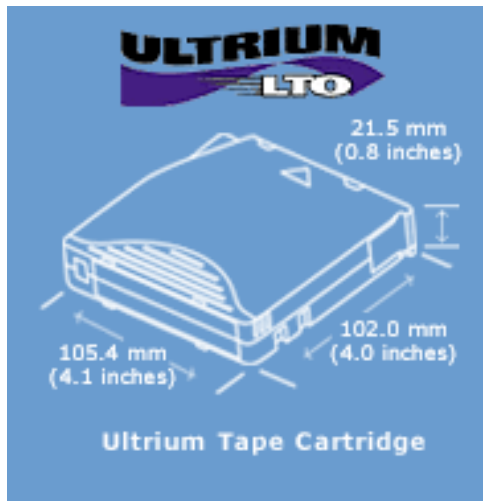


**FUJIFILM**

**FUJIFILM Recording Media U.S.A., Inc.**

# **LTO Ultrium Technology**

## What is LTO Ultrium Technology?



- LTO stands for “Linear Tape Open”, since it is linear data tape, and targeted to “open systems” environments in today’s data center.
- LTO Ultrium is a non-proprietary technology supported by multiple hardware and media manufacturers including Fujifilm with a leading manufacturer share of media.
- LTO is ideally suited for data backup, restore and archival applications.
- LTO Ultrium data cartridges can be used in standalone drives but are most commonly used in automated library systems with multiple drives.
- LTO Ultrium data cartridges feature a single reel of ½ inch wide tape with pre-written magnetic servo tracks for accurate positioning of the drive’s read/write head.

## Benefits of LTO Ultrium Technology

- **High Capacity:** LTO is ideally suited for mass data storage based on its high capacity, currently at 1.5 TB native capacity (3.0 TB with 2:1 compression) with Generation 5 cartridges.
- **Rapid Data Transfer Rate:** LTO technology features a rapid native data transfer rate of 140 MB per second (280 MB per second with 2:1 compression) with Generation 5 cartridges.
- **Cartridge Memory (CM):** each LTO Ultrium data cartridge features a built in CM chip that maintains basic usage information that can be read by external reader such as Fujifilm's Data Cartridge Analyser.
- **Reliability:** LTO Ultrium technology allows for a robust error correction scheme superior to most HDD systems ensuring readability of archived data.
- **Long Life:** LTO tape media has a life expectancy of up to 30 years when maintained in controlled storage environments.
- **Encryption:** LTO Ultrium generation 4 and 5 drives have (optional) in-drive encryption capability.
- **Partitioning:** LTO Ultrium generation 5 media have (optional) dual partitioning capability for faster data access and improved data management.
- **WORM:** LTO generations 3, 4, and 5 also feature special cartridges with WORM functionality, allowing secure backup and storage of critical data in a non-erasable, non-rewritable format.

## LTO Ultrium Generations/Specifications



**LTO 1:** introduced in 2000, 100/200 GB native/compressed capacity, 20/40 MB/s native compressed transfer rate

**LTO 2:** introduced in 2002, 200/400 GB native/compressed capacity, 40/80 MB/s native compressed transfer rate

**LTO 3:** introduced in 2004, 400/800 GB native/compressed capacity, 80/160 MB/s native compressed transfer rate

**LTO 4:** introduced in 2007, 800/1600 GB native/compressed capacity, 120/240 MB/s native compressed transfer rate

**LTO 5:** introduced in 2010, 1.5/3.0 TB native/compressed capacity, 140/280 MB/s native compressed transfer rate

**LTO UCC (Universal Cleaning Cartridge):** compatible with all 5 generations of LTO drives-50 cleanings per cartridge

## Fujifilm LTO Ultrium Cartridge Color

Unique shell color for each generation of Fujifilm LTO Ultrium data cartridges:



Black LTO 1



Purple LTO 2



Slate-Blue LTO 3



Green LTO 4  
(grayish green)

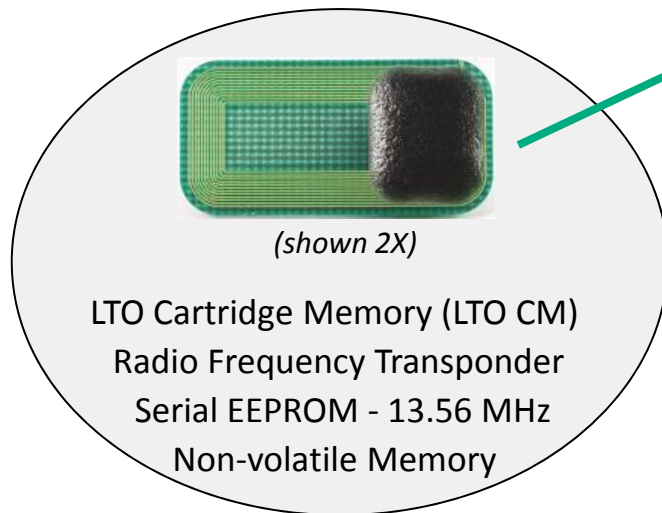


Red LTO 5

(WORM: two-tone Slate-Blue / Platinum Ultrium 3 WORM, two-tone Green / Platinum Ultrium 4 WORM, and two-tone Red/Platinum Ultrium 5 WORM. -see page 16)

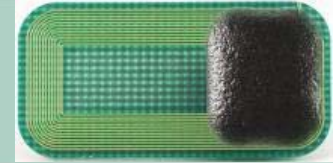
## LTO-CM

**LTO Cartridge Memory: Stores usage history and manufacturer information on a non-contact passive RF interface memory chip**



- 8K Byte Memory for Generation 4 & 5
- 4K Byte Memory for Gen 1 – 3

## LTO Ultrium Cartridge Memory



### LTO Data Cartridge Memory (LTO-CM)

**LTO-CM** (cartridge memory) – An embedded Electronically Erasable Programmable Read Only Memory (EEPROM) module that stores cartridge ID, usage history and metadata in a non-volatile memory chip with a non-contact passive Radio Frequency (RF) interface.

Usage and performance history can be accessed by the Fujifilm DC Analyser to track cartridge history and health



Cartridge Memory: a contactless storage device mounted in the cartridge shell, which is used to hold information about the specific tape cartridge, the tape media in the cartridge and the data on the tape.

# LTO Ultrium Servo-Tracking

## Ultrium Data Cartridges

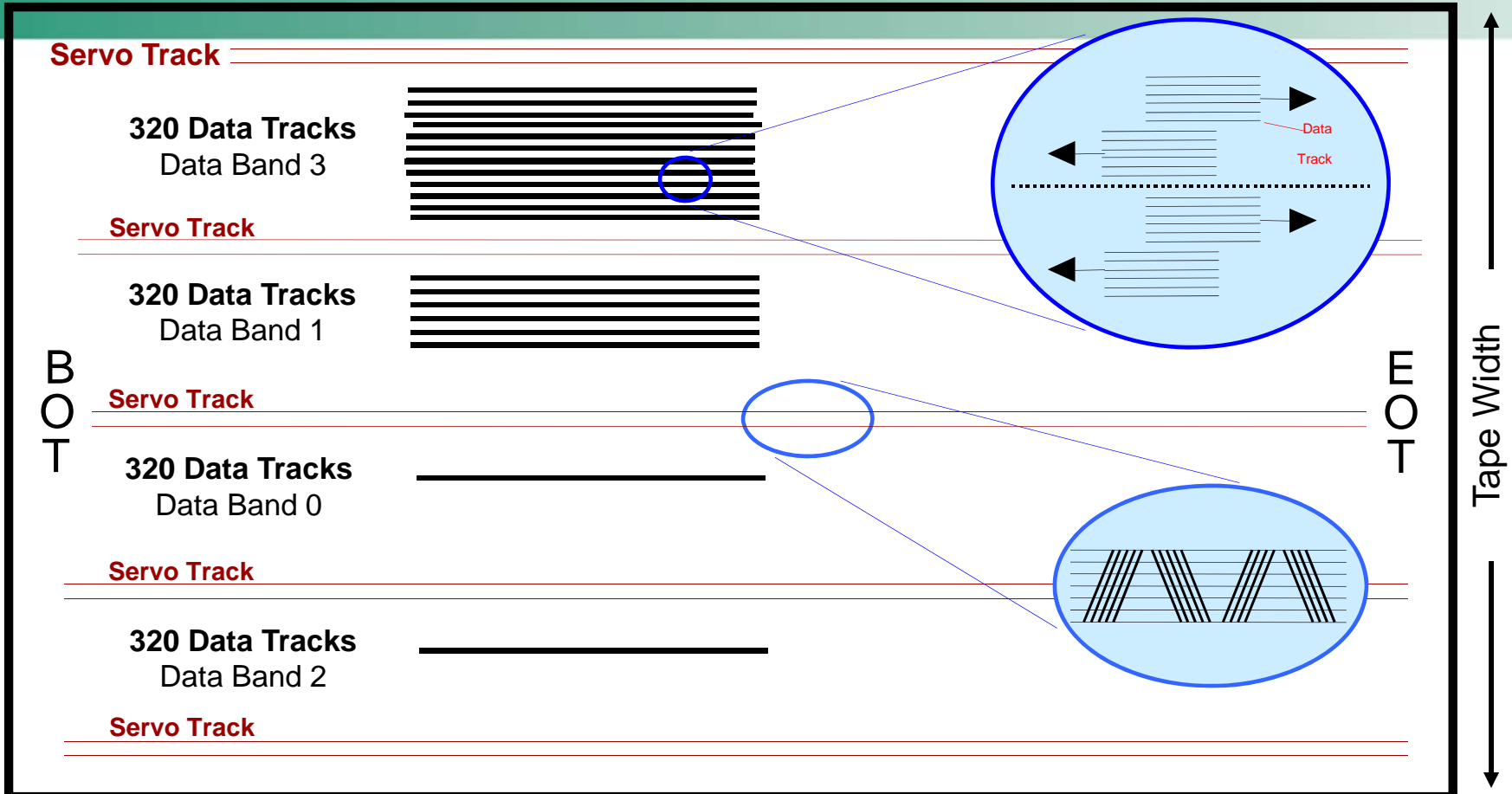
### **Pre-written Magnetic Servo Tracks –**

**Magnetic** servo tracks for positioning the drive's read/write head are factory written.

Do not degauss (bulk erase) LTO Ultrium data cartridges that you intend to reuse! Degaussing makes the tape unusable!



**Ultrium 1:** 8-element Read/Write Head writes 12 sets of 8 tracks in each of 4 data bands = 384 tracks;  
**Ultrium 2:** 8-element, 512 tracks; **Ultrium 3:** 16-element, 704 tracks. **Ultrium 4:** 16-element, 896 tracks



**Ultrium 5:** 16-element, 1280 tracks

Diagram not to scale. Five factory recorded servo bands occupy < 8% of recording surface area. Servo Tracks are scalable and do not change for LTO 1, 2, 3, 4, & 5 (unique code for each and for WORM media).

## LTO Ultrium Tape Drives Full-height & Half-height Models

Example Full-height Model



Example Half-height Model



Nominal height dimension, including bezel.

Nominal height dimension, including bezel shown in Rack Units, one rack unit is 44.45 mm (1.75 in) high; actual height dimension of the examples shown is very-slightly less than indicated, dimensions can vary by manufacturer and model.

# LTO Ultrium Tape Media & Drives

| LTO Ultrium Tape Media                        | Drive Model         | Data Capacity<br>Native /<br>Compressed | Data Transfer Rate<br>Native / Compressed | Speed Matching<br>Minimum Data Rate<br>Native / Compressed |
|---|---------------------|---|---|--|
| <b>LTO Ultrium 5 &amp;<br/>Ultrium 5 WORM</b> | IBM LTO-5           | 1.5 / 3.0 TB                            | 140 / 280 MB/sec                          | Specs not published  |
|   | HP LTO-5            |   | 140 / 280 MB/sec                          | 47 / 94 MB/sec   |
|   | Quantum LTO-5       |   | 140 / 280 MB/sec                          | Specs not published  |
|   | IBM LTO-5 [HH]      |   | 140 / 280 MB/sec                          | Specs not published  |
|   | HP LTO-5 [HH]       |   | 140 / 280 MB/sec                          | 47 / 94 MB/sec   |
|   | Quantum LTO-5 [HH]  |   | 140 / 280 MB/sec                          | Specs not published  |
| <b>LTO Ultrium 4 &amp;<br/>Ultrium 4 WORM</b> | IBM LTO-4           | 800 / 1600 GB                           | 120 / 240 MB/sec                          | 30 / 60 MB/sec   |
|   | HP LTO-4            |   | 120 / 240 MB/sec                          | 40 / 80 MB/sec   |
|   | IBM LTO-4 [HH]      |   | 120 / 240 MB/sec                          | 31 / 62 MB/sec   |
|   | Quantum LTO-4 [HH]  |   | 120 / 240 MB/sec                          | 37 / 74 MB/sec   |
|   | HP LTO-4 [HH]       |   | 80 / 160 MB/sec                           | 33 / 66 MB/sec   |
| <b>LTO Ultrium 3 &amp;<br/>Ultrium 3 WORM</b> | IBM LTO-3           | 400 / 800 GB                            | 80 / 160 MB/sec                           | 40 / 80 MB/sec   |
|   | HP LTO-3            |   | 80 / 160 MB/sec                           | 27 / 54 MB/sec   |
|   | Quantum LTO-3       |   | 68 / 136 MB/sec                           | 31 / 62 MB/sec   |
|   | Quantum LTO-3 [HH]  |   | 68 / 136 MB/sec                           | 20 / 40 MB/sec   |
|   | Tandberg LTO-3 [HH] |   | 60 / 120 MB/sec                           | 30 / 60 MB/sec   |
|   | IBM LTO-3 [HH]      |   | 60 / 120 MB/sec                           | 30 / 60 MB/sec   |
|   | HP LTO-3 [HH]       |   | 60 / 120 MB/sec                           | 20 / 40 MB/sec   |

| LTO Ultrium Tape Media | Drive Model                  | Data Capacity Native / Compressed | Data Transfer Rate Native / Compressed | Speed Matching Minimum Data Rate Native / Compressed |
|------------------------|------------------------------|-----------------------------------|--|--|
| LTO Ultrium 2          | IBM LTO-2                    | 200 / 400 GB                      | 35 / 70 MB/sec                         | 17.5 / 35 MB/sec                                     |
|                        | Quantum LTO-2                |                                   | 34 / 68 MB/sec                         | 12 / 24 MB/sec                                       |
|                        | HP LTO-2                     |                                   | 30 / 60 MB/sec                         | 10 / 20 MB/sec                                       |
|                        | Quantum LTO-2 [HH]           |                                   | 26 / 52 MB/sec <sup>(1)</sup>          | 12 / 24 MB/sec                                       |
|                        | HP LTO-2 [HH]                |                                   | 24 / 48 MB/sec                         | 8 / 16 MB/sec  |
|                        | IBM LTO-2 [HH]               |                                   | 24 / 48 MB/sec                         | 12 / 24 MB/sec                                       |
|                        | Tandberg LTO-2 [HH]          |                                   | 24 / 48 MB/sec                         | 12 / 24 MB/sec                                       |
| LTO Ultrium 1          | Tandberg LTO-1 [HH]          | 100 / 200 GB                      | 16 / 32 MB/sec                         | N/A  |
|                        | Quantum LTO-1                |                                   | 16 / 32 MB/sec                         | 8 / 16 MB/sec  |
|                        | HP LTO-1 [HH] <sup>(2)</sup> |                                   | 16 / 32 MB/sec                         | 6.7 / 13.4 MB/sec                                    |
|                        | HP LTO-1                     |                                   | 15 / 30 MB/sec                         | 6 / 12 MB/sec  |
|                        | IBM LTO-1                    |                                   | 15 / 30 MB/sec                         | N/A  |
|                        | IBM LTO-1 [HH]               |                                   | 7.5 / 15 MB/sec                        | 6 / 12 MB/sec  |

HH indicates Half-height form factor drive models; all others are full height drives

How the Speed Matching Feature functions varies among manufacturers and their different drive models.

## LTO Ultrium Tape Media & Drives (Cont.)

- **Manufacturers' drives shown – these same drives can be found marketed under several other hardware brands. Not all drive models represented above are currently shipping; some models may have been retired by the manufacturer.**
- **Certance (formerly Seagate Removable Storage Solutions Division) LTO drives are now shown as Quantum drives. Quantum LTO Ultrium Drives: former Seagate RSS Division / Certance was acquired by Quantum 12 / 2004.**
  - (1) **Enhanced speed (26 MB/sec Native) Quantum LTO-2 half-height drive; firmware revision upgrade 2005.**
  - (2) **HP LTO-1 HH drive model 232 has a higher data transfer rate versus HP's LTO-1 HH model 215 drive.**
- **Transfer Rate is drive dependent; where rate varies by drive interface – the faster model is shown. Current transfer rate may be different from shown due to model upgrade or model substitution.**
- **Speed Matching: as long as the data supply to the tape drive is  $\geq$  the minimum, the tape drive will be able to stream. This can improve media and transport life by reducing repositions.**
- **Compressed values assume 2:1 compression.**
- **Nominal Values Shown. One GB equals 1,000,000,000 bytes. One MB equals 1,000,000 bytes.**

# LTO Ultrium Media and Drive Compatibility

| Tape Media Capacity, Length          | LTO-1 Tape Drive              | LTO-2 Tape Drive              | LTO-3 Tape Drive              | LTO-4 Tape Drive              | LTO-5 Tape Drive              |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| LTO Ultrium 1<br>100/200 GB, 609m    | Full Read/Write Compatibility | Full Read/Write Compatibility | Read-Only                     | NOT COMPATIBLE                | NOT COMPATIBLE                |
| LTO Ultrium 2<br>200/400 GB, 609m    | NOT COMPATIBLE                | Full Read/Write Compatibility | Full Read/Write Compatibility | Read-Only                     | NOT COMPATIBLE                |
| LTO Ultrium 3<br>400/800 GB, 680m    | NOT COMPATIBLE                | NOT COMPATIBLE                | Full Read/Write Compatibility | Full Read/Write Compatibility | Read-Only                     |
| LTO Ultrium 4<br>800/1600 GB, 820m   | NOT COMPATIBLE                | NOT COMPATIBLE                | NOT COMPATIBLE                | Full Read/Write Compatibility | Full Read/Write Compatibility |
| LTO Ultrium 5<br>1500/3000 GB, 846 m | NOT COMPATIBLE                | NOT COMPATIBLE                | NOT COMPATIBLE                | NOT COMPATIBLE                | Full Read/Write Compatibility |

- Ultrium 5 drives are backward read & write compatible with Ultrium 4 data cartridges. When using an Ultrium 4 data cartridge, the Ultrium 5 drive will write or read 800 GB (1600 GB assuming 2:1 compression), same as an Ultrium 4 drive.
- When using the Ultrium 5 data cartridge, the Ultrium 5 drive will read & write 1.5 TB (3 TB assuming 2:1 compressed) at up to 140 MB/second native (280 MB/second assuming 2:1 compression).

## WORM Format LTO Ultrium 3, 4, & 5 Cartridges

### **LTO WORM (Write Once / Read Many) Cartridges**

LTO 3 was the first generation in the LTO Roadmap to support WORM functionality. Once data is written to WORM tape, it cannot be altered.

For LTO Generations 3, 4, and 5 special cartridges with WORM functionality allow secure backup and storage of critical data in a non-erasable, non-rewritable format.

The LTO specification includes the ability for WORM & non-WORM media to function in WORM enabled LTO drives and provides a very cost effective means to store critical information in a non-erasable, non-rewritable format.

## WORM Cartridge - 2 Tone Color for Easy ID



Fujifilm LTO-5 data cartridge



Fujifilm LTO-5 WORM cartridge

The different generations of Fujifilm LTO Ultrium data & WORM cartridges can be identified by their unique shell color: Black Ultrium 1, Purple Ultrium 2, Slate-Blue Ultrium 3 & **two-tone Slate-Blue / Platinum Ultrium 3 WORM**, Green (grayish green) Ultrium 4 & **two-tone Green / Platinum Ultrium 4 WORM**, Red Ultrium 5 & **two-tone Red/Platinum Ultrium 5 WORM**.



## LTO Ultrium 5

### Capacity:

1500 Gigabytes (GB) [ 1.5 TB ]

w/ 2:1 compression:

3000 Gigabytes [ 3.0 TB ]

### Transfer Rate:

140 Megabytes (MB) per second

w/ 2:1 compression:

280 Megabytes per second

LTO-5 drives are backwards read and write compatible with generation 4 format media and backwards read compatible with generation 3 media.



## LTO Ultrium 4 & 5 Drive-based Encryption

The LTO standard provides for encryption capability built into LTO-4 and 5 drives. The specification includes hardware-based AES 256 bit encryption capabilities to provide data security.

The encryption feature provides users the option to encrypt the data on their LTO-4 and 5 tapes, helping protect information if the tape cartridges are lost or stolen.

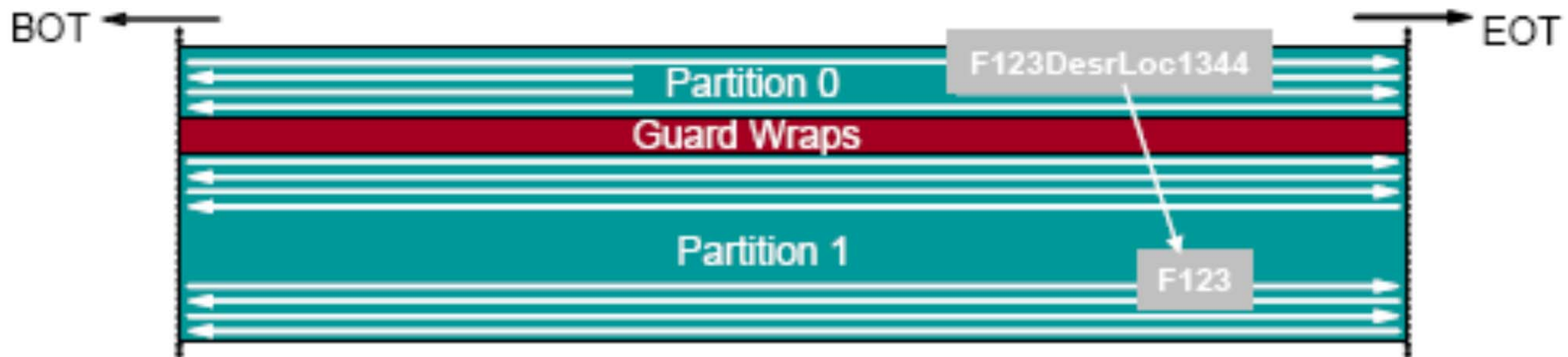
Uses standard LTO-4 and 5 rewritable and WORM media [no special media needed].

In-drive encryption offers advantages over appliance or software based encryption:

- No performance penalty (appliance/software encryption can drain host resources)
- Data compression- Appliance/software encrypted data cannot be compressed by drive, but in-drive encryption is performed after in-drive compression, thus allowing full compression
- Portability: Any encrypted LTO-4 tape can be read on another LTO-4 and 5 drive, (LTO-5 tape in LTO-5 drive) provided encryption key is presented. [Appliance /software are proprietary solutions and are less portable]

## LTO-5 New: Dual-Partition Capability

The LTO-5 specification enables a new dual partitioning feature which can help provide faster data access through the enhancement of file control and space management with improved data management.



## LTO Ultrium 5 Dual Partitioning

**The LTO-5 specification enables a new dual partitioning feature which can help provide faster data access and improved data management**

- Capability for 2 media partitions which can be independently accessed to provide faster data access and improved data management.
- Self-describing tape: One partition holds the content, & the other holds the content's index.
- Enable capabilities that can manage files directly on tape and can allow for easy sharing of the tape cartridge with others.
- Provides file system access at the operating system level.
- Allows viewing and access of tape files in a fashion like disk or other removable media with directory tree structure.
- Addresses the growing needs of marketplace segments with rich media such as Media and Entertainment, Medical, Digital Surveillance, and others.

## LTO Ultrium 5 Dual-Partition Benefits

### **Ease of use**

- Self describing tape enabling hierarchical directory structure, file names, file properties, metadata files, fast search indexes, domain-specific information
- Simply drag and drop files to and from tape
- Mount a tape as if it was a hard drive

### **Fast access**

- Once you load a tape, the directories and files are displayed on your screen directory, without the need to run backup software first. You never need to rebuild a catalog.

### **Hardware & software Independent**

- Compatible across various OS platforms
- No backup or archive software required to view content

## LTO Ultrium 5 Dual-Partition Benefits (cont'd)

### File portability

- Since the information written to tape is self-contained, data recovery is independent of hardware or software platforms. Tapes can be exchanged easily between different operating systems and software.

### Archival

- 30+ year archival life for tape when stored as recommended
- Contents easily viewed without backup software, on any compatible drive

### Cost savings

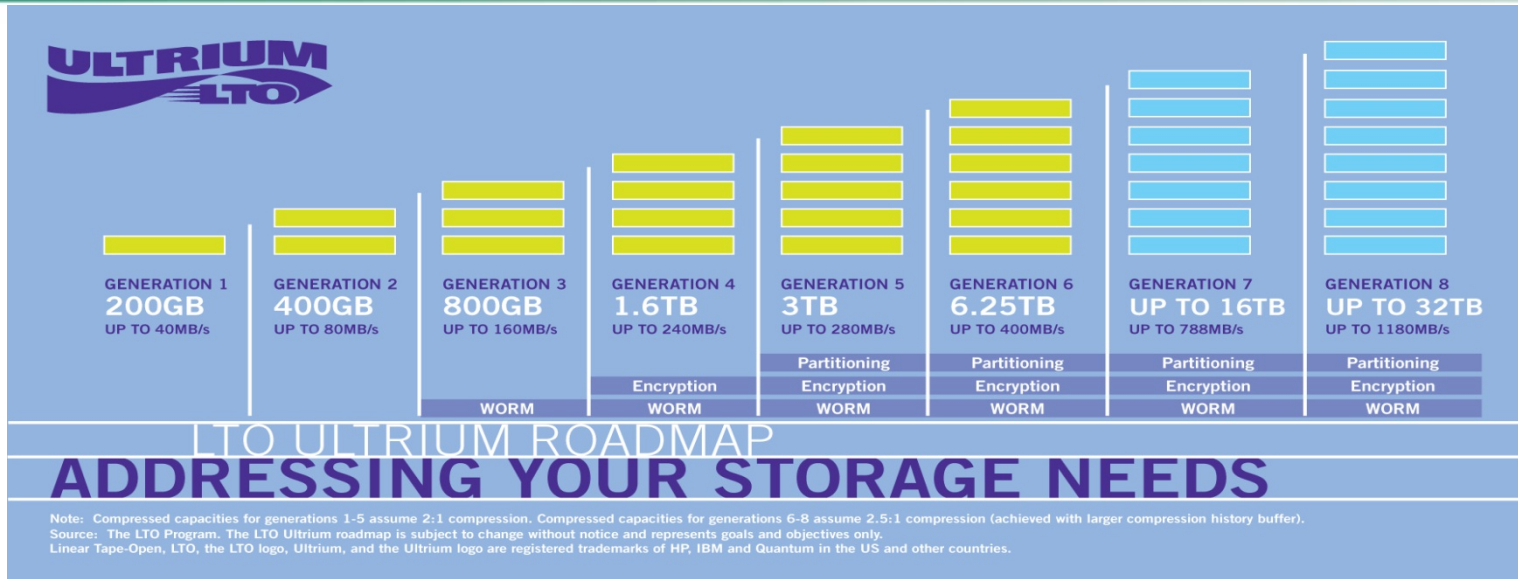
- Lower cost than video storage and equipment
- Faster data ingest time
- Reduce archive storage space by 10x (compared to video-tape)
- Supports green initiatives: can reduce energy consumption by up to 100x (compared to HDD)

## Fujifilm LTO Ultrium Review

| Data Cartridge | Tape drive | Native Capacity | Native data rate |
|----------------|------------|-----------------|------------------|
| LTO Ultrium 1  | Ultrium 1  | 100 GB          | 7.5 - 16 MB/sec  |
| LTO Ultrium 2  | Ultrium 2  | 200 GB          | 24 - 35 MB/sec   |
| LTO Ultrium 3  | Ultrium 3  | 400 GB          | 60-80 MB/sec     |
| LTO Ultrium 4  | Ultrium 4  | 800 GB          | 80-120 MB/sec    |
| LTO Ultrium 5  | Ultrium 5  | 1.5 TB          | 140 MB/sec       |

\* Data transfer rate varies among drive manufacturers and drive models. The range of current rates for different LTO Ultrium drive models is shown. *For example*, the IBM LTO-3 half-height model drive transfers data at 60 MB/second native and IBM's LTO-3 full-height model drive has a transfer rate of 80 MB/second native. The allowable range (LTO specification) for design of LTO-3 drives is between 40 and 80 MB/second native. Consult with drive manufacturer for current offerings and specifications.

# LTO Ultrium Roadmap-8 Generations



Source: The LTO Program    2000    2002    2004    2007    2010 →→→

## LTO 1-3 Fujifilm ATOMM Technology

## LTO-4 & 5 Fujifilm NANOCUBIC Technology

- The LTO Ultrium Roadmap extends well into the future with capacities & performance to meet the needs of evolving data storage requirements
- Fujifilm’s advanced ATOMM and NANOCUBIC coating technologies are a key enabler behind LTO Technology



## Archival Longevity- 30 + years

- **Fujifilm's superior binder and lubricant technology:** Fujifilm media has an archival life greater than 30 years, when stored as recommended
- **Tape life expectancy study by NARA** (National Archives and Records Administration) [2002] predicting Longevity of High Density Magnetic Media - "[Environmental Stability and Life Expectancies of Magnetic Media for use with IBM 3590 and Quantum Digital Linear Tape Systems.](#)" The National Archives based their recommendations on this study and **Fujifilm brand media is shown to be superior.** Same basic technology is used in LTO with additional & ongoing enhancements.

## LTO—Environmental Conditions

### LTO 1-5

#### 1) Operating Conditions

Temperature: 10 °C to 45 °C (50 to 113F)

Relative humidity: 10 % to 80 %

Max. wet bulb temperature: 26 °C (79F)

#### 2) Short Term Storage Environment

Temperature: 16 °C to 35 °C (61 to 95F)

Relative humidity: 20% to 80%

Max. wet bulb temperature: 26 °C (79F)

The short term storage environment is recommended for cartridge storage durations of up to six months.

#### 3) Archival Storage Environment (Long Term)

Temperature: 16 °C to 25 °C (61 to 77F)

Relative humidity: 20% to 50%

Max. wet bulb temperature: 26 °C (79F)

## Additional information

For additional information, please contact us or visit our website.

**1) Contact Fujifilm**

<http://www.fujifilmusa.com/support/ServiceSupportContactInfo.do?catid=464128&prodcats=233838>

**2) Fujifilm Website**

[www.fujifilmusa.com/tapestorage](http://www.fujifilmusa.com/tapestorage)

**3) Case Studies/White Papers**

[http://www.fujifilmusa.com/products/tape\\_data\\_storage/case\\_studies/](http://www.fujifilmusa.com/products/tape_data_storage/case_studies/)