(Please first see the video file of Larry Blake’s presentation of Part 1.)

The Future of LTO Technology in Digital Preservation

1. Media and Drives
2. LTFS
3. Object Storage

Linda Tadic, Digital Bedrock
Email: Ltadic@digitalbedrock.com

Why Digital Bedrock Uses LTO Data Tape as Its Primary Data Storage Medium

- Sustainability (low power use, media made with no rare earth materials)
- Cost
- Security
- Open file system (LTFS) is *required* for digital preservation (should not use any proprietary system)

Digital Bedrock's LTO Use in Practice

- Tape libraries: Quantum, SpectraLogic
- LTO generations supported: LTO-2 through LTO-9
- Only write LTFS, but can restore tapes written in LTFS, tar, BRU, Retrospect, NT Backup, BackupExec, XenData
- Standard practice: make 3 copies, geographically distributed
- Run fixity checks annually (SHA-512)

1. LTO-10+

Tape will get thinner as data capacity increases to support the longer tape in a cartridge. Must use a different substrate polymer blend than in LTO-9 for improved reaction to temp/humidity changes.

LTO-9 is 5.2 µm (micrometer, or one millionth of a meter) thick. Future generations need to achieve 4.2 & less **for PET substrates**.

2. LTFS Future

LTFS standard and specification managed by Storage Networking Industry Association (SNIA).

Development performed by IBM engineers and others. **Current spec: v2.5.1**

Using LTFS in writing data to LTO is critical for digital preservation since it is non-proprietary.

July 2023: Windows EOL beyond LTFS v2.4.5

Announcement that LTFS version 2.4.5 is the final release of LTFS for Windows.

Quantum news release: Announcing the End of Life of Windows LTFS

“There is a known issue within Windows, after Windows 10 Security Patch version KB5025221 – April 11,2023; and Windows 11.

Security Patch version KB5023706 March 14, 2023, which affects **LTFS capabilities on writing data.** Unfortunately, as Windows LTFS is now end-of-life, there will be no updates to fix this bug.

Windows Server 2016 and 2019 are not affected by this bug.”

LTFS Update (as of March 10, 2025)

IBM has added engineers to develop Windows 10 (?) & 11 support.
Should be released in June 2025.

Mac OS is next. [*LTFS v2.5.1 not supported on MacOS 12-15*]

3. LTO Used in Object Storage

Object Storage breaks data into three shards/objects:

1. Data (actual essence)
2. Unique identifier that links the 3 parts
3. Metadata (header, permissions, policies)

Shards can be split across different locations. By default, the data “owner” is locked into the storage provider, since the vendor controls the UID and shards.

LTO Used in Object Storage

LTFS is **file-based** storage.

LTO tape library vendors pivoting to **S3 object storage on LTO as a cloud storage backup**.

Files' shards are split across several tapes which can be in different tape libraries and different geographic locations.

Can only get data out by using the storage provider to restore/rehydrate the data, then move it to another system.

Possible to take tapes from one vendor and put it in another system without using the original data manager, but the user must re-create the data mapping, which is complex.

Questions/Concerns on LTO's Future In Digital Preservation

1. As LTO storage capacity increases, will LTFS in its current specification **no longer be usable for writing to LTO-11 +?**

   To revise LTFS, need: (1) three SNIA members to propose revisions and be willing to work on it, and (2) developers to work on the new spec technology.

2. Going backwards to proprietary systems?

   Forcing a reliance on enterprise-level "backup" solutions – moving tape to the cloud. "Regular humans" will no longer be able to control managing their data on LTO.

3. If object storage is the future, can it be developed to be "open" and easily interchangeable between systems?

References and Background Information

LTO Substrate: INSIC Report

Note: The INSIC report specifically mentions Aramid substrate. This is used just as an example of meeting the substrate requirements for larger capacity LTO generations.

"…only the **Aramid** substrate approaches the TDS* needs for the roadmap, in the absence of active TDS compensation. However, Aramid is significantly more expensive than the other substrates. To utilize the other substrate materials, the drive system will need to actively compensate for the changes in track width due to environment or other factors."

"**Aramid**" is short for "aromatic polyamide," a strong heat-resistant fiber. [*Already used in 3592 gen6 JF enterprise tape, which does not have the issues that LTO-9 has.]*

LTO-9 is 5.2 µm (micrometer, or one millionth of a meter) thick. Future generations need to achieve 4.2 & less for PET substrates. **Need 3.6 & less for Aramid.**

INSIC International Magnetic Tape Storage Technology Roadmap 2024. Information Storage Industry Consortium (INSIC). March 2024. https://www.lto.org/wp-content/uploads/2024/07/INSIC-International-Magnetic-Tape-Storage-Technology-Roadmap-2024.pdf

* Tape Dimensional Stability

INSIC Report 2.3.3.5 (p. 20)

“Commercial tape drives with multiple parallel channels must deal with **variations caused by head element pitch tolerances as the tape is interchanged from one drive to another**. In addition, the tape substrate is not rigid and therefore the width of the tape and relative locations of written data tracks change under **different environmental conditions. ***

…

One contributor that is becoming increasingly important is the tolerance variation between the **write heads** in the **drive that originally wrote the data** on the tape and the **read heads** in the **drive that will eventually read the data**. In this context critical tolerances include variations in the width and position of the transducers on the head that arise from the manufacturing process. To keep all the read transducers in a head accurately positioned on tracks that are only 79 nm wide, head manufacturing processes will need to continually improve to improve these tolerances.”

[*ref. the September 2024 LTO-9 drive firmware update to “Modify tape tension limit to improve reliability in cold/dry environments.”]

LTFS Specification and GitHub site

Current specification version: 2.5.1 (released August 2020) **ISO standard ISO/IEC 20919:2016**

https://www.snia.org/sites/default/files/technical-work/ltfs/release/SNIA-LTFS-Format-2-5-1-Standard.pdf

Development work is on GitHub development page:
https://github.com/LinearTapeFileSystem/ltfs

Focus of GitHub site is to build v2.5.