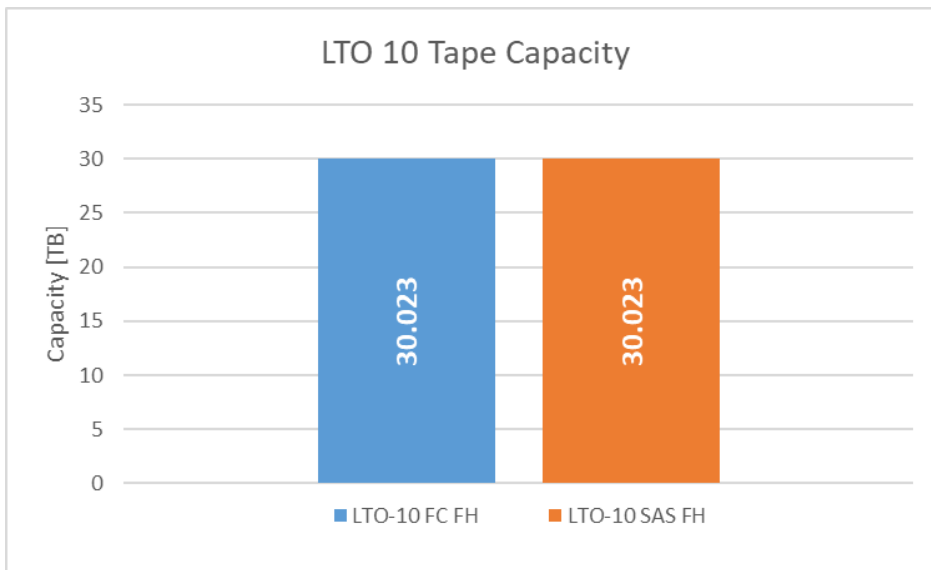
The data rate performance of the IBM LTO 10 SAS full height tape drive is described by the following set of charts that show how the drive behaves when writing or reading data that compresses uniformly at ratios 1:1, 2:1, 3:1 and maximum (80:1) using differing block sizes and LTO gen 10 media.



**Note:** LTO 10 SAS tape drive GA code was not performance tuned, and its maximum compressed data rate is around 200 MB/sec lower than this result. To achieve the best performance, the drive firmware must be updated to the PGA1 level.

### Tape Capacity

The following chart shows the capacity for LTO gen10 measured with the LTO 10 tape drive. Tape capacity is obtained by writing 512 KB blocks of uncompressible data until an error code is returned when EOT (End of Tape) is reached. The LTO 10 tape drive with gen10 media increases about 67% over gen9 tape cartridge capacity offering a native physical capacity of 30 TB.



The LTO 10 tape drive with gen 10 media offers a significant capacity increase over gen 9 media.

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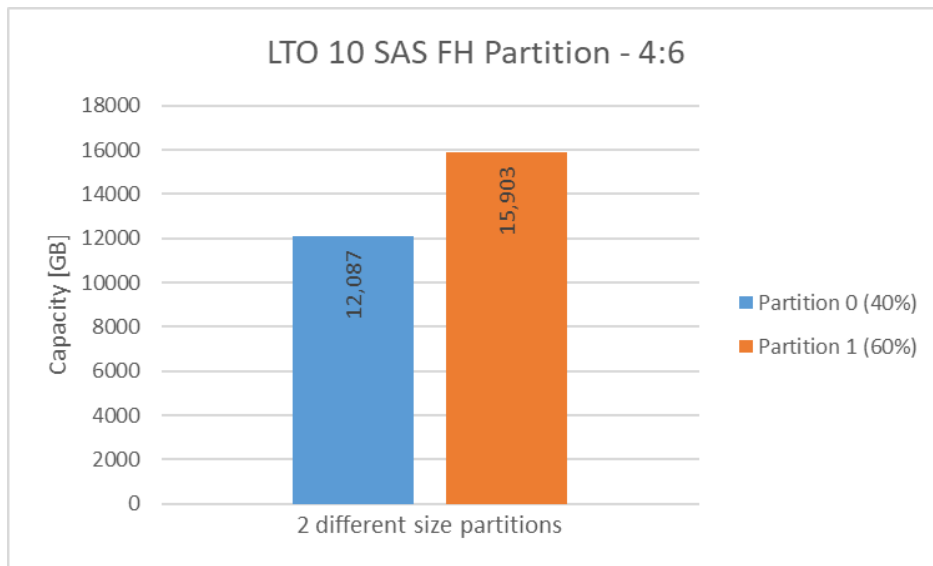
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### Tape Capacity when partitioned

The following chart shows the capacity for LTO gen10 measured with the LTO 10 tape drive when partitioned. The tape is partitioned into 2 partitions at a rate of 40%:60%, 3 partitions at a rate of 20%:40%:40% and 4 partitions at a rate of 10%:30%:30%:30%. Tape capacity is obtained by writing 512 KB blocks of uncompressible data until an error code is returned when EOT (End of Tape) is reached. The capacity of the last partition is smaller than the others as the size of guard wraps between partitions is consumed.

LTO 10 tape drive requires 32 wraps for the guard wraps between partitions, which correspond to around 2 TB. The more the number of partitions increases, the less the size of the last partition. The user must take the capacity loss into account when the tape is partitioned.

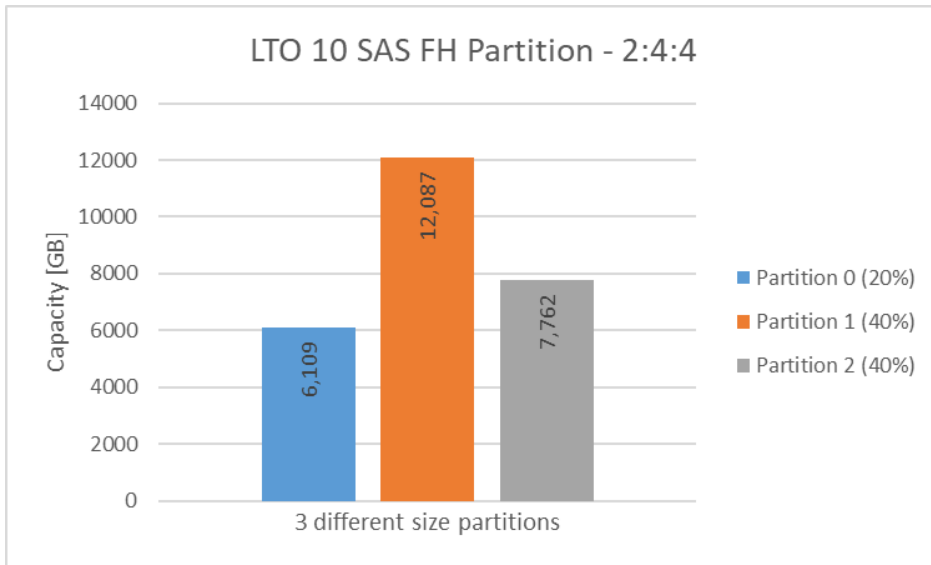
When a partition is created, the total size of the partitions becomes around 2 TB smaller than the native capacity of LTO 10 tape drive.



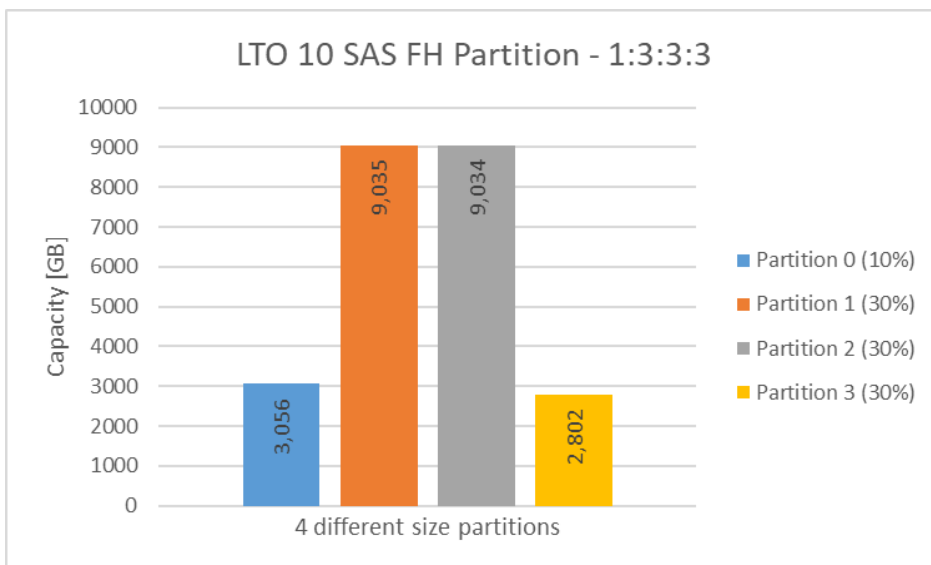
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When additional two partitions are created, the total size of the partitions becomes around 4.4 TB smaller than the native capacity of LTO 10 tape drive. The expected partition 2 size is the same size as partition1 (12.087 TB) but has only 7.762 TB.

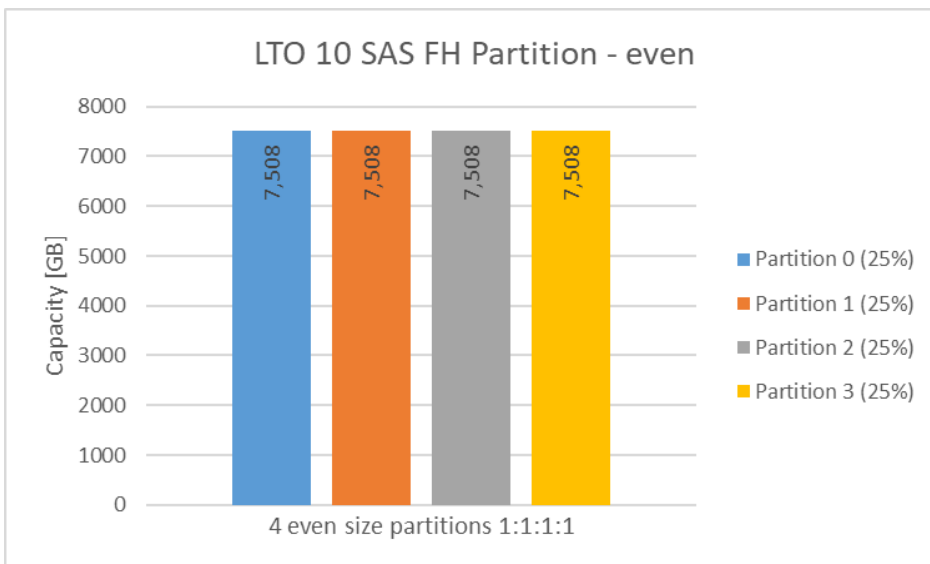
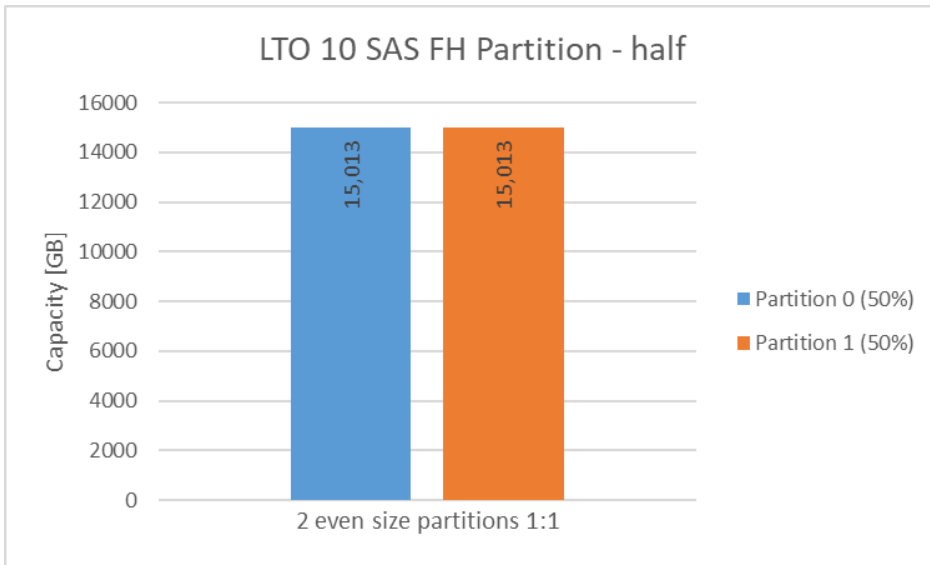


When additional three partitions are created, the total size of the partitions becomes around 6.2 TB smaller than the native capacity of LTO 10 tape drive. The expected partition 3 size is the same size as partition1 (9.03 TB) but has only 2.8 TB.



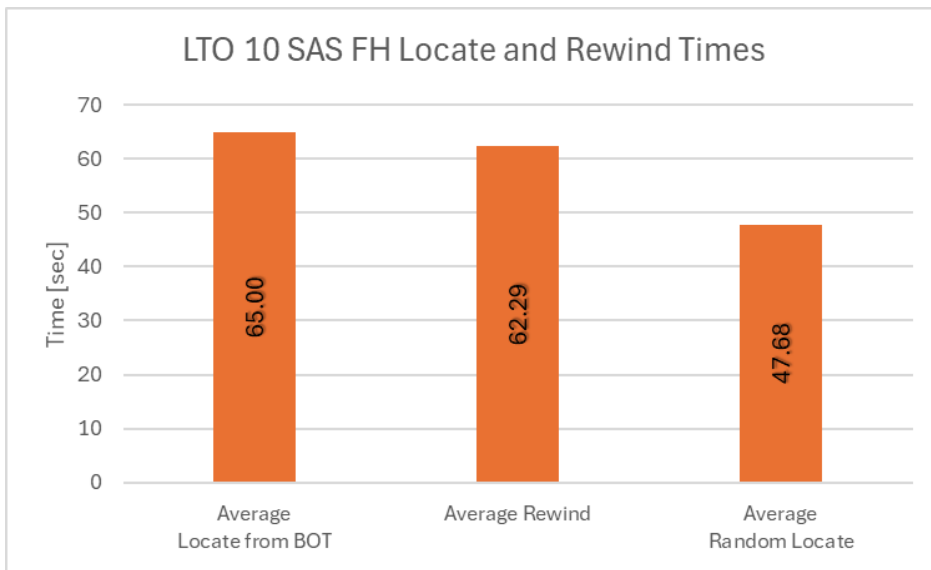
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The capacity of each partition is lost by the guard wraps between partitions. New partitioning features have been supported since LTO 9 when the tape is partitioned into 2 or 4 partitions at the same capacity. The features allow the tape to be partitioned in 2 partitions at a rate of 50%:50% or in 4 partitions at a rate of 25%:25%:25%:25% without capacity loss.



### Locate and Rewind Performance

The following charts show the average time for the LTO 10 drive to locate a random block on the tape starting at BOT (Beginning of Tape), the average time to locate a random block starting at some random location on the tape, the average rewind time as well as maximum times measured for the three operations. To determine the average and the maximum times, many locate commands and rewind commands were performed on a filled tape.

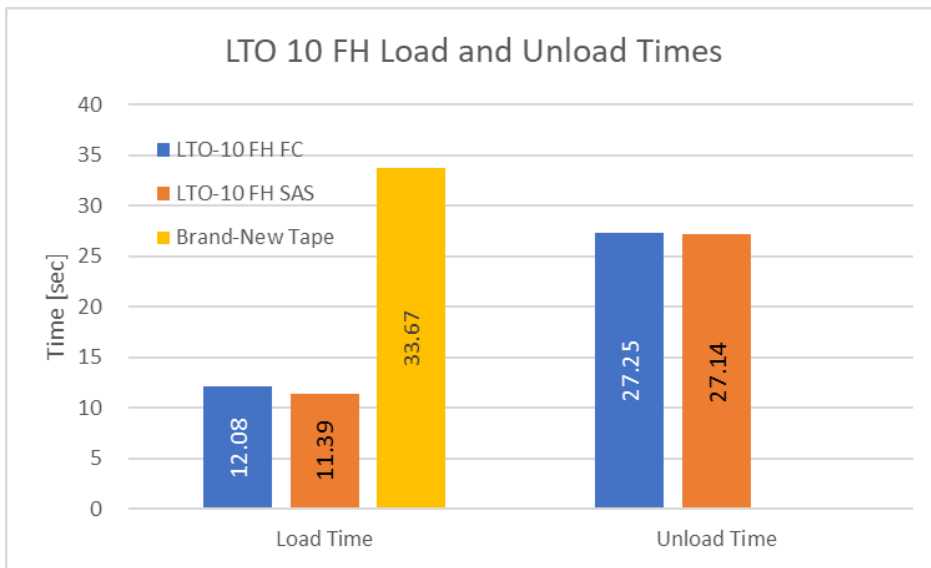


The LTO 10 tape drive with Gen 10 media offers similar performances for Locate and Rewind as compared with Gen 9.

### Cartridge Load and Unload Performance

The following chart shows the tape cartridge load and unload times for the LTO 10 tape drive with LTO gen 10. The chart also shows the brand-new LTO gen 10 tape cartridge load time for the LTO 10 tape drive.

There is no significant difference regarding the interface type used. It takes three times longer than used tape cartridges load time because the tape drive initializes the contents of the cartridge memory and writes a Format Identification Dataset (FID) to the tape.



The IBM LTO 10 tape drive has good load performance for both interface types.

Power on to ready time

The following chart shows the time from the tape drive's power on to ready time.



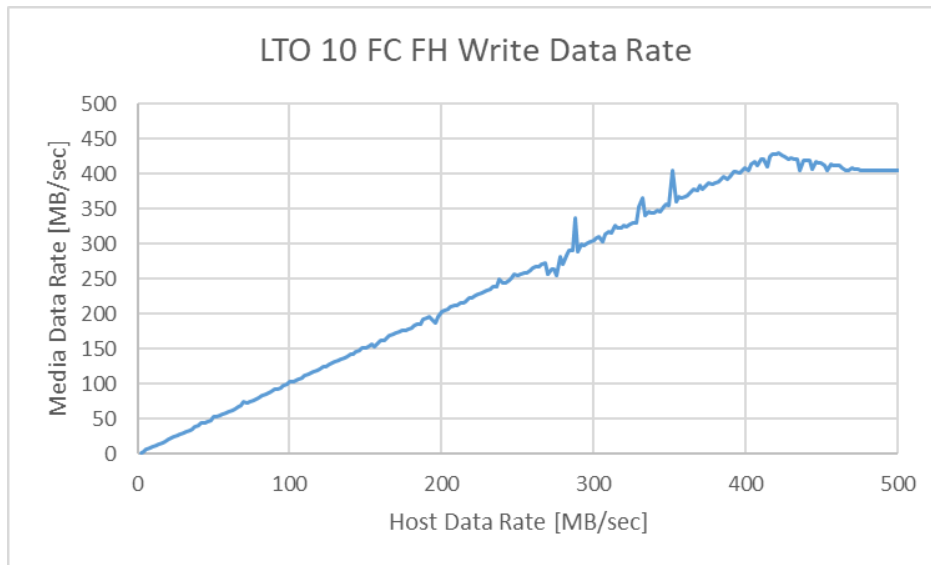
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### Speed Matching Performance

The IBM LTO 10 tape drive full height model uses 14 speeds (from speed 1 to speed 14) to match the host data rate. The implementation of this feature allows the tape drive to reduce the number of backhitches when the net host data rate is less than the maximum drive native data rate, reducing unnecessary tape motion, and may increase overall performance in certain environments.

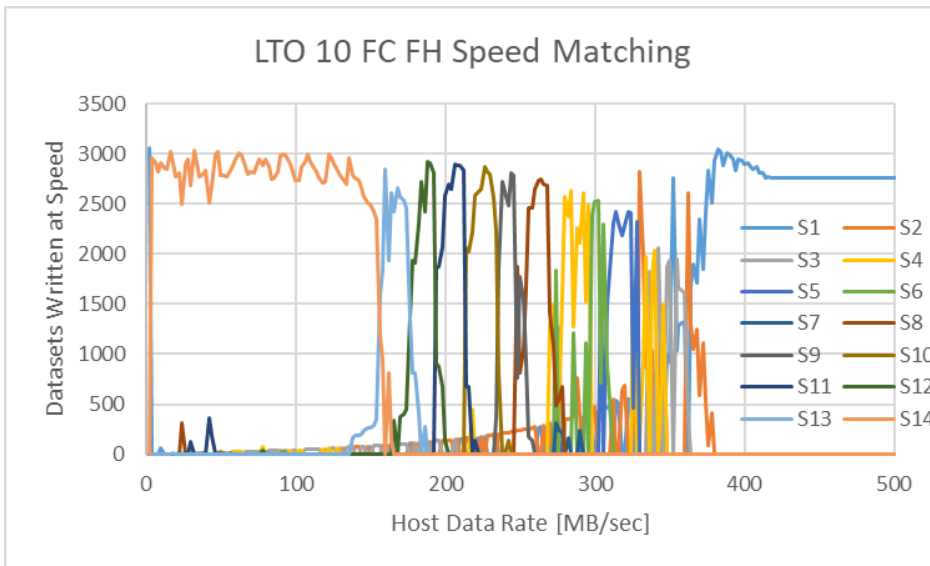
To perform this test, non-compressible data is written, and host delays vary the speed of the data from the host to the LTO 10 tape drive. At each host data rate, the number of datasets handled by each speed is recorded (a dataset is the unit of writing for the drive on the physical tape side and consists of collection of logical blocks, file marks, ECC, and other format attributes). The first chart shows the effective data rate to media (vertical axis) to the host data rate (horizontal axis) on LTO 10 FC FH drive.



Speed matching helps to improve the overall tape drive data rate at lower host data rates.

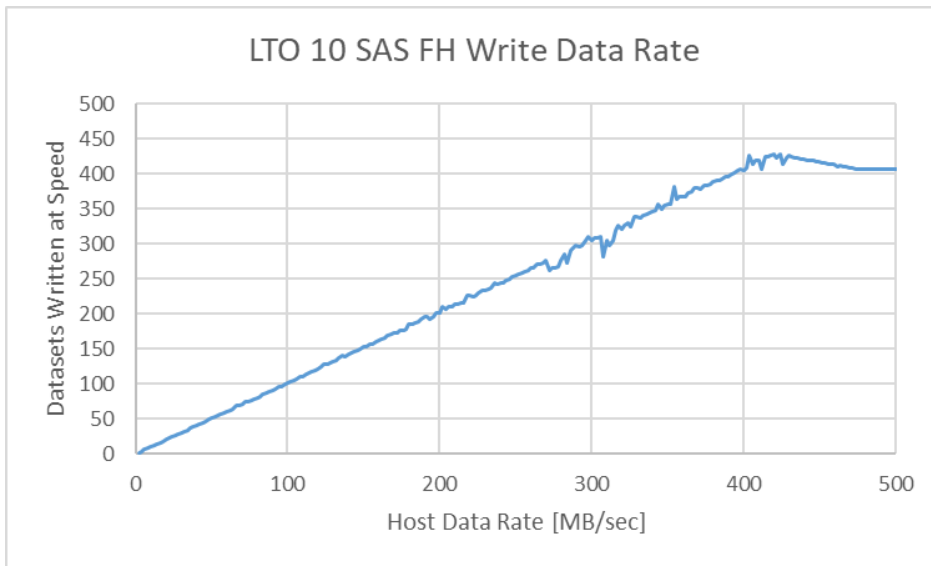
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The second chart shows how the tape drive selects the appropriate speed from the available 14 speeds to match the host data rate and most of the datasets written are handled by the suitable speed on LTO 10 FC FH drive.

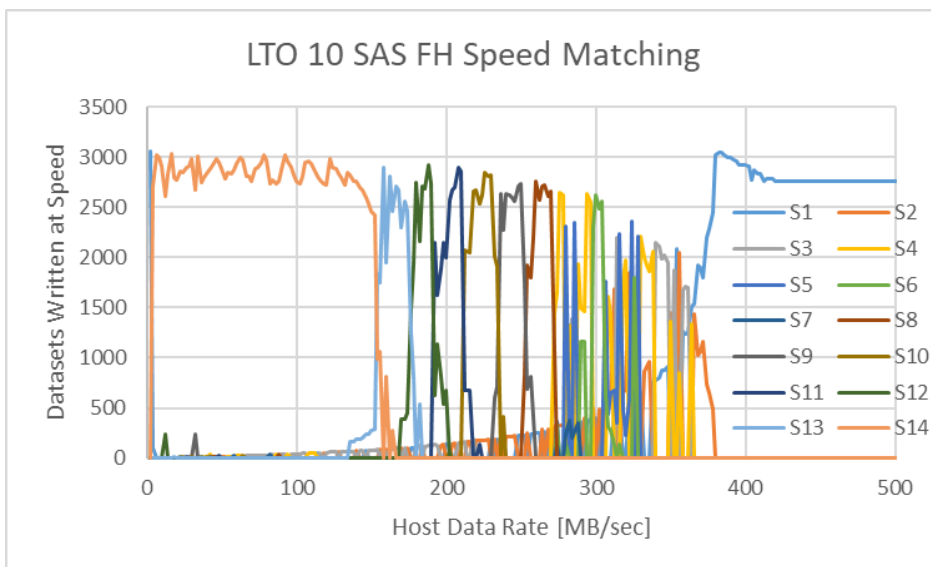


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The third chart shows the effective data rate to media (vertical axis) to the host data rate (horizontal axis) on LTO 10 SAS FH drive.



The fourth chart shows how the tape drive selects the appropriate speed from the available 14 speeds to match the host data rate and most of the datasets written are handled by the suitable speed on LTO 10 SAS FH drive.



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## RAO Performance

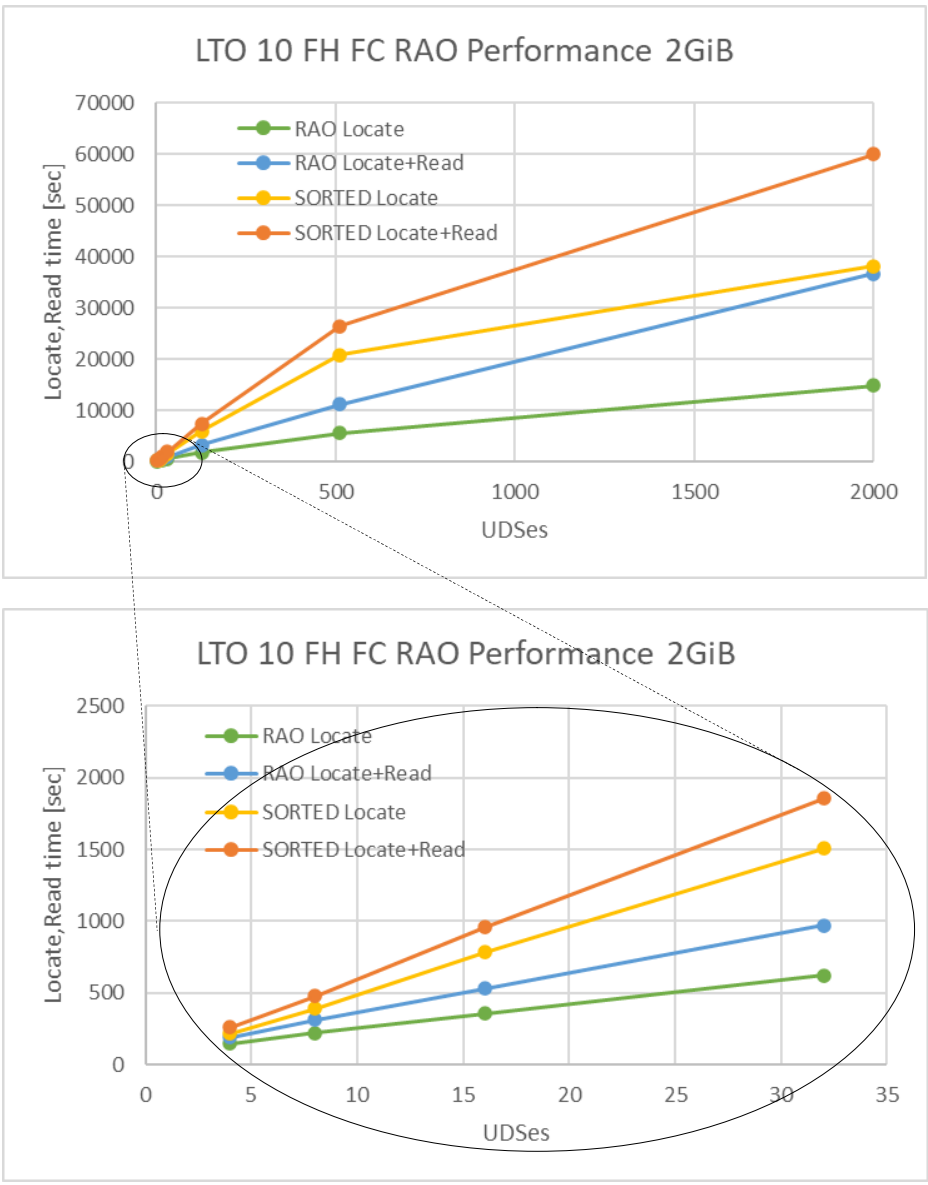
The Locate and Locate+Read performance of the LTO 10 FC FH tape drive is described by the following set of charts that show how the drive behaves when locating or locating+reading data in the access order determined by RAO and Sorted by record number using differing numbers of 200 MiB UDSeS (4, 8, 16, 32, 128, 512, and 2000). Here, MiB=2<sup>20</sup>. Similar results are obtained on LTO 10 SAS FH tape drive as well.



It took less time to locate and locate+read when the order of access was determined by RAO compared to when the order of access was determined by sorting by record number.

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The Locate and Locate+Read performance of the IBM LTO 10 tape media on the IBM LTO 10 tape drive is described by the following set of charts that show how the drive behaves when locating or locating+reading data in the access order determined by RAO and Sorted by record number using differing numbers of 2 GiB UDSeS (4, 8, 16, 32, 128, 512 and 2000). Here 1 GiB = 2<sup>30</sup>.



It took less time to locate and locate+read when the order of access was determined by RAO compared to when the order of access was determined by sorting by record number.

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## Conclusions

Since the introduction of the first LTO tape drive, every following generation has incorporated new features and performance improvements to respond to storage needs. Now the IBM LTO 10 tape drives in conjunction with the new LTO Gen 10 media represent an efficient solution for today's growing storage demands.

Native capacity increases from 18 TB (gen 9 media) to 30 TB (gen 10 media) and even more with data that is compressible (75 TB with 2.5:1 compression). This capacity increase does not impact locate/rewind performance.

In addition, the IBM LTO 10 tape drive continues to support media partitioning, encryption of data, and WORM media.

The IBM LTO 10 tape drive is a smart storage solution for businesses requiring backup and archival storage of their data.

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