White Paper Linear and Helical Recording Technologies

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WHITE PAPER

EXECUTIVE SUMMARY

The use of tape recording technologies for data backup and storage in entry-level and mid-range server environments is dominated by two recording technologies; Linear and Helical.

This white paper is a condensed summary of the results from a previous White Paper written by Imation Corp., in June of ’99 titled, Comparison of Reliability, Durability and Performance of Linear and Helical Recording Technologies in Entry-Level to Mid-Range Tape Products. The purpose of this white paper is to give readers a quick summary of the two technologies, concerning tape media specifically. In the white paper mentioned above, the major conclusion is that linear technololgy provides greater reliability than helical technologies. This white paper will look at the major factors contributing to this result.

DIFFERENCES IN LINEAR AND HELICAL RECORDING TECHNOLOGIES

The most significant differences between Linear and Helical technologies are in the design of the tape cartridges, tape handling mechanisms, head-tape interfaces, and areal density. These differences in basic design philosophy account for significant differences in reliability and durability, with Linear formats having the clear advantage.

This condensed white paper will look specifically at the mechanics of the tape media, but a full analysis of the mechanism, areal density and migration trends, capacity, drive cost, drive size/form factor, transfer rate, and throughput are available in the White Paper mentioned earlier.

Mechanical

The advantages of Linear tape systems begin with the simplicity of its tape path and the limited motion of the head. This results in far fewer moving parts, a less complicated mechanism and reduced stress on the tape.

In a Linear drive such as Travan NS, SLR and MLR, the tape never leaves the cartridge. The tape path is defined by a small number of guides rigidly mounted in the cartridge. The tape path requires no additional physical space beyond that taken up by the cartridge itself. The tape path involves a minimum number of angle changes, all of which are relatively small.

The tape path in a Helical scan drive, by contrast, is defined by a number of movable guides that must pull the tape out of the cartridge and position it in relation to the rotating head drum. The tape is guided through severe acute angles at various points along the tape path, placing additional strain on the tape. Additional space is needed in the Helical drive to accommodate this tape path operation.

The head motion of a Linear tape drive is perpendicular to the data track and the head is stationary while data is being read; the heads on a Helical scan drive are constantly in motion, with the associated vibrations involved.

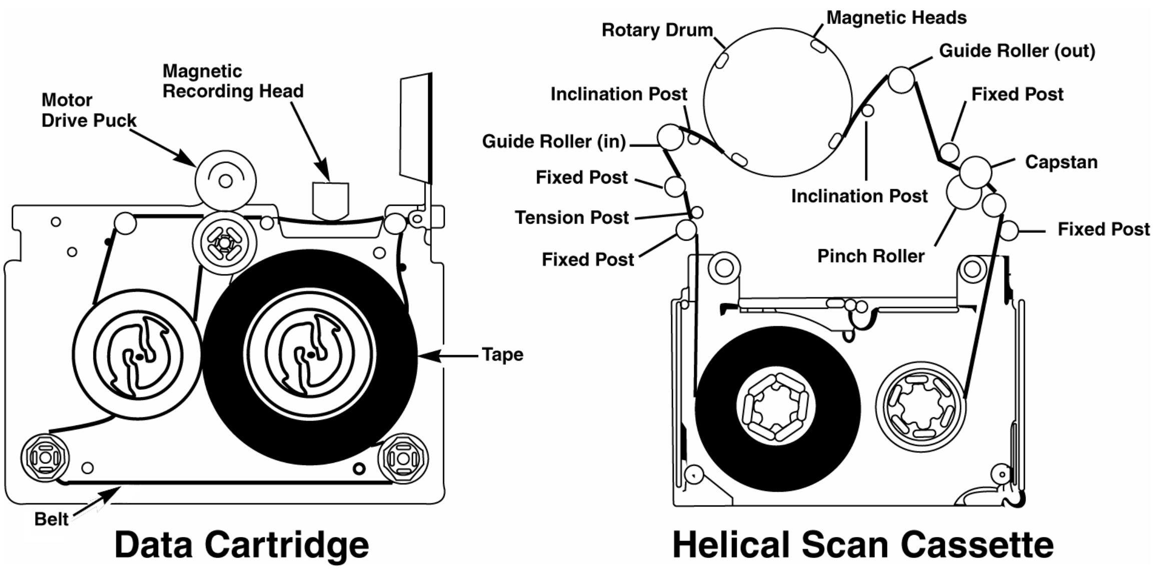

Figure 1. Tape Path Comparison

The mechanical simplicity of the Linear drive translates into a low part count. The Travan NS drive, for example, has only two motors: one to drive the cartridge and one to move the head up and down. A Helical scan drive has up to five motors: one to move the tape, one to rotate the heads, one motor to extract the tape and position it around the head drum, and two motors to wind the tape onto the hubs.

Because of the simple head motion in a Linear tape drive, the head elements can be directly connected to electronic circuitry. The Helical scan drum, because it is rotating, requires a rotary coupler with its inherent noise contribution, as well as limitation at high frequency operation.

The small number of fixed and moving parts and motors in the Linear tape drive directly contributes to its higher reliability and durability, along with the advantages of lower cost and less physical space.

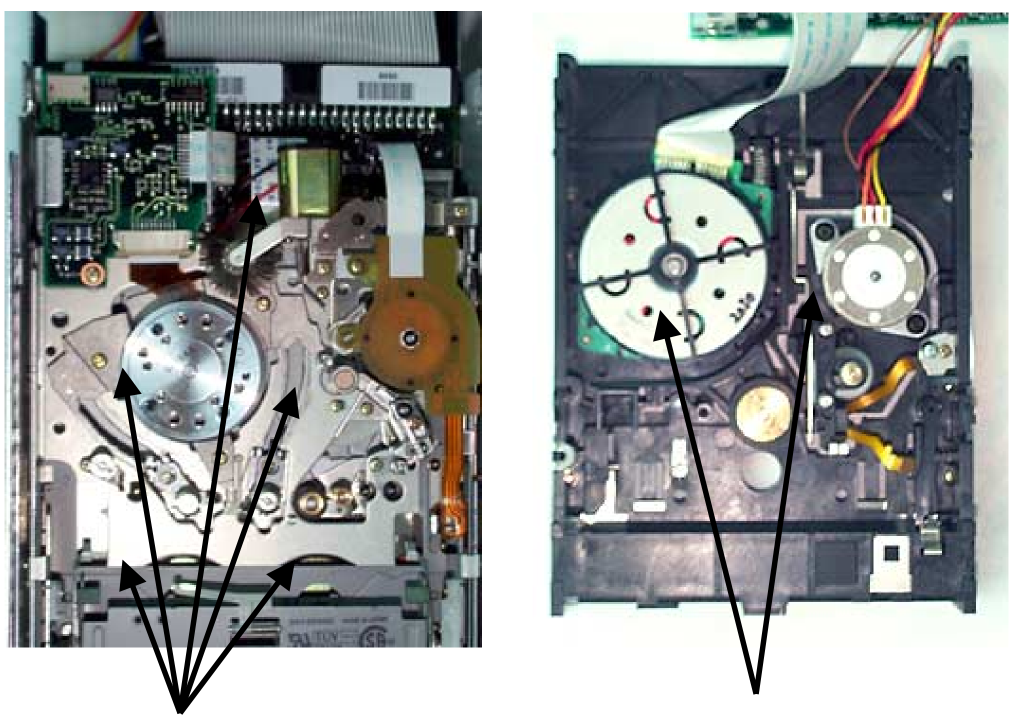

Figure 2. DDS vs. Travan NS Mechanisms

MTBF (Mean Time Between Failures) and Annual Failure Rates

To look at the complete reliability picture for tape drive technologies, several factors must be considered. They are:

- MTBF (Mean Time Between Failures)
- Duty cycle
- Head life
- Annual failure rate
- Error rate

All drive manufacturers specify an MTBF, along with duty cycle and error rates. It is more difficult to obtain head life data and annual failure rate data.

Table 3 shows that the Linear formats (Travan NS and MLR) have the highest Mean Time Between Failures (both specification and actual) and the lowest annual failure rates (both theoretical and actual).

Table 3. Tape Drive Technologies Comparative Data

Drive Technologies	Type	MTBF	Duty Cycle	Annual Failure Rate – Theoretical	Annual Failure Rate – Actual	Actual MTBF
Travan NS8	Linear	330,000	20%	2.7%	<1.0%	486,667
MLR1	Linear	300,000	100%	2.9%	1.5%	584,000
Mammoth	Helical	250,000	20%	3.5%	2.0%	461,053
AIT1	Helical	200,000	20%	4.3%	3.0%	288,000
DDS2	Helical	200,000	20%	4.4%	11.1%	78,919
8mm 8505	Helical	160,000	20%	5.4%	6.9%	125,217

Daily Backup Rate = Transfer Rate (MB/s) x 3600 sec/hr x 24 hrs x Duty Cycle
[1]All calculations assume 20% duty cycle.
[2] Minimum value at normal office environment @ 20% duty cycle.
[3] Unknown environment & duty cycle.
[4]Average as of July 10, 1998 on www.pricewatch.com.

MTBF: A specification in hours of the reliability of the drive's mechanisms and electronics as a complete system under controlled test environmental conditions. All MTBF numbers are associated with the duty cycle that was exercised during the testing. MTBF is not meant to specify the drive's useful life. Actual life of the drive is much less than the MTBF numbers.

Duty Cycle: The percentage of time the drive is used for reading, writing, rewinding or repositioning. It is calculated as: duty cycle = (tape motion hours of read, write, rewind, reposition) / total hours of power on.
The total hours of power on are usually 24 hours. Therefore if a drive is used for 4.8 hours a day, then its duty cycle is 4.8/24 = .2 = 20%

Head Life: The total number of hours the drive's head operates without failure with tape in motion.

Annual Failure Rate: The percentage of all installed tape drives that failed in one year.
Theoretical AFR = 8760 hours/MTBF
Actual AFR = 8760/Actual MTBF.
Actual AFR is the actual data collected from annual field failures.

Error Rate: The rate at which uncorrectable errors could occur.

As seen in the chart above, Linear technology is much more durable than the Helical technologies represented. For example, Travan NS8 has an actual field failure rate of less than 1%, while DDS2 has an actual field failure rate of 11.1%. In this example, Linear technology is more than 10 times reliable than its Helical technology counterpart.

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