

# Using Track-Following Servo Technology on LTO Tape Drives

**Randy Glissmann**

Fujitsu Computer Products of America  
1751 S. Fordham Street, Suite 100  
Longmont, CO 80503  
[rglissmann@intellistor.com](mailto:rglissmann@intellistor.com)  
tel +1-303-682-6555  
fax +1-303-682 6401

## Abstract

Fall COMDEX was the center of numerous showings of new tape technologies offering significant increases in tape capacity and performance. Of interest to users of midrange tape technology was the showing of Linear Tape Open (LTO) tape drives. Just as the upstart Linux operating system is nurturing a small but growing base of users, LTO-compliant products promise to secure a significant portion of the backup marketplace. The strength of LTO is in its organization and its technology. This paper will highlight these strengths and compare them to other tape products.

## Introduction

In 1997, LTO technology was developed jointly by HP, IBM and Seagate to promote a tape technology that is accessible to any drive or media manufacturer through a license arrangement.<sup>1</sup> This is in contrast to the typical policy of tape manufacturers to keep their technology proprietary. Users will benefit from the cooperative and competitive environment created by an initiative organized to promote LTO. The technology used on LTO products is the result of the collective drive development expertise of the three founding companies. The roadmap of the technology is carefully plotted against future technologies to enable customers to replace their tape products for significantly higher capacities and performance without forgoing compatibility to earlier LTO written media.

## Ultrium Tape Roadmap

	Generation 1	Generation 2	Generation 3	Generation 4
Capacity*	100GB	200GB	400GB	800GB
Transfer Rate*	10-20MBs/sec	20-40MBs/sec	40-80MBs/sec	80-160MBs/sec

\* Native capacity and transfer rates  
[www.lto-technology.com](http://www.lto-technology.com)

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## Track-following Technology Enables Significant Capacity Increases

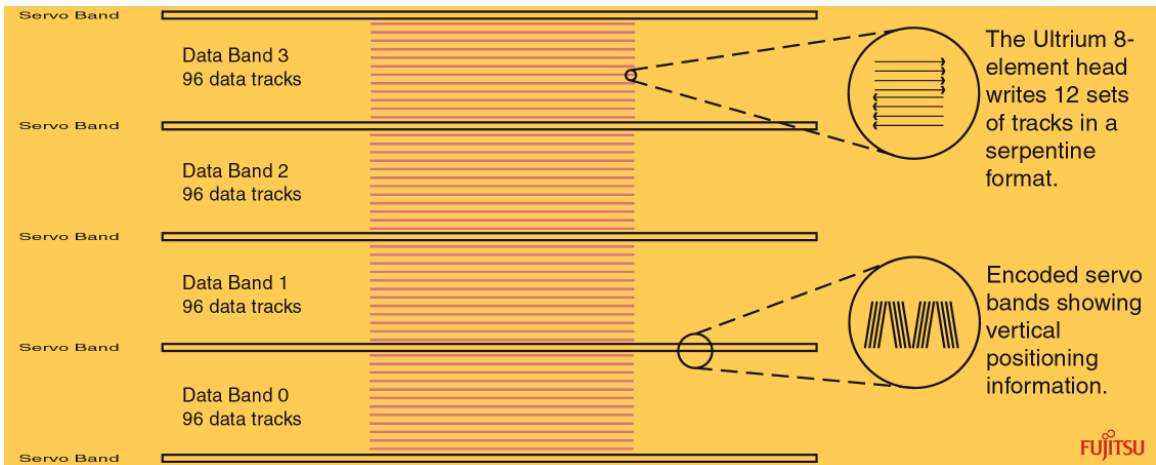
Track density, bit density, and media surface area are factors that determine the capacity that tape can support. Until recently, track density has been constrained on linear tape drives to around 400 tracks per inch due to the risk of overwriting neighboring tracks. Even with noteworthy engineering efforts to ensure accurate guidance of the tape moving across the recording head, overwriting and data recovery problems can be caused by small lateral tape movements which occur due to mechanical tolerances, environmental factors, and general wear of the media and of the drive mechanism. Increasing track densities only exasperates the problem.

In track-following technology, the head moves to compensate for any lateral tape movement so that higher track densities can be achieved. Current drives using track-following are IBM's Magstar™ 3590 and Storagetek's 9840 drive which support 256 and 288 tracks respectively. Quantum's DLT8000™ does not use track-following and achieves its high capacity through a high bit density along the track. Only 208 tracks are used on the DLT8000.

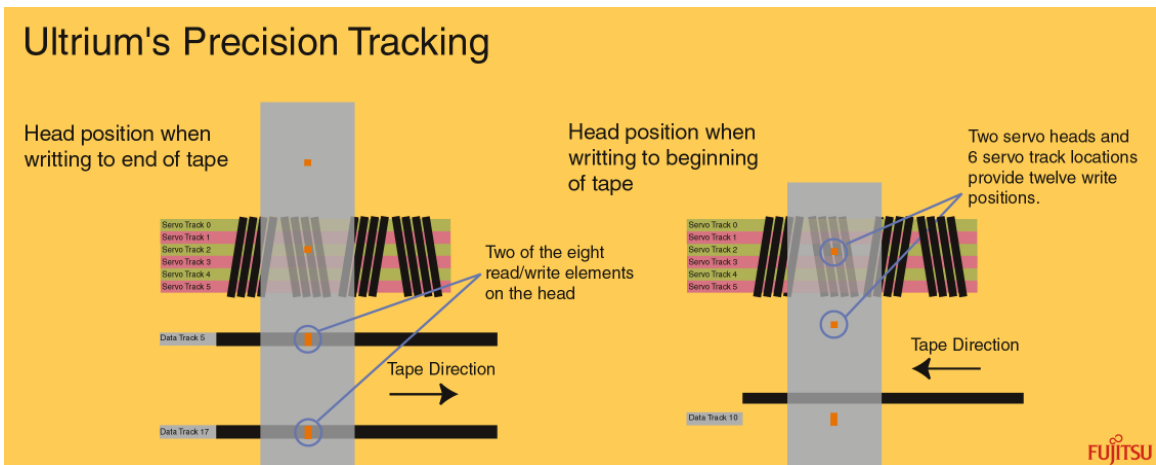
LTO has defined two tape technologies: Accelis and Ultrium. The Accelis format uses dual reels in its cartridge for fast time to data. The Ultrium implementation is similar to Magstar and DLT where a single reel holds a long length of ½" wide media. In addition to the three founding manufacturers, Fujitsu has indicated that they will manufacture Ultrium drives. Seven media manufacturers including Emtec, Fuji, Imation, Maxell, Sony, TDK, Verbatim, have indicated that they will produce Ultrium media. First generation Ultrium drives will be capable of storing 100GBs on a tape.

Quantum, the market share leader in tape drive shipments, has also indicated that their next generation Super DLTape product will support at least a 100GB capacity. While both Ultrium and Super DLT technologies will use track-following techniques, their implementations are radically different. Table 1 shows the differences in their technologies.

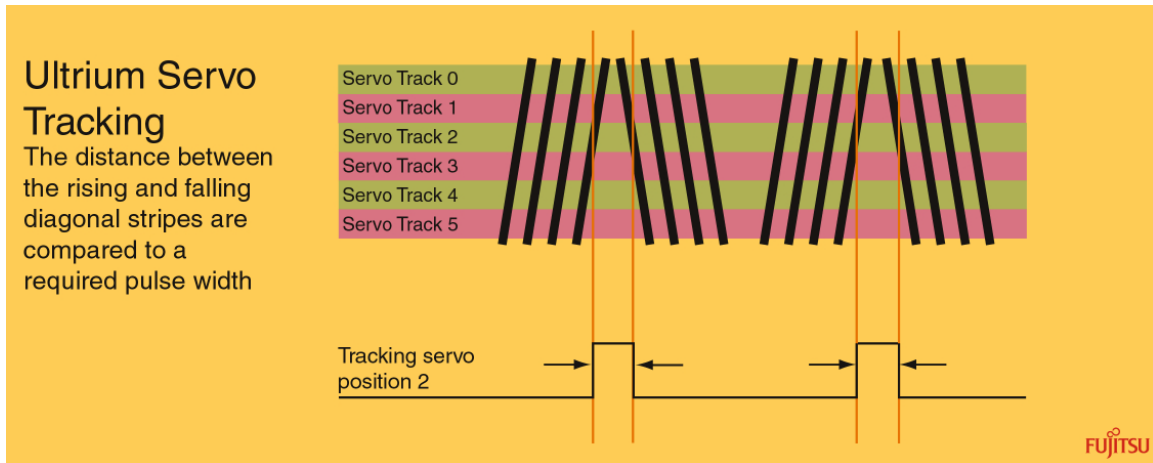
	LTO	SDLT
Servo	Magnetic track-following	Optical track-following
Servo Redundancy	Two head elements and redundant servo tracks	Limited due to single laser beam
Media	Metal Particle	Advanced Metal Particle with embedded laser-sensitive servo
Encoding	Run-length encoding	Enhanced partial response
Recording Heads	Magneto Resistive	Magneto Resistive Clustered



First generation LTO (Linear Tape Open) tape drives will achieve track densities of 768 tracks per inch.<sup>2</sup> Special elements on the drive's head monitor the servo tracks on the tape and detect whether the tape is moving laterally. The servo will automatically move the head to compensate for the tape movement. Additional elements on the head, used for reading and writing data, are located at precise locations relative to the reference tracks. Within four data bands, 96 tracks are written in twelve end-to-end passes over the media. Altogether across the four bands, 384 tracks are written. The heads are manufactured using photolithography, used commonly in fabricating integrated circuits, to provide the accuracy required enabling LTO's aggressive roadmap of increased capacity.

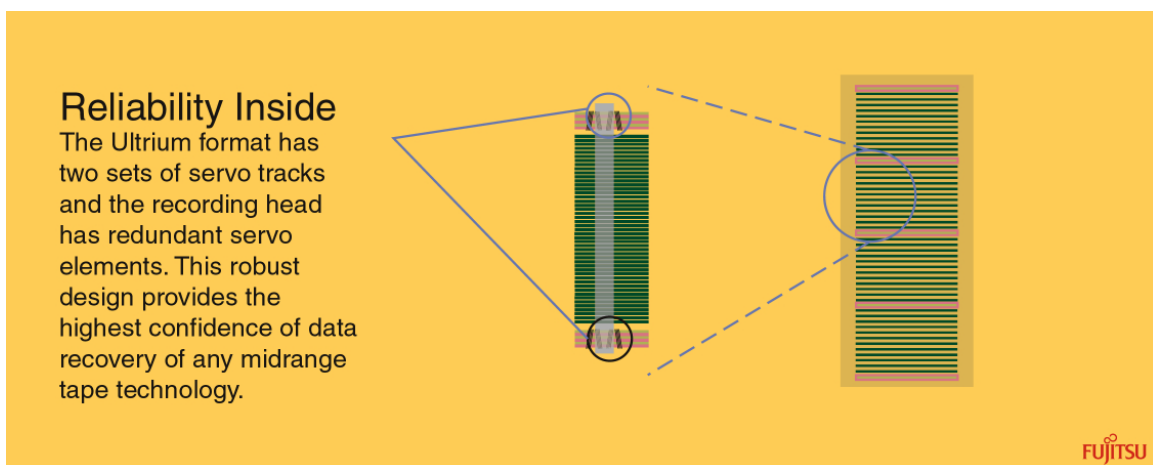


A dependable servomechanism is necessary when using track-following. The recording and reading of data depends on accurately positioning the head. Diagonal stripes are preformed by the media manufacture on the tape and are used by the servo to determine the head's position relative to the tape. By measuring the pulse width between the rising and falling stripes, the head's position is determined.

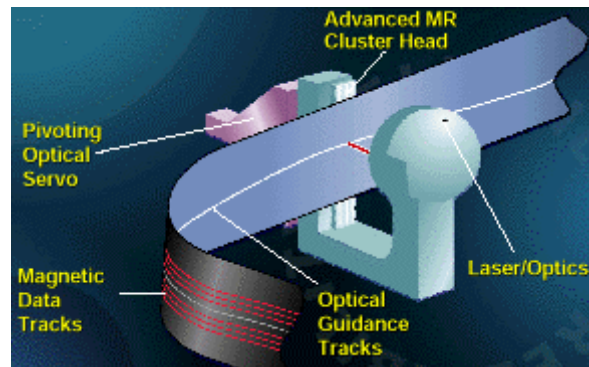


### Reliability Inside

The recording head has two separate servo elements that can be used to determine the head position. Each data band also has a servo track above and below it. This redundancy allows the drive to recover from both head and media problems. Powerful error correction codes can restore user data even if one of the eight data elements on the head completely fails. In the event that 1" of tape is unreadable, user data can still be recovered.



Super DLTtape will reportedly use a revolutionary laser guided servo system.<sup>3</sup> Optical tracks are embedded on the back of the tape and a laser is used to detect lateral tape movement. Since the optical pickup and recording head are on opposite sides of the tape, maintaining mechanical tolerances without the accuracy provided by photolithography will be challenge.<sup>4</sup> Robustness will be an issue without multiple lasers to provide redundancy.



Source: Quantum

## Conclusion

Track-following techniques will enable significant increases in tape capacity to be possible. By offsetting the position of data tracks from magnetic reference tracks, higher track density will be obtainable and the Ultrium format will be able to offer four generations of capacity increases. The level of redundancy that been designed into the Ultrium format will rival the robustness of mainframe tape products.

Trademarks:

Brand names are trademarks of their respective owners.

<sup>1</sup> For more information, see <http://www.lto-technology.com>.

<sup>2</sup> Teale, Altree, and Thompson; "Tape Drive Makers Adopt Open Format", *Data Storage*, June 1998: 51-54.

<sup>3</sup> Steve Scully, "Laser Guided Magnetic Recording; Carrying Super DLT into the next Millennium", THIC Conference, July 1999, <http://www.thic.org/pdf/Jul99/quantum.sscully.990714.pdf>.

<sup>4</sup> Randy Glissmann, "Fundamental Differences Between SDLT and LTO Tape Drive Servo Systems", *Computer Technology Review*, August 1999: 46.