

Digital Speed Matching

Getting the Most Performance

Aug 2003



EXECUTIVE SUMMARY

The tape drive has traditionally been saddled with the burden of being viewed as the speed bottleneck in data backup throughput. However, with the introduction of super tape drives, IT managers are now finding that other system components, such as the operating system, ISV software, host adapters, servers and disk subsystems, are having trouble keeping up with the “streaming” performance capabilities now being delivered by these super drives.

And, the performance variability among system component generally causes the tape drive to fall out of data streaming mode several times during a backup session, causing what is known as a tape write re-position, or shoeshine. To help solve this performance inconsistency problem, tape drive vendors have devised various ways to maintain throughput under slow or varying host data transfer rate conditions.

Two such methods to stabilize performance are DLTape’s Digital Data Rate Agent (DDRA) and HP’s Ultrium Adaptive Tape Speed (ATS). DDRA is a pure digital solution, while ATS is a hybrid digital/analog/mechanical solution.

Under a series of benchmark tests to compare the relative performance of the two algorithms, it was found that DDRA enabled the SDLT 320 tape drive to deliver a significant performance advantage over the ATS-enabled Ultrium 230:

Block Size	Host Transfer Rate Type	Write or Read Mode	SDLT 320 Transfer Rate Bytes/sec	HP Ultrium 230 Transfer Rate Bytes/sec	SDLT 320 Performance Edge
64K	Fixed @ 30 MB/s	Write	17,239,311	14,012,506	23.03%
	Random	Write	10,402,452	8,851,343	17.52%
	Toggled	Write	10,383,724	9,384,560	10.65%
64K	Fixed @ 30 MB/s	Read	16,795,863	9,511,093	76.59%
	Random	Read	10,445,824	7,506,365	39.16%
	Toggled	Read	10,290,178	6,578,583	56.42%

Table 1. Performance under Fixed, Random and Toggled Host Transfer Data Conditions @ 1:1 Compression

DLTape’s Digital Data Rate Agent technology proved itself to be the best for slow or varying host data transfer rate conditions.

BACKGROUND

With the March 2001 introduction of the SDLT 220, the super drive class of tape drive was born. Tape drives in this class are defined as having native capacities greater than 100 GB and native transfer rates greater than 10 MB/s. Since that initial introduction, several generations of super drive class products have been introduced into the marketplace. Soon, native capacities will exceed 300GB. These new tape drives have helped IT administrators manage and protect the large – and growing -- amounts of business data generated in their organizations.

However, now that super drives can transfer data at very high speeds, IT managers are finding that other system components, such as the operating system, ISV software, host adapters, servers and disk subsystems, are having trouble sustaining the high transfer rates required to get optimal tape backup speed “streaming” performance.

This is particularly true in environments where the tape drive is directly attached to the backup server and is responsible for backing up File, Print, and eMail application data. This type of data is generally comprised of mostly small (< 50K) and medium (< 100K) size files. In this configuration the speed at which the server transfers data to the tape drive can vary widely (see figure 1), dramatically affecting backup performance.

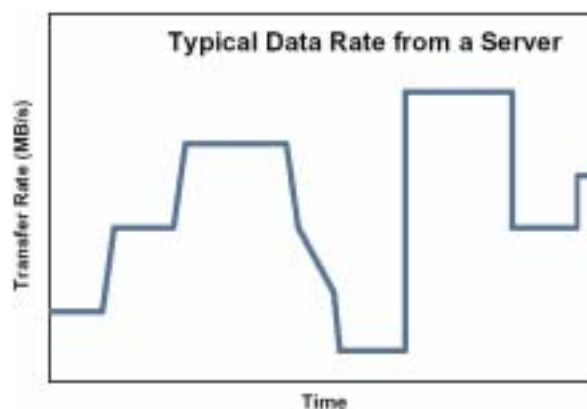


Figure 1. Typical Server Transfer Data Rate

This performance variability generally causes the tape drive to frequently fall out of data streaming mode during a backup session and perform a tape re-position, or “shoeshine.” Under normal operation, a tape drive’s read/write heads are positioned precisely against the tape media which then “streams” past the heads. The tape drive takes data from the host and writes that data to the tape media. Because the tape media continually streams past the tape drive heads, the data transfer rate from the host must remain high enough to keep the tape streaming. If the transfer rate slows down too much the tape drive runs out of information to write and must stop in order to rewind and reposition itself for continued writing. Rewinding to the point it ran out of information takes a foot or two of actual tape. Once it reaches this point, it stops again and then restarts, accelerating so that it is up to appropriate speed by the time it reaches the last point it wrote data. The starting and stopping activities of this process looks much like the back and forth motion of a shoe shine, hence it’s name – shoeshining.

Tape shoeshining significantly degrades overall backup throughput. To solve the problem tape drive vendors have devised various ways to maintain high backup throughput under slow host or varying host data transfer rate conditions.

TESTING OBJECTIVE

This White Paper describes the performance test results of tape super drives in slow host or varying host data transfer rate conditions. The objective of the test was to compare the performance of DLTape's Digital Data Rate Agent -- used in SDLT tape drives -- against HP's Adaptive Tape Speed -- used in HP-branded LTO tape drives. The test measured the write/read transfer rates with compression mode disabled, while limiting the host data transfer rate under various conditions. The specific host transfer rate conditions were:

- ▶ Fixed Host Transfer Rate
- ▶ Random Host Transfer Rate
- ▶ Toggled Host Transfer Rate

Quantum contracted Percept Technologies, an independent Product Test and Development Firm, to perform this performance testing. Percept Technologies audited the test methodologies and procedures, performed the tests and evaluated all test results according to the test plan provided.

TAPE DRIVE SPECIFICATIONS

The tape drives used during the test were the SDLT 320 and the HP Ultrium 230. A summary of each tape drive's specifications is shown in the table below.

	SDLT 320	HP Ultrium 230
Capacity (native)	160 GB	100 GB
Transfer Rate (native)	16 MB/sec	15 MB/sec
Cartridge Load Time (from BOT)	12 sec	25 sec
AVG File Access Time (from BOT)	70 sec	71 sec
8 TB Library Storage Density	50 Cartridges	80 Cartridges
Interfaces	SCSI	SCSI
Infrared Management Interface	Yes	No
Data Channels	8	8
Tape Format	Linear serpentine	Linear serpentine
Servo Method	Optical Servo	Magnetic Servo
Channel Technology	PRML	Peak Detect
Data Compression Algorithm	DLZ	LTO ALDC
Backward Compatibility	Yes	No
MTBF	250,000 @ 100%	250,000 @ 100%
Uncorrected Bit Error Rate	< 1 in 10 ¹⁷ bits read	< 1 in 10 ¹⁷ bits read

Table 2. Tape Drive Specifications.

Both manufacturers have introduced drive technologies to minimize the number of re-positions and thereby maximize overall backup throughput under slow or varying host transfer data rate conditions.

DLTTAPE DIGITAL DATA RATE AGENT

The DLTape SDLT drives use a technology known as the Digital Data Rate Agent (DDRA) to dynamically manage the data flow rate from the host system to the Super DLTape media. The technology is 100% digital and was first used in the SDLT 220 tape drive.

DDRA works by continually monitoring the data rate from the host system and intelligently buffering the data to the write/read channel to smooth out any variability in the host transfer rate.

HP LTO ADAPTIVE TAPE SPEED

The HP Ultrium tape drives use a hybrid digital/analog/mechanical feature known as 'adaptive tape speed' (ATS) which can dynamically vary the speed (ips) of the tape media according to the data flow rate to or from the host system. The technology was first used in the Ultrium 230 tape drive. The Ultrium 460 has an enhanced version of ATS.

Using ATS, the tape drive's firmware continually monitors the incoming data rate and sets a watermark. This watermark determines the throughput of the write/read channel and adjusts the analog servo motors (pulling the tape media) to match the write/read channel throughput.

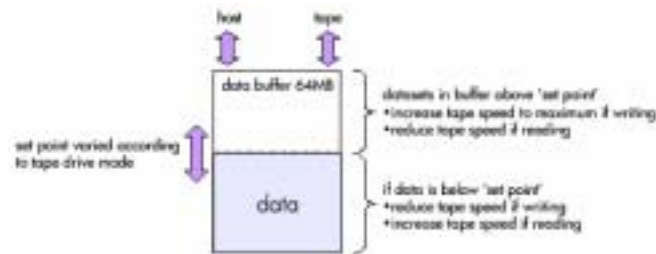


Figure 2. Ultrium 460 data buffer control.¹

TEST SETUP AND PROCESS

The test set-up consisted of three WinSCSI test platforms, each with two Adaptec 29160 boards, a SDLT 320 tape drive and a HP Ultrium 230 LTO 1 tape drive. Each test case was designed to write and read 2.5 Gigabytes, using specified compression and transfer rate modes, under the following block sizes: 32k, 64k, 128k, and 256k

The data transfer rates were measured using the WinSCSI framework, MaxTransfer Performance test. All continuous data transfer rates are measured in 16-bit Wide Ultra SCSI-3, LVD mode.

All tests were repeated 10 times for each tape drive under test case configuration. The average of the 10 test runs was recorded.

Fixed Host Transfer Rate Test

This test was designed to simulate the case of a constant slow host and to provide a baseline for the other two test cases. This test was performed using a 1:1 compression ratio.

The selected compression ratio and block size were maintained for each complete write/read pass. Each pass was completed 10 times with the average being recorded. During each pass the host transfer rate was fixed to each of the following values:

- 1.5 MB/sec
- 3 MB/sec
- 5 MB/sec
- 10 MB/sec
- 15 MB/sec
- 30 MB/sec

¹ HP Ultrium 460 Technical Whitepaper

Random Host Transfer Rates Test

This test was designed to simulate the case of normal File, Print, eMail server data where there's a mixture of small, medium and large files. This test was performed using a 1:1 compression ratio. This test should reveal which algorithm is best suited for managing a variety of host transfer conditions.

The selected compression ratio and block size were maintained for each complete write/read pass. Each pass was completed 10 times with the average being recorded. During each pass the host transfer rate was selected at random every 5 seconds from each of the following values:

- 1.5 MB/sec
- 3 MB/sec
- 5 MB/sec
- 10 MB/sec
- 15 MB/sec
- 30 MB/sec

Toggle Host Transfer Rate Test

This test was designed to specifically understand how well each anti-shoeshining feature response to alternating fast and slow host conditions. This test was performed using a 1:1 compression ratio.

The selected compression ratio and block size are maintained for each complete write/read pass. Each pass was completed 10 times with the average being recorded. During each pass the host transfer rate was toggled every 5 seconds between 5 MB/sec and 15 MB/sec.

TESTING RESULTS

FIXED HOST TRANSFER RATE PERFORMANCE RESULTS

As stated earlier, for this test the host transfer rate was fixed at the selected speed for an entire test pass (2.5 GB per pass, 10 passes per run). Under these conditions one would expect that each of the host speed matching algorithms would perform roughly the same. This was true when the host transfer rate was below 5 MB/s (see tables 1 & 2 below). But as the host transfer rate increased above 5 MB/s, the SDLT 320 write throughput was up to 23% faster than the HP Ultrium 230 LTO 1 tape drive.

Host Transfer Rate MB/s	SDLT 320 Transfer Rate Bytes/sec	HP Ultrium 230 Transfer Rate Bytes/sec	SDLT 320 Performance Edge
1.5	1,571,142	1,573,721	-0.06%
3	3,147,490	3,146,066	0.05%
5	5,245,607	5,235,502	0.19%
10	10,478,975	10,049,871	4.27%
15	15,509,859	14,402,047	7.69%
30	17,239,311	14,012,506	23.03%

Table 3. Fixed Host Write Transfer Rate Test Results w/64K Block Size and 1:1 Compression.

The SDLT 320 read transfer rate out performed the HP Ultrium 230 LTO by up to 76%.

Host Transfer Rate MB/s	SDLT 320 Transfer Rate Bytes/sec	HP Ultrium 230 Transfer Rate Bytes/sec	SDLT 320 Performance Edge
1.5	1,570,042	1,573,806	-0.24%
3	3,135,215	3,146,105	-0.35%
5	5,213,686	5,217,326	-0.079%
10	10,353,328	9,364,371	10.56%
15	15,264,852	10,451,584	46.05%
30	16,795,863	9,511,093	76.59%

Table 4. Fixed Host Read Transfer Rate Test Results w/64K Block Size and 1:1 Compression.

The HP Ultrium read performance falls off dramatically as figure 3 illustrates.

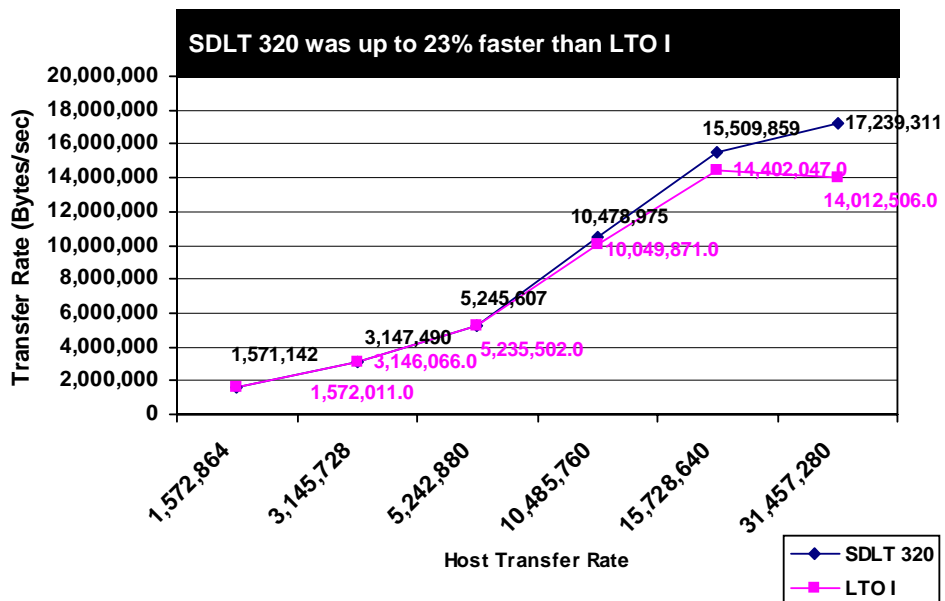


Figure 3. Fixed Host Write Transfer Rate @ 64K Block Size @ 1:1 Compression

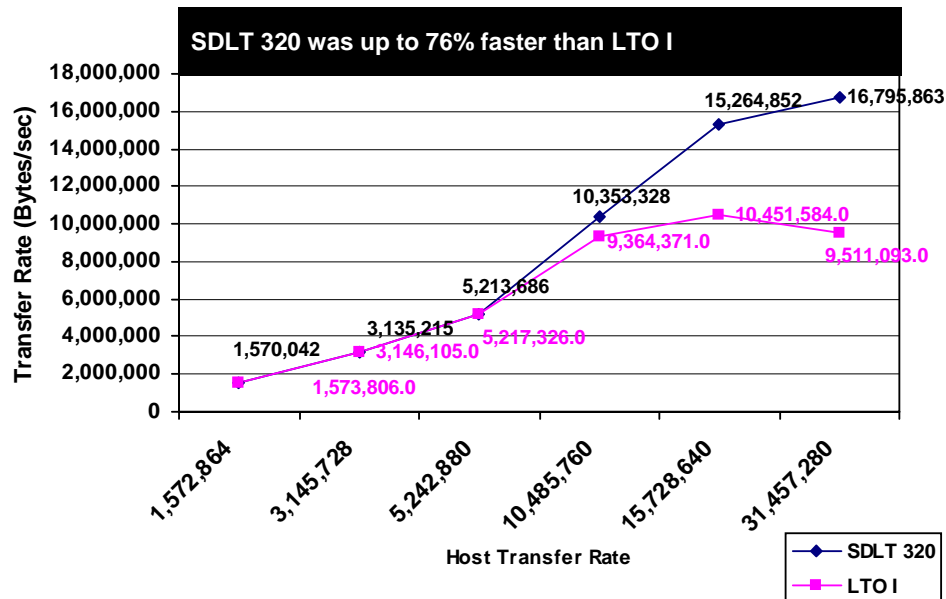


Figure 4. Fixed Host Read Transfer Rate @ 64K Block Size @ 1:1 Compression

RANDOM HOST TRANSFER RATE PERFORMANCE RESULTS

Under the more difficult test conditions of randomly changing the host’s transfer rate during each pass, the relative strengths of each speed matching algorithm would be determined. As was the case of the previous test, the SDLT 320 was significantly faster than the HP Ultrium 230 tape drive. Overall, the SDLT 320 write transfer rate out performed HP Ultrium 230 LTO by an average of 17.48%.

Block Size	SDLT 320 Transfer Rate Bytes/sec	HP Ultrium 230 Transfer Rate Bytes/sec	SDLT 320 Performance Edge
32K	9,701,616	8,435,428	15.01%
64K	10,402,452	8,851,343	17.52%
128K	10,243,311	8,573,634	19.47%
256K	10,297,745	8,733,262	17.91%

Table 5. Random Host Write Transfer Rate Test Results @ 1:1 Compression.

The SDLT 320’s read performance was even more dramatic (see table below). Overall, the SDLT 320 read transfer rate out performed HP Ultrium 230 LTO by an average of 39.46%.

Block Size	SDLT 320 Transfer Rate Bytes/sec	HP Ultrium 230 Transfer Rate Bytes/sec	SDLT 320 Performance Edge
32K	10,433,708	7,004,173	48.96%

64K	10,445,824	7,506,365	39.16%
128K	10,781,637	7,554,875	42.71%
256K	10,087,038	7,941,102	27.02%

Table 6. Random Host Read Transfer Rate Test Results @ 1:1 Compression.

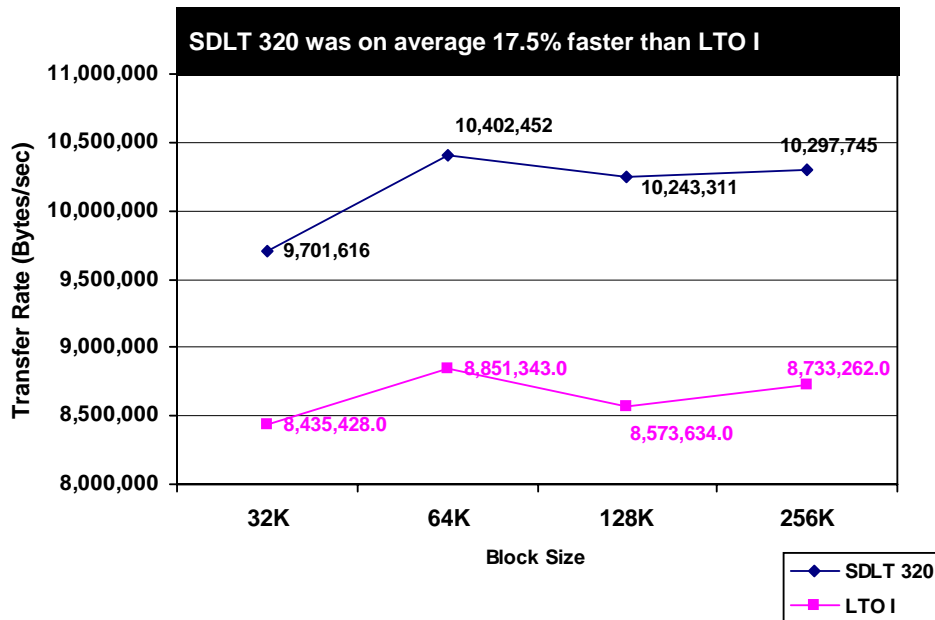


Figure 5. Random Host Write Transfer Rate Test @ 1:1 Compression.

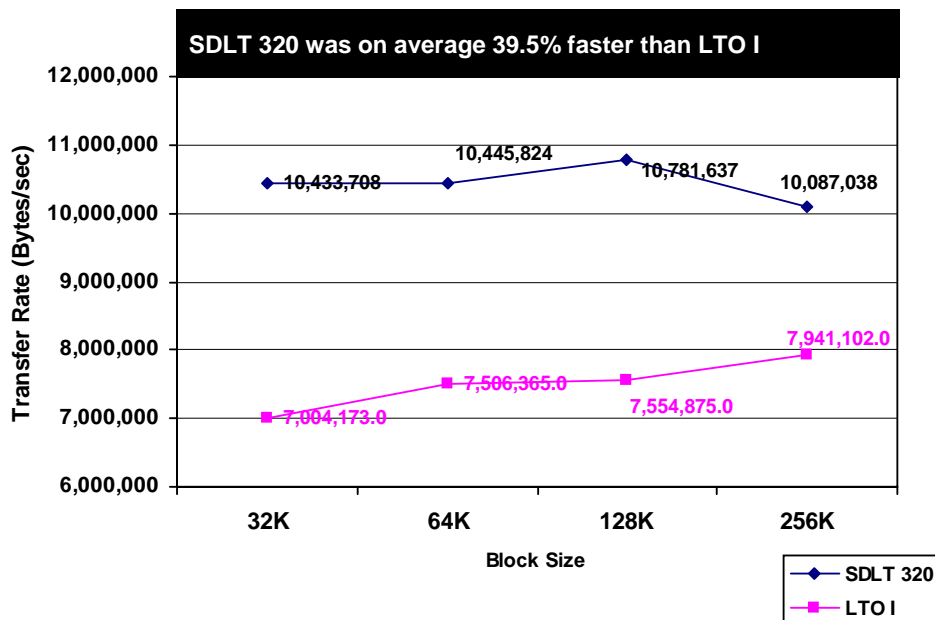


Figure 6. Random Host Read Transfer Rate Test @ 1:1 Compression.

TOGGLED HOST TRANSFER RATE PERFORMANCE RESULTS

Under the toggled host transfer rate conditions, the SDLT 320 continued to out perform the HP Ultrium 230 tape drive. Overall, the SDLT 320 write transfer rate out performed HP Ultrium 230 LTO by an average of 10.07% (see table below).

Block Size	SDLT 320 Transfer Rate Bytes/sec	HP Ultrium 230 Transfer Rate Bytes/sec	SDLT 320 Performance Edge
32K	10,379,991	9,499,118	9.27%
64K	10,383,724	9,384,560	10.65%
128K	10,384,285	9,478,018	9.56%
256K	10,385,790	9,375,263	10.07%

Table 7. Toggled Host Write Transfer Rate Test Results @ 1:1 Compression.

The SDLT 320 read data on average 55.59% under the same conditions (see table 8).

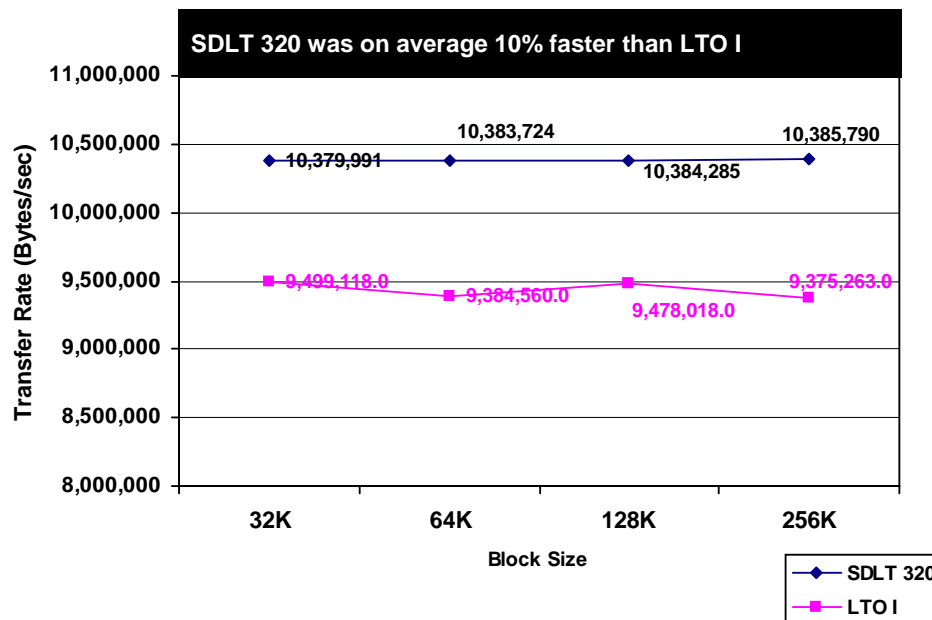


Figure 7. Toggled Host Write Transfer Rate Test @ 1:1 Compression.

Block Size	SDLT 320	HP Ultrium 230	% Delta
32K	10,262,226	7,026,963	46.04%
64K	10,290,176	6,578,583	56.42%
128K	10,278,198	6,615,235	55.37%
256K	10,286,185	6,252,211	64.52%

Table 8. Toggled Host Read Transfer Rate Test Results @ 1:1 Compression.



SUMMARY OF ANALYSIS

Under a series of benchmark tests to compare to the performance of the DLTtape's Digital Data Rate Agent against HP's Adaptive Tape Speed, the Quantum Corporation's SDLT 320 displayed a significant performance advantage over the HP Ultrium 230. Specifically:

1. The SDLT 320 wrote data up to 23% faster than the HP Ultrium 230 and read data up to 76% faster than the HP 230, under fixed host write data transfer tests
2. The SDLT 320 wrote data up to 17% faster than the HP Ultrium 230 and read data up to 39% faster than the HP 230, under random host write data transfer tests.
3. The SDLT 320 wrote data up to 10% faster than the HP Ultrium 230 and read data up to 64% faster than the HP 230, under toggled host write data transfer tests.

DLTtape's Digital Data Rate Agent technology proved itself to be the best for slow or varying host data transfer rate conditions, on average, HP's hybrid digital/analog/mechanical Adaptive Tape Speed technology.