

LTO Program Format Compliance Verification Testing -- Focus on Interchange

Introduction

LTO Program Objectives

The LTO program is a joint initiative of Hewlett-Packard, IBM and Seagate Technology (referred to as the Technology Provider Companies, or TPCs).

The three companies have joined in a unique effort to establish new **open-format** specifications for tape storage products for the midrange and network server computing environments. Today, these environments are characterized by multiple, incompatible tape technologies, and several of these formats are available only from single-source manufacturers. The pace of innovation for each of these formats is also dependent on these individual manufacturers. Customer choices are limited, and their data protection strategies are complicated by the difficulties of tape cartridge interchange.

The LTO program objective is to promote an open and competitive environment that will serve all customers more effectively. Critical elements of this strategy are:

- 1) **Best-of-breed tape format and technologies, and an enhancement roadmap that will help protect customer investments.**
The Ultrium format is designed to provide ultra-high capacity. A four-generation roadmap has been published for each format (see appendix), with specific information on the technologies that support the growth in capacity and transfer rates.
- 2) **A business environment that encourages participation from multiple respected suppliers of tape drives, tape cartridges, and tape automation systems.**
Behind the LTO program initiative is a philosophy of openness, cooperation, and protection of the individual interests of all participants. Licensing rights to specifications and documentation for the Ultrium format are available through procedures administered independently by the law offices of Ladas and Parry in Los Angeles, California. A continuing series of meetings with the LTO program licensees has clarified and enhanced the Ultrium format definitions, and provided a forum for exchange of information on the technology. To date, in excess of 20 companies have acquired LTO program licenses.
- 3) **Genuine competition among suppliers in pricing, packaging, product quality, and performance.**
Although there is strong cooperation among the LTO program licensees focused on the definition and development of the formats, information about product development plans and progress is not available between the LTO program licensees. The LTO program format definitions give both drive and cartridge developers substantial flexibility in product design and implementation, and competition is expected to be very strong.
- 4) **Interchangeability of LTO technology cartridges - Ultrium to Ultrium - across the complete range of participants**
The TPCs have recognized from the start of the initiative that successful data interchange across same-format Ultrium drives and cartridges is required to create the desired competitive open-market conditions. Achievement of these objectives requires a unique level of cross-vendor interchange capability.

LTO Program Compliance Verification

Many factors affect interchangeability, and some of these are beyond the control of any tape vendor.

In spite of external factors, rigid adherence to the LTO program format specifications, by both cartridge and drive manufacturers, is the most critical factor in establishing interchangeability. Format compliance verification can be controlled by the LTO program participants, and is believed to be the best approach to help achieve interchangeability.

The TPCs have therefore established a unique format verification program to determine that Ultrium drives and cartridges conform to their respective format specifications. This LTO program format verification process is independently administered and executed.

The objective of the compliance tests is to verify that the technical parameters of the LTO program formats are met. A wide range of format/cartridge/media parameters critical to interchangeability is tested to determine if they meet exact individual specifications.

Compliance verification will allow computing and automation manufacturers to select Ultrium format drives and cartridges based on price, quality, and vendor relationships, with the knowledge that these LTO program formats provide leading-edge performance, capacity and data integrity, and are also consistent in their compliance with format specifications.

The objective of the compliance testing is to test only the ability to produce and/or read and write Ultrium cartridges that meet the format specifications. It is not an objective of this format compliance testing to evaluate Ultrium drive quality, MTBF, physical form factor, or other parameters not directly related to the LTO program formats and interchangeability. LTO program licensees have wide latitude to establish their own mechanical, electrical and logic designs to meet the format specifications. These factors will not be tested as part of the compliance verification process.

Compliance testing occurs in many industries and in many areas to meet safety requirements, or to meet other government mandated requirements. LTO program compliance verification, however, is self-imposed by the LTO program licensees to help meet the open-market, free-interchange objectives of the LTO program.

Use of LTO Program Trademarks

A major benefit of format compliance verification to licensees, to OEMs and to end-user customers is that only through initial and subsequent annual passing of the compliance tests, will licensees be allowed to use the LTO program trademarks, and the trademarks of the two LTO program formats. Any "me-too" products that do not carry these marks will not have been compliance-verified, and may carry higher interchange risks as a result. All licensees, including the TPCs, must pass the format compliance verification tests to receive the right to use these logos.

Shown below is the compliance verification trademark for the LTO program format. As shown, this trademark logo will be used only for promotion of the individual LTO program format, and only by licensees whose product(s) have successfully passed compliance verification testing.



This same trademark, followed by the number **1**, **2**, **3**, or **4**, as illustrated below, will appear on Ultrium drives and cartridges. This number will represent the technology generation of the product bearing the trademark, and the presence of the trademark itself, will signify that the product has successfully passed the format compliance verification tests.



Buyers seeking LTO program format-compliant products should look for this mark on Ultrium drives and cartridges.

The cartridge for the Ultrium format is shown below:



Finally, the LTO program mark is also illustrated below. This logo is intended as an "umbrella" for use in promotion of the LTO program and its Ultrium format and will not appear on Ultrium products.



The Compliance Verification Process

To remain consistent with the spirit of the LTO program initiative, compliance verification is based on a process that is equitable to all licensees, and protects their private intellectual property. The TPCs have taken great care to administer and execute this process through independent agencies, such that information on compliance verification testing results flows back only to the licensee requesting the testing.

The TPCs also set goals to ensure that the process is effective, but not burdensome to the LTO program licensees. The ultimate test of whether Ultrium drives are complying to their format is whether the cartridges written by these drives meet the format specifications, and whether these drives can read cartridges which conform to the format. Ultrium drives, therefore, will be tested for format compliance through testing of cartridges only. This simplifies the process and avoids the risk of proprietary drive design information becoming visible to the other licensees. This protection of the licensees' interests allows innovation to flourish, within a structure of interchangeability.

Compliance Process Overview

The law offices of Ladas and Parry, in Los Angeles, will handle all administration of the process. (Ladas and Parry also handles the administration of the LTO technology licensing process).

A drive licensee wishing to start the compliance verification process is required to sign a confidentiality agreement and an agreement with the Compliance Verification Entity (CVE) covering the terms of the testing. Once this is accomplished, the drive licensee receives a test package of Ultrium format tape cartridges. Half of these cartridges are to be read by the licensee, and an affidavit must be returned attesting that they have been successfully read. The other half will be supplied unrecorded. These are to be written with specified data patterns on drives manufactured by the submitting licensee, and then returned to the CVE for test and analysis.

If all tests are successfully passed, the licensee receives rights to use the Ultrium compliance verification trademark and a schedule for annual re-testing is established. If a licensee fails the compliance verification test, they will receive specific information about which tests failed, and will have the opportunity to resubmit cartridges that properly conform to the format in the failed areas. The same cartridges must pass all tests.

The process for cartridge licensees is similar, but only servo-written and otherwise unrecorded tapes will be submitted to the CVE for their analysis.

Licensees will not have visibility to testing in process for other licensees.

Verification

The compliance verification entity performing all technical testing and analysis is Measurement Analysis Corporation (MAC) of Torrance, California.

MAC is a leading provider of independent testing and evaluation services for the data storage, instrumentation, video and audio industries. It is a fully integrated engineering services company that provides independent systems engineering and technical support services in the fields of information sciences, electronics, mechanical and applied physics. Through its Independent Recording Media Laboratory (IRML), MAC has provided independent technical services to major commercial and US Government clients for almost 25 years. Their credentials encompass all aspects of tape data storage systems, including basic magnetic tape media manufacturing and performance testing, head-tape interaction, tape transport guiding and data encoding and formatting.

MAC is a private, 100% employee-owned company with approximately 50 employees. Over two thirds of these employees hold technical or advanced degrees. MAC was founded by its current president, Michael Lamers, in 1975. Mr. Lamers holds MSEE and MSME degrees in Electronic Information and Communication Systems, and Mechanical Kinematics and Dynamic Systems from the University of Southern California.

MAC's program manager for LTO format compliance verification is Kay Yoshimoto. Mr. Yoshimoto has been one of MAC's leading Principal Engineers for the past 12 years, supporting numerous advanced data storage technology projects. These have ranged from test and evaluation of thin film tape-head interaction to data encoding for optimum tape error correction. Kay holds a BSEE degree from UCLA, and has also completed extensive graduate studies in analog and digital control systems.

MAC's IRML facilities include three controlled-environment clean rooms, an environmentally controlled room for long-term storage of magnetic media, and facilities for controlled testing over wide ranges of temperature and humidity and mechanical shock and vibration. These facilities offer state-of-the-art instrumentation and measurement systems for evaluating:

- ?? Dimensional tolerances of mechanisms, structures and materials
- ?? Mechanical properties of magnetic tape, heads and structures
- ?? Electro-magnetic characteristics of magnetic tape
- ?? Record/playback signal to noise ratios, and wavelength response
- ?? Burst data rates and burst error rates
- ?? Spectro-chemical properties of materials
- ?? Digital and analog control systems
- ?? Signal data synchronization, encoding and format processing

Much of the equipment used for these evaluations is not commercially available and was internally developed to meet MAC's client needs.

MAC will conduct an extensive range of tests to verify compliance with the LTO program format. These include:

- ?? **Recording format** parameters such as cartridge initialization, tape capacity, use of error correction codes and data compression, RLL encoding, servo-tracking faults, write equalization, and proper formatting and use of the LTO cartridge memory.
- ?? **Media electrical and magnetic recording** properties, including magnetic layer thickness, electrical resistance of recording surface, longitudinal coercivity (a measure of magnetic sensitivity), signal amplitude, and signal to noise ratio.
- ?? **Media interchange** tests of read/write capability at wide variations in temperature and humidity, after storage and shipping in a wide range of environmental conditions, and repeated write/read cycles across a small section of the media.
- ?? **Cartridge shell mechanical** characteristics, such as dimensional consistency, adherence to clutch tooth profile, material deflection, and the moment of inertia of the reel(s) and tape pack.
- ?? **Media mechanical** properties such as tape width and width fluctuation, tape thickness, edge condition, tensile strength, tape curl and twist, elasticity, and others.
- ?? **Media reliability and durability** factors. These include coating adhesion, coefficients of friction, surface roughness, adhesion and stiction.

A key tool used in these tests is a precision tape transport system developed by MAC for LTO compliance verification testing. This system, termed "LFTES" (LTO Format Tape Evaluation System), is configured to interface to an Ultrium data cartridge, and allows multiple tests to be executed in a single end-to-end pass of the tape. LFTES includes two independent Ultrium format write/read head stations for servo track code verification, data signal amplitude performance, and data encoding and format verification. Also parts of the LFTES system are media test stations for measuring tape wear, end-to-end transverse physical position of each servo track, and the tape's physical width and curvature characteristics. A schematic of the LFTES tool is shown in the second appendix to this paper.

The tests and measurements made by MAC are all directly related to determining whether data written to tape is fully compliant with the Ultrium format specifications. These tests are, of course, in addition to the extensive tests likely to be executed by the individual LTO program licensees for product quality, durability, performance, and other characteristics unique to each manufacturer's specific product implementation.

MAC was selected after a thorough search. They are highly qualified for this role through their long and unique experience in tape testing, and their enthusiasm for their role in the LTO program initiative.

Summary

The LTO program objective is to establish an open and competitive marketplace that will serve customers more effectively. Critical to this objective are:

- ?? Best-of-breed tape formats and technologies
- ?? A business environment that encourages participation from multiple respected suppliers
- ?? Genuine competition among these suppliers
- ?? Interchangeability of LTO technology cartridges - Ultrium to Ultrium, across the complete range of participants

The LTO program initiative is meeting these objectives.

Establishment of the LTO program format verification process - the procedures, the tools and the independent agencies to execute the process - represents a major LTO program milestone. Cartridges, media and drives are now advanced enough to allow format verification across multiple manufacturers.

The LTO program is gaining momentum. The number and strength of licensees continues to grow, the licensing and testing mechanisms are in place, and the customer need is strong and growing. Products are expected to debut in 1999, and LTO technology is poised to reshape this part of the tape industry.

(For more information on the LTO program, please visit www.ltotechnology.com)

LTO Program Enhancement Roadmaps

ULTRIUM FORMAT	Generation One	Generation Two	Generation Three	Generation Four
Capacity (2:1 compression)	200GB	400GB	800GB	1.6 TB
Capacity (Native)	100GB	200GB	400GB	800GB
Transfer Rate (2:1 compression)	20-40 MB/s	40-80 MB/s	80-160 MB/s	160-320 MB/s
Transfer Rate (Native)	10-20 MB/s	20-40 MB/s	40-80 MB/s	80-160 MB/s
Media	Metal Particle	Metal Particle	Metal Particle	Thin Film
Encoding	RLL 1,7	PRML	PRML	PRML

For the Ultrium format:

- ?? Generation two products will benefit from a greater than 30% increase in the number of tracks and average tape speed, and an improved recording method.
- ?? Generation three products will benefit from a greater than 30% increase in the number of tracks and in the maximum tape length.
- ?? Generation four products will benefit from a greater than 30% increase in the number of tracks and the use of more advanced recording media.

Hewlett-Packard, IBM and Seagate reserve the right to change the information in this enhancement roadmap without notice.

LTO Format Tape Evaluation System

(Ultrium Configuration)

