ChannelScience

Establish the State-of-the-Art ™

Introducing a Modern, Multiformat, Minimal-Contact Legacy Tape Reader

“Let’s Make Obsolete Tape Formats Obsolete!”

“There is New Value in Old Data”

Rev. July 21, 2025

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U.S. DEPARTMENT OF ENERGY AWARDEE™

SBIR Grant Award: DE-SC0021879

Irreproducible Data is being Lost on Deteriorating Legacy Media

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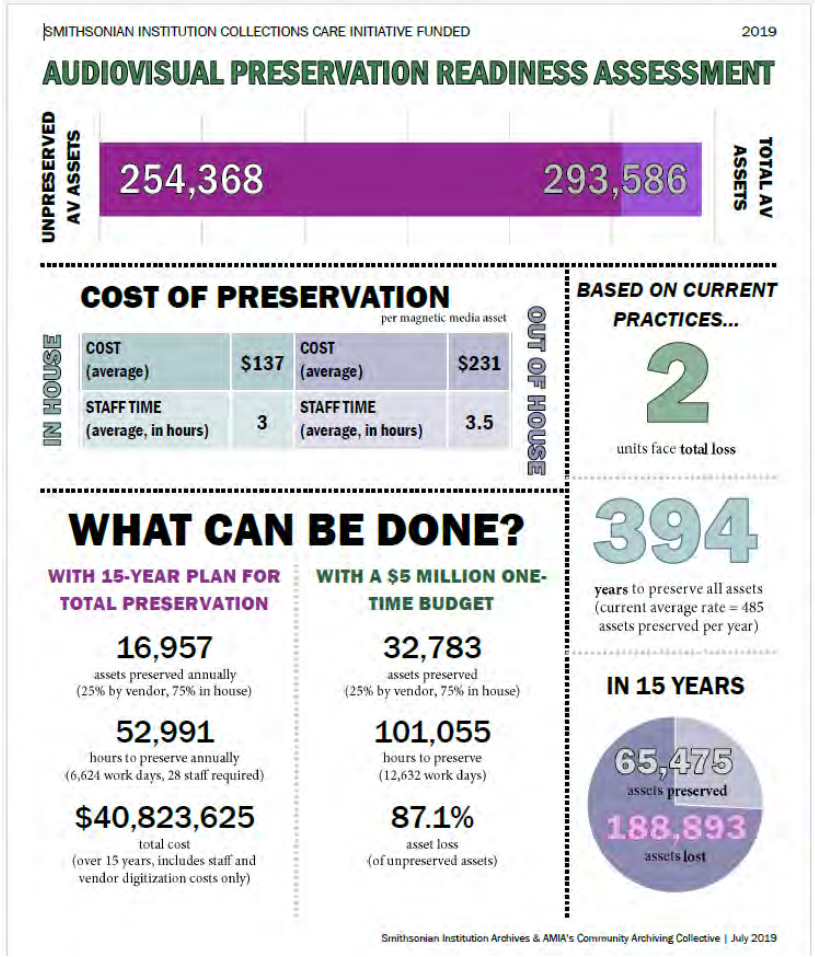
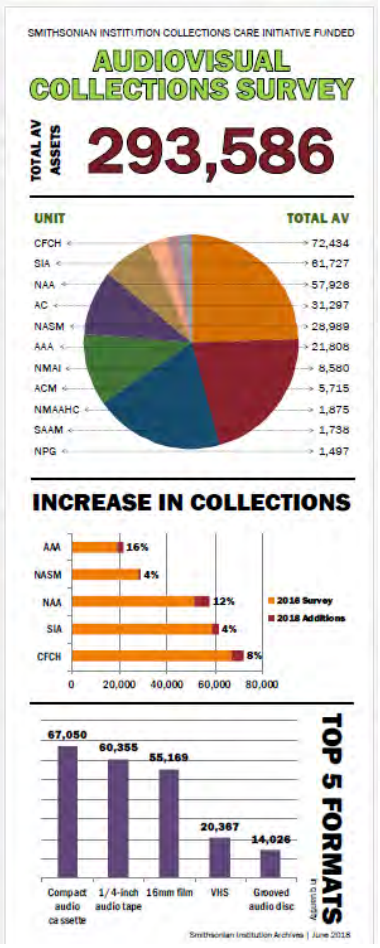
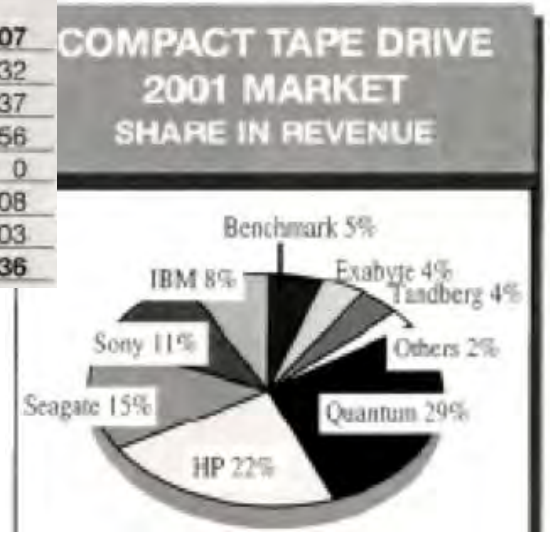
Recognized Issue with Millions of Tapes





WW MARKET FOR COMPACT TAPE DRIVES			
Unit shipments (in thousands)	**2001**	**2002**	**2007**
Cartridge	604	520	683
DAT	1,312	1,126	370
8mm	121	172	334
Magstar MP	2	1	0
DLT	444	450	650
LTO	92	189	621
Total units	**2,575**	**2,458**	**2,658**
Revenue (in $ millions)	**2001**	**2002**	**2007**
Cartridge	127	111	132
DAT	601	498	137
8mm	141	163	256
Magstar MP	10	4	0
DLT	625	668	1,008
LTO	273	508	1,103
Total revenue	**1,777**	**1,952**	**2,636**



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Current "State-of-the-Art" Recovery of Legacy Tapes Requires Finding and Refurbishing Vintage Drives

Data migration companies for legacy tapes are working museums!

KATALYST DATA MANAGEMENT

Even a perfectly refurbished 1970s tape drive only has 1970s' capabilities!

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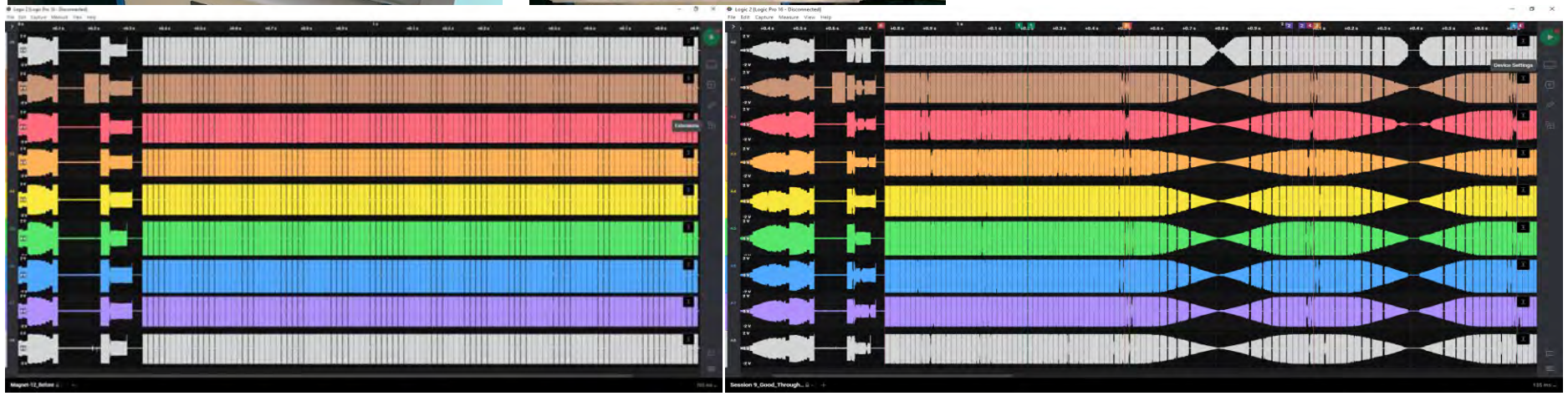
There are Fewer and Fewer Vintage Heads

In short supply
Expensive
Wear out

Recovery with Refurbished Vintage Drives

QualStar drives are fantastic!

But they will never perform better than their analog-filtered peak detection allows



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If the Data hasn't been Recovered in the Last 60 Years, Why is it Useful Now?

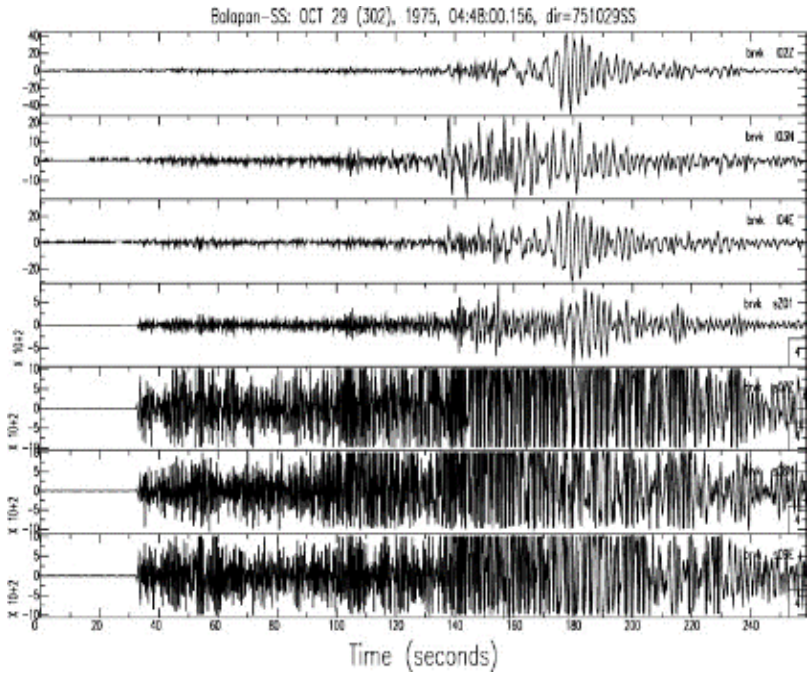
AI Agents and ML Models need massive amounts of unique training data!

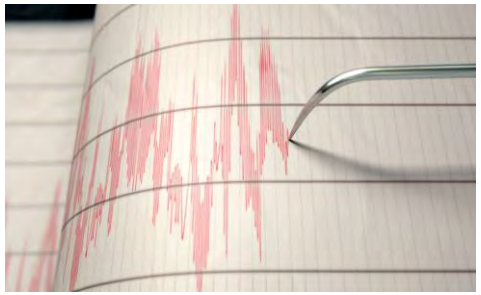
(scraping the web for training data just uses what everyone else is using)

Training on domain-specific legacy data differentiates your AI/ML

Sovereign AI: LLMs trained on a country's history and language

It is Easier to Take Data than to Analyze it – Until AI/ML





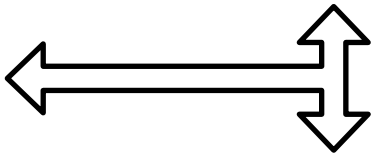


Figure 1. 1975 Test in Kazakhstan

https://www.sciencedirect.com/science/article/pii/S2214242815000224

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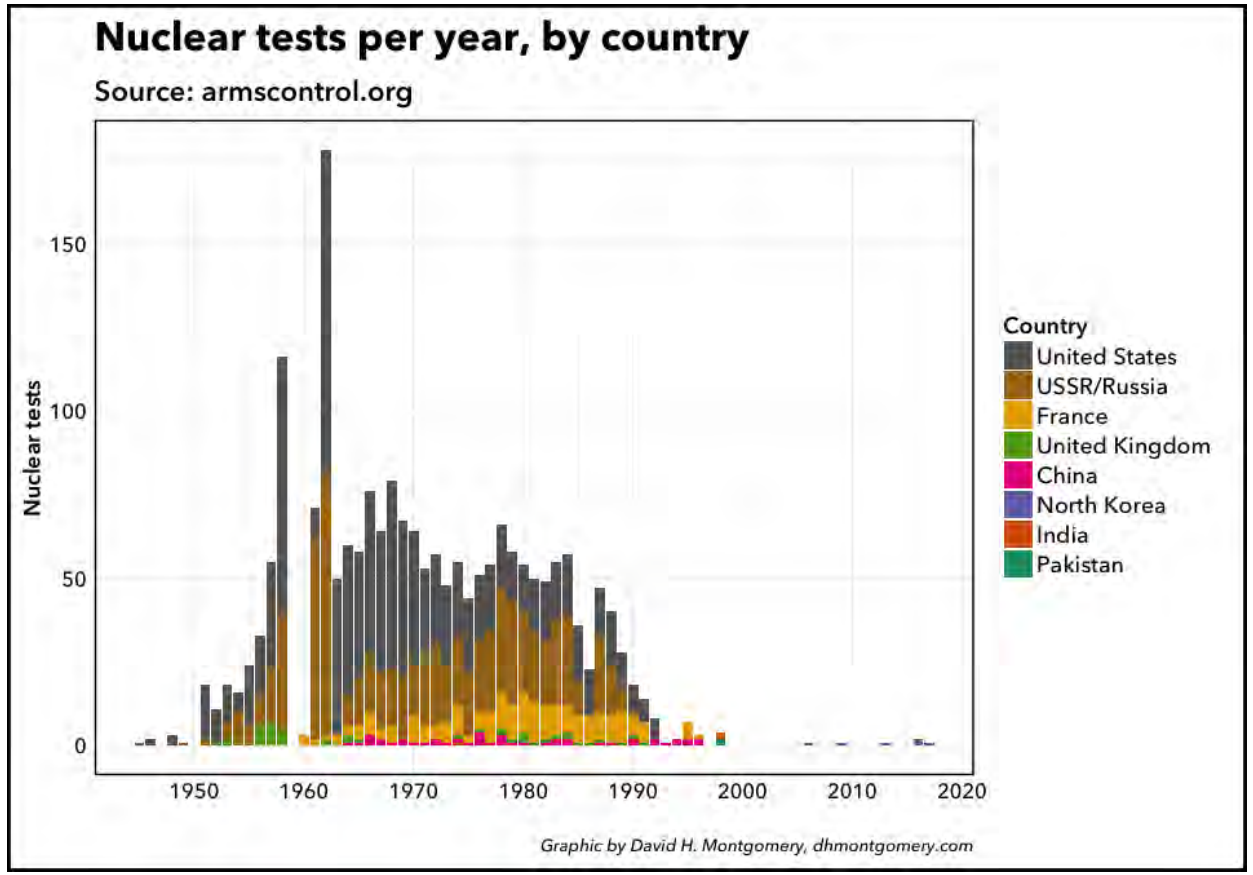
DOE-Funded Development to Access Irreproducible Scientific Data



Number of nuclear tests per year by country from 1945 to 2017. This figure is based on publicly available data at: http://dhmontgomery.com/2018/02/nuclear-tests/

ChannelScience's multiformat tape reader technology is a 4-time SBIR award winner from the DOE National Nuclear Security Administration (NNSA)!

SBIR Grant Award: DE-SC0021879

We are building the best tape reader ever created for legacy formats

Our tape reader must be better than the original equipment, because the tapes are in deteriorated condition

DTRA Waveforms from Nuclear Explosions: https://www.wfne.info/
https://www.ctbto.org/our-work/detecting-nuclear-tests

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ChannelScience's Breakthrough Solution

- Modern, sensitive, plentiful GMR sensors
- Custom electronics for high-fidelity signal capture
- Gentle tape path, high-speed tape transport
- Advanced signal processing, detection, and decoding
- AI-driven throughout (learns from experienced technicians and operators; predictive maintenance; format detection)
- Multiformat hardware frontend; Software modules for each format

SBIR Grant Award:
DE-SC0021879

Winner of 4 SBIR grants from US DOE!

Simply put:

The best tape reader ever built for legacy formats

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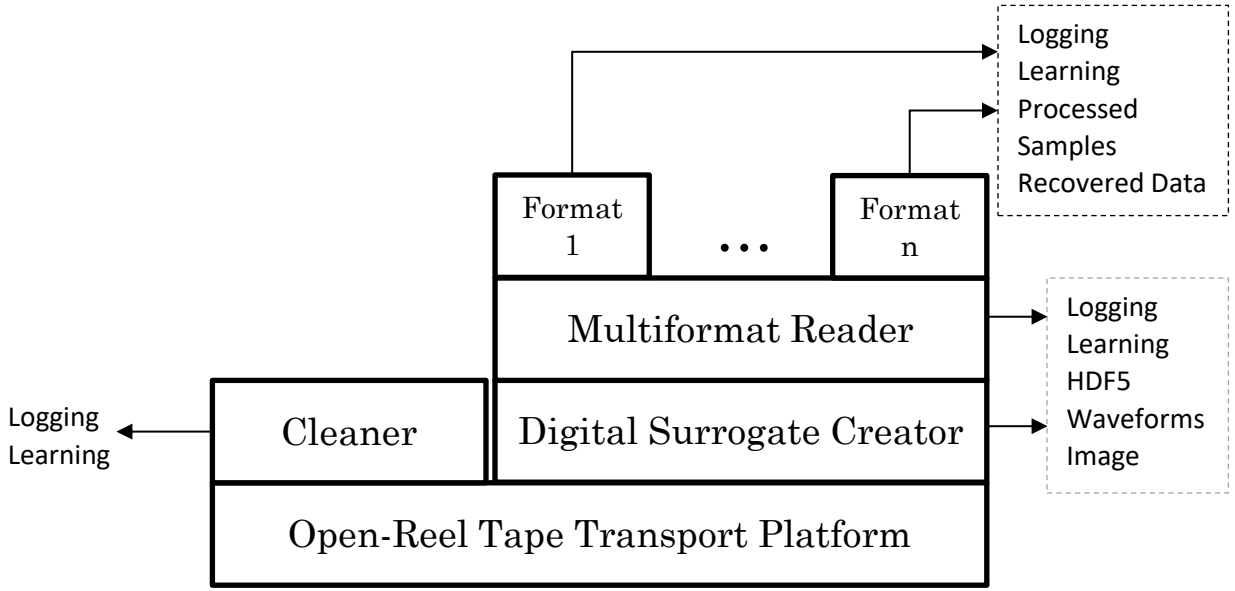
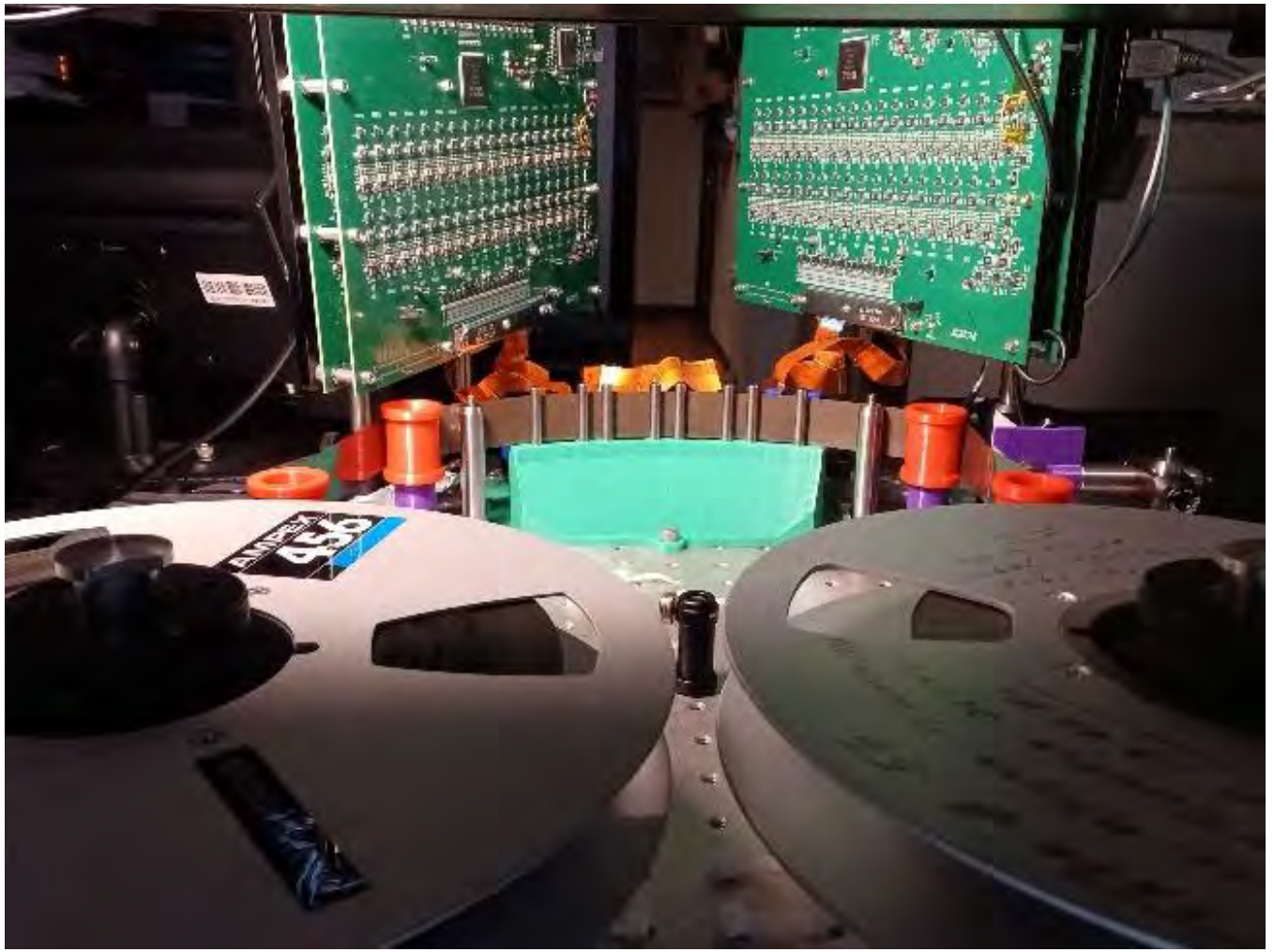
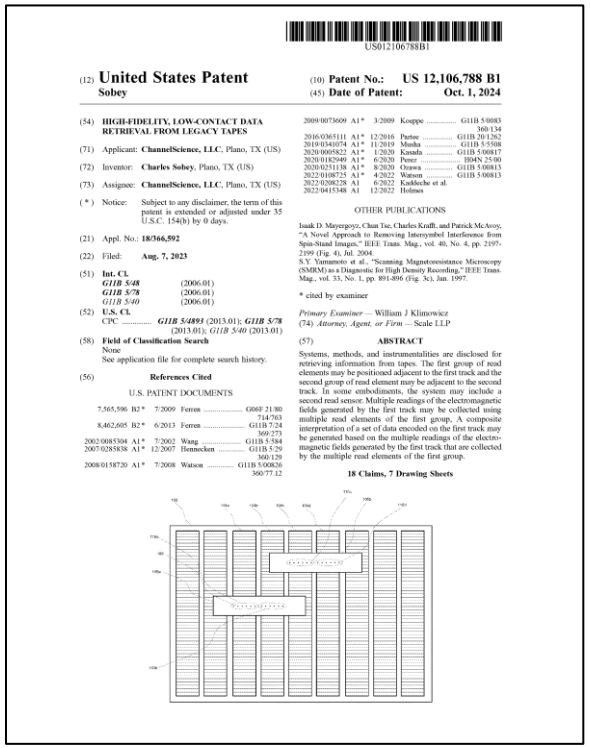
Hardware Platform with Format-Specific Software Modules



We intend to support open-source software modules for decoding additional formats.

ChannelScience's Prototype: Project Landau





US0012106788B1

(12) **United States Patent**
Sobey

(10) **Patent No.: US 12,106,788 B1**
(45) **Date of Patent: Oct. 1, 2024**

(54) **HIGH-FIDELITY, LOW-CONTACT DATA RETRIEVAL FROM LEGACY TAPES**

(71) Applicant: **ChannelScience, LLC**, Plano, TX (US)

(72) Inventor: **Charles Sobey**, Plano, TX (US)

(73) Assignee: **ChannelScience, LLC**, Plano, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/366,592**

(22) Filed: **Aug. 7, 2023**

(51) **Int. Cl.**
G11B 5/48 (2006.01)
G11B 5/78 (2006.01)
G11B 5/40 (2006.01)

(52) **U.S. Cl.**
CPC ***G11B 5/4893*** (2013.01); ***G11B 5/78*** (2013.01); *G11B 5/40* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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S.Y. Yamamoto et al., "Scanning Magnetoresistance Microscopy (SMRM) as a Diagnostic for High Density Recording," IEEE Trans. Mag., vol. 33, No. 1, pp. 891-896 (Fig. 3c), Jan. 1997.

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Primary Examiner — William J Klimowicz
(74) *Attorney, Agent, or Firm* — Scale LLP

(57) **ABSTRACT**

Systems, methods, and instrumentalities are disclosed for retrieving information from tapes. The first group of read elements may be positioned adjacent to the first track and the second group of read element may be adjacent to the second track. In some embodiments, the system may include a second read sensor. Multiple readings of the electromagnetic fields generated by the first track may be collected using multiple read elements of the first group. A composite interpretation of a set of data encoded on the first track may be generated based on the multiple readings of the electromagnetic fields generated by the first track that are collected by the multiple read elements of the first group.

18 Claims, 7 Drawing Sheets

US Patent 12106788, Issued October 1, 2024; Additional Patents Granted and Pending

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SBIR Grant Award: DE-SC0021879

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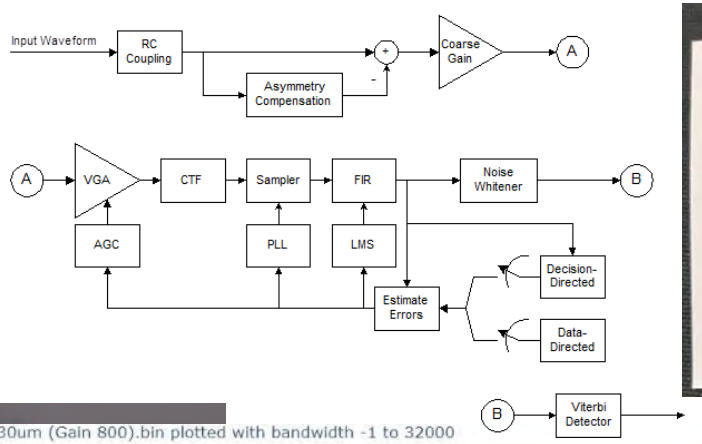
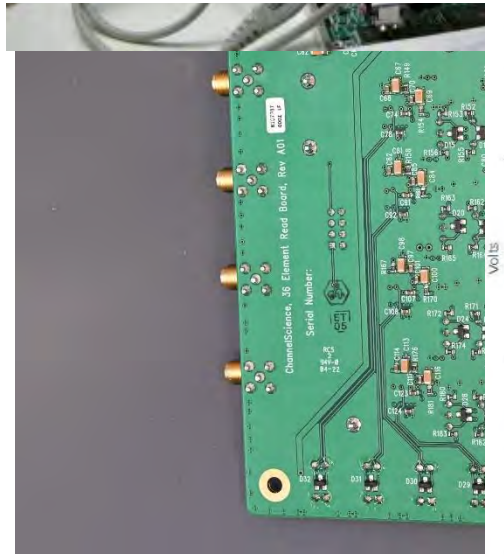
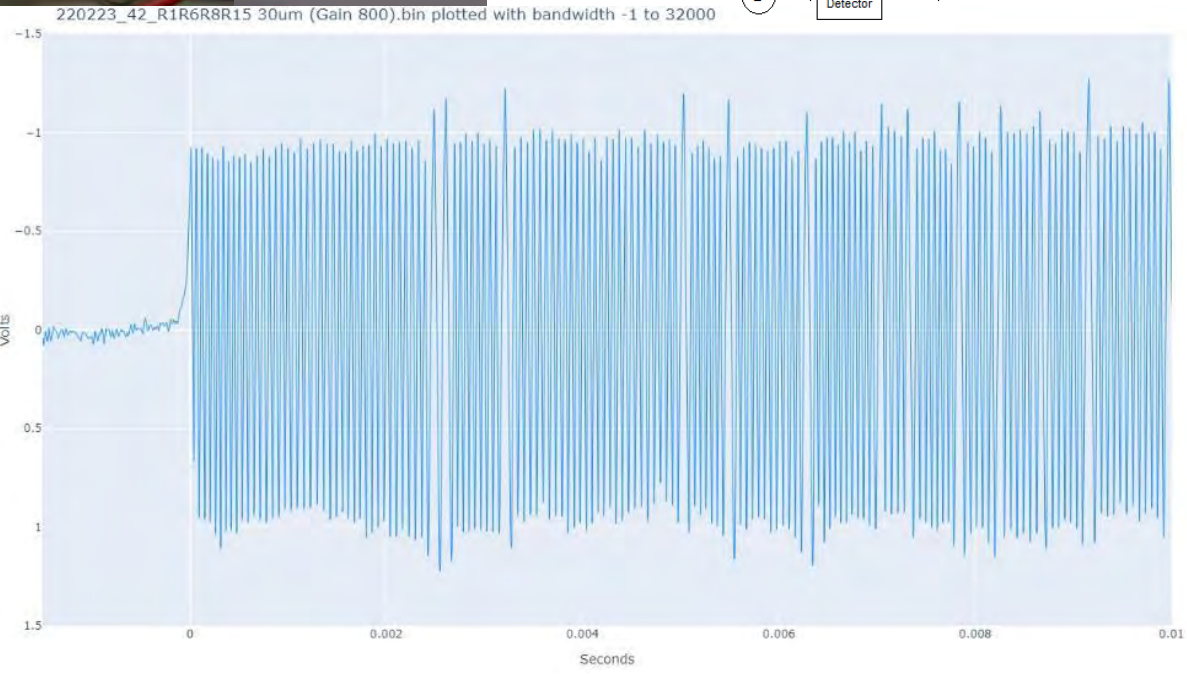


ChannelScience's PRML*pro*™ read channel model





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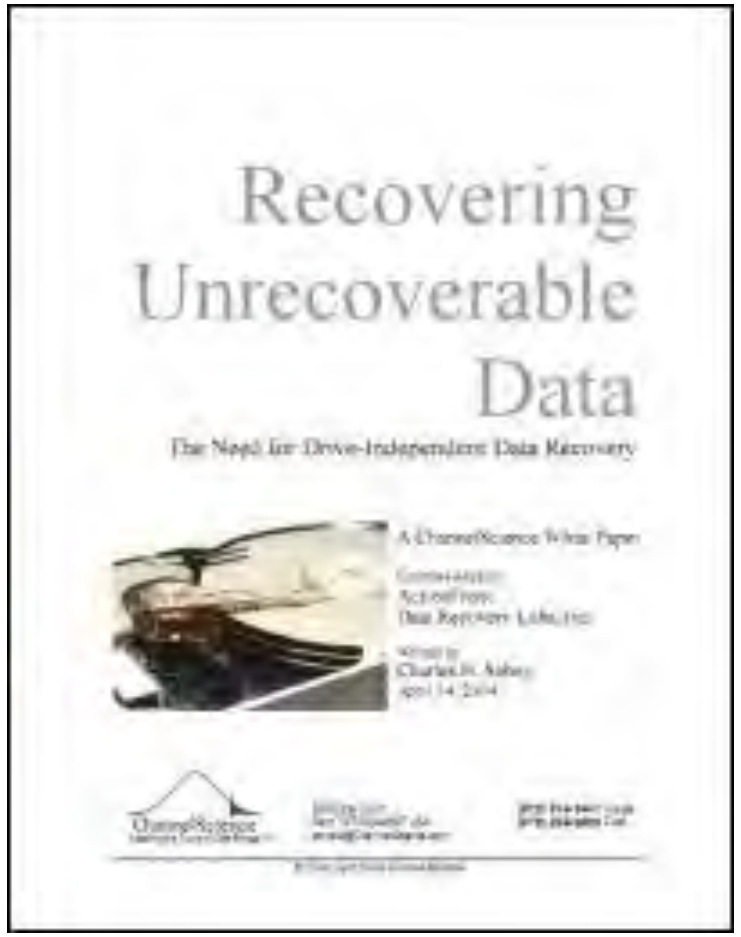
We Literally Wrote the Papers on How to Recover Unrecoverable Data


Recovering Unrecoverable Data

The Need for Drive-Independent Data Recovery

A ChannelScience White Paper

Charles H. Sobey

http://www.channelscience.com/files/Drive-Independent_Data_Recovery.pdf


Drive-Independent Data Recovery: The Current State-of-the-Art

Charles H. Sobey[1], Laslo Orto[2], and Glenn Sakaguchi[2]

[1]ChannelScience, Plano, TX 75024 USA

[2]ActionFront Data Recovery Labs, Inc., Markham, ON L3R 2Z5, Canada

The term "data recovery" herein refers to accessing logically and/or physically damaged storage media, for which no functioning backup exists. The state-of-the-art physical techniques for recovering data from failed hardware can all be described as "part replacement." To achieve high data density and high manufacturing yields, modern drives are "hyper-tuned" in the factory so that their data layout, zone frequencies, and various channel settings are optimized for each head, surface, and zone. This greatly complicates part replacement because a transplanted headstack, for example, no longer matches the servo, preamp, and read channel parameters that were optimized for the original headstack. Methods and challenges are discussed for replacing, or "refreshing," firmware and system area information and for replacing all of the drive's electronics. The data recovery industry's point of view, limitations of current techniques, and some probable future directions in data recovery are also presented. It is predicted that data recovery will be more important in the future as drives are exposed to more extreme mobile environments. Drive manufacturers may be able to differentiate themselves from their competition by designing for recoverability.

Index Terms—Calibration, computer crime, data recovery, defect management, digital magnetic recording, disk drives, ECC, logical block address (LBA), maintenance tracks, optimization, PRML, servomechanism, system area.

I. Introduction

THE term "data recovery" often refers to restoring or retrieving data (i.e., files, blocks) from backup media. Depending on the field, data recovery also refers to the results of data mining; detecting data in waveforms (often involving phase-locked loops); decryption; or decompression. In this paper, data recovery refers to accessing logically damaged and/or physically damaged media, specifically from hard disk drives (HDDs), to obtain files or blocks that have no functioning backups—or are themselves backups.

The techniques for recovery from logical damage are more closely related to the operating system and the software programs used to create the data than to the HDD itself. The interested reader will find more information on logical recoveries in [1]–[3]. The techniques for recovering data from modern disk drives experiencing hardware failures have been shrouded in secrecy and are largely unpublished, except for [4]. In fact, the authors could not find any reference to peer-reviewed papers on the topic of hardware data recovery, except [5]. After submission of the draft of this manuscript, the publication of [6] came to the authors' attention also.

Other references describe magnetically imaging a disk by scanning a magnetoresistive (MR) or giant magnetoresistive (GMR) head over its surface [7]–[12]. This is presented as a way to analyze the written magnetization patterns, with the possibility of data recovery by generating a readback waveform from the image of the magnetization, as described in [5] using a spin-stand. In [4], the excessive requirements in time, storage, processing, and complexity of such a data recovery method are briefly discussed.

The reasons for the secrecy surrounding hardware data recovery techniques and the lack of public information include the desire to protect intellectual property (trade secrets) of data recovery companies, general lack-of-knowledge in the data recovery community about the inner workings of HDDs, misdirection (so that the true scope of recovery capabilities is not known to data saboteurs), and obscuring the often crude and simple nature of techniques that, up until recently, have exemplified the state-of-the-art.

These techniques for recovering data from physically damaged HDDs can all be described as *part replacement*. Printed circuit boards (PCBs) are swapped; heads are transplanted; motors and base castings are "replaced" by re-mounting the disks onto the spindle of a donor drive; and firmware or system information is replaced or "refreshed" by rewriting it. Placing the disks in a donor drive swaps everything—except for the on-disk system information, which is described in more detail later. Data stored on portions of the magnetic layer of the disk that have been physically removed, such as due to a slider (head) scraping away the surface as in Fig. 1, cannot be recovered—unless the future holds a way to reassemble the saved magnetic debris.

Data recovery is difficult now, and is getting more difficult. In order to simultaneously achieve higher data density and higher manufacturing yields, drives are "hyper-tuned" in the factory. This precisely matches the head/disk/preamp to other system components. The tuning parameters are stored in the *system area* (not accessible to the user) on the disk and sometimes in flash ROM. Hyper-tuning is the reason data recovery by traditional part replacement almost always fails for some drive models. As this trend continues, drive-independent methods of data recovery will be required for practically all drives built in the coming years.

Furthermore, the need for data recovery is expected to grow. This is not because drives are being built more poorly. Instead, the expectation that all of one's data are always available, even when mobile, will put massive amounts of information in more vulnerable places. For example, as disk drives continue to enter

Digital Object Identifier 10.1109/TMAG.2005.861737

0018-9464/$20.00 © 2006 IEEE

http://www.channelscience.com/files/Drive%20Independent%20Data%20Recovery%20Sobey%20Orto%20Sakaguchi%20TMRC%202005%20D5%20PREPRINT.pdf

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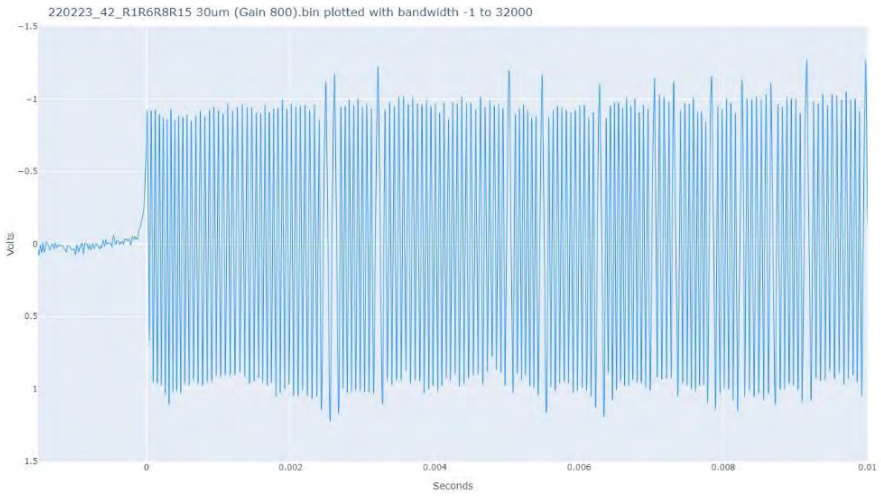

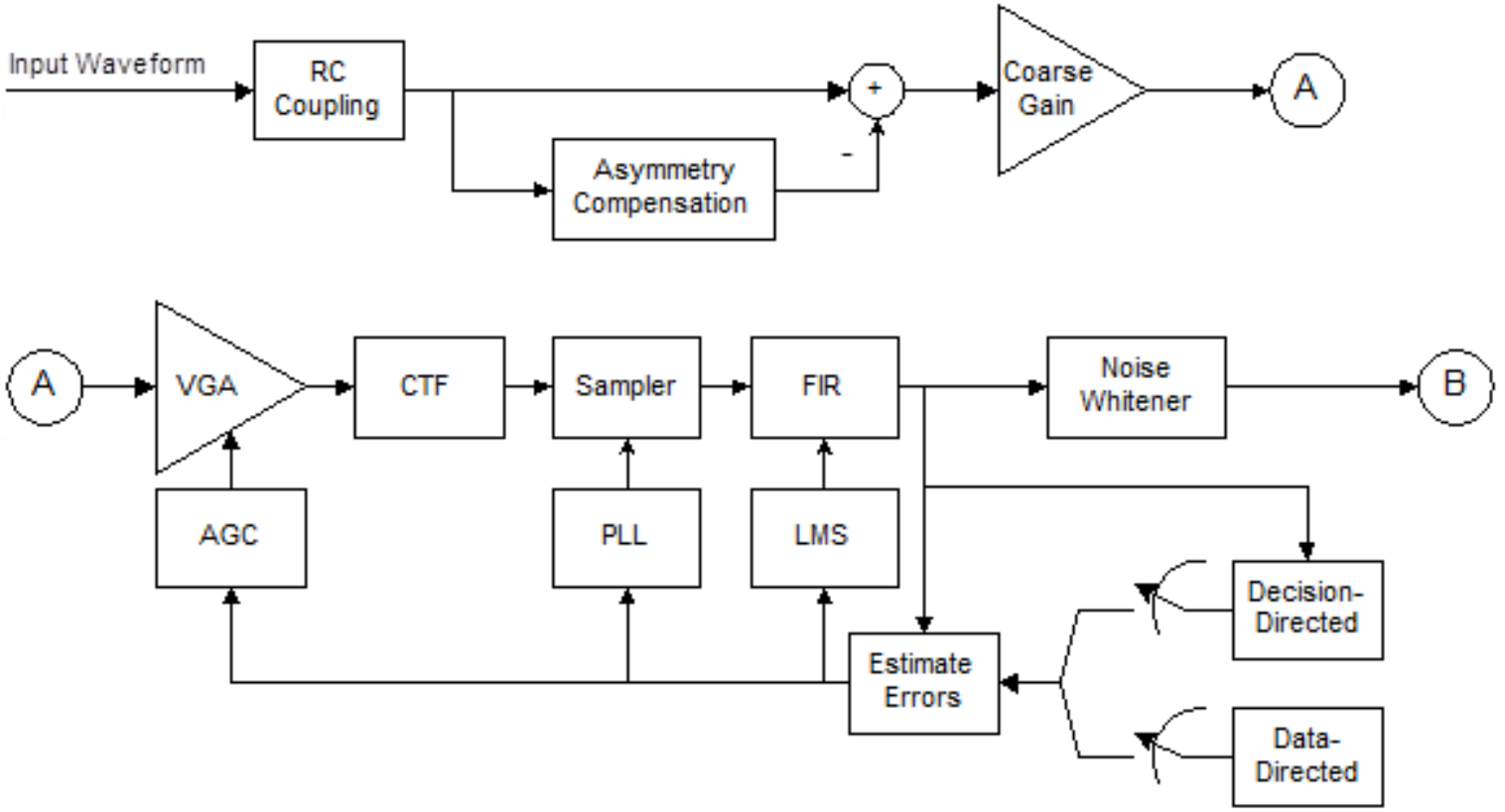

ChannelScience's PRML*pro*™ read channel model

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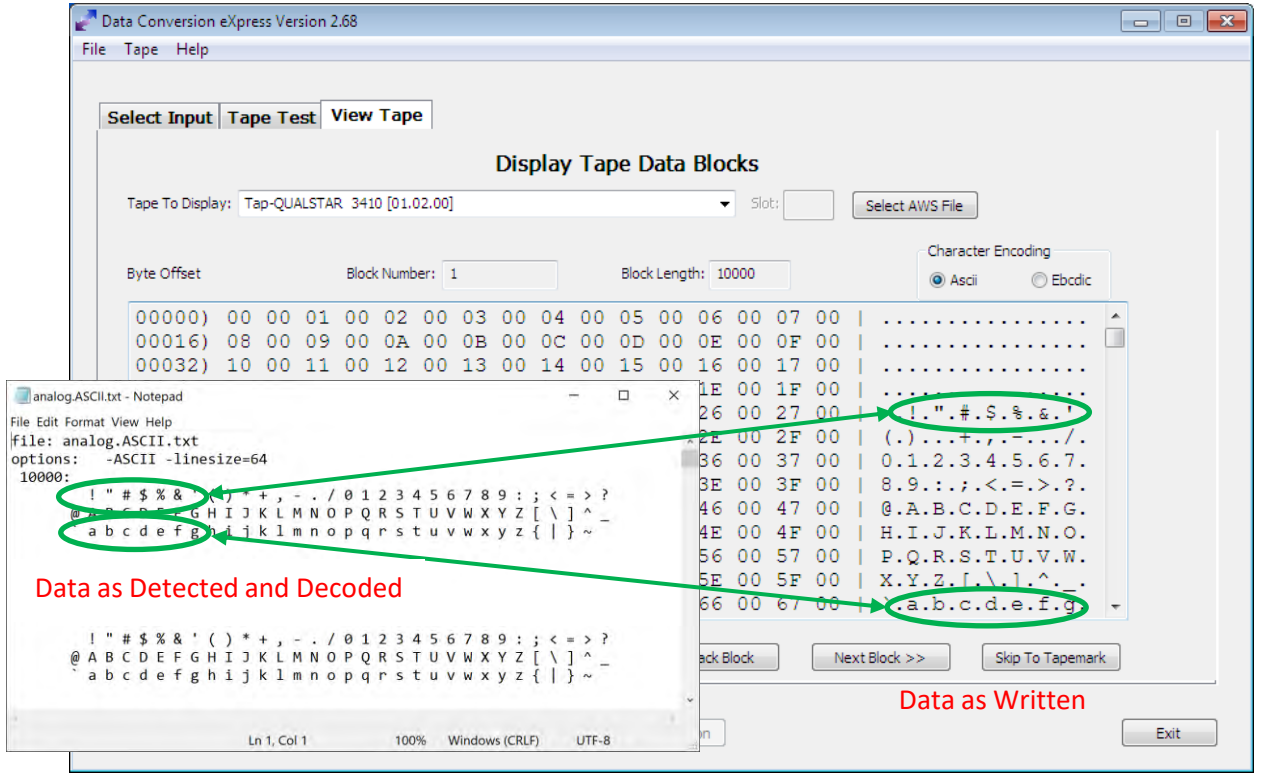
Detection and Decoding



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One-pass Scanning of ½” Tape

Scan of 7-track tape

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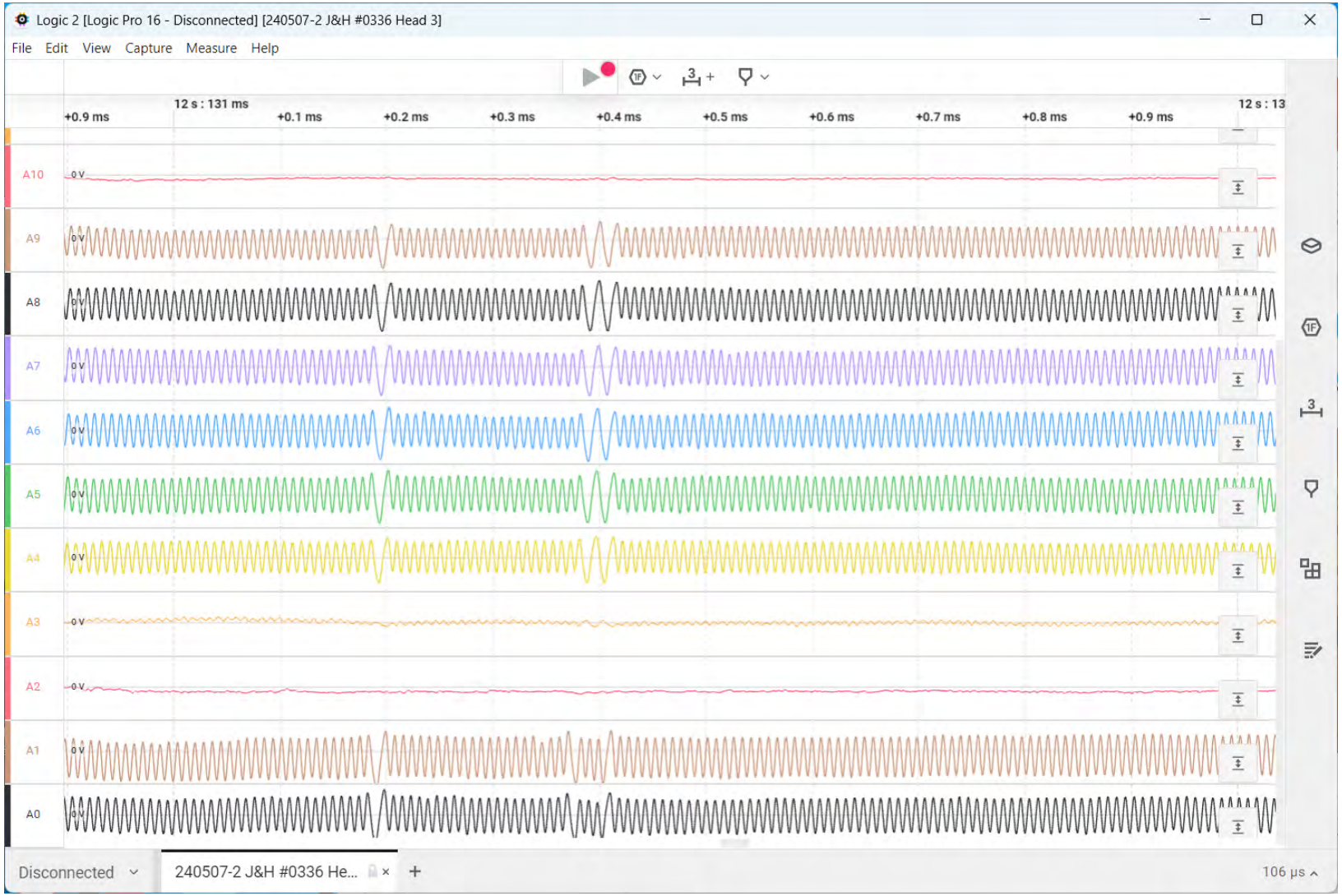
Landau Capabilities:
Multiple High SNR Reads of Each Track



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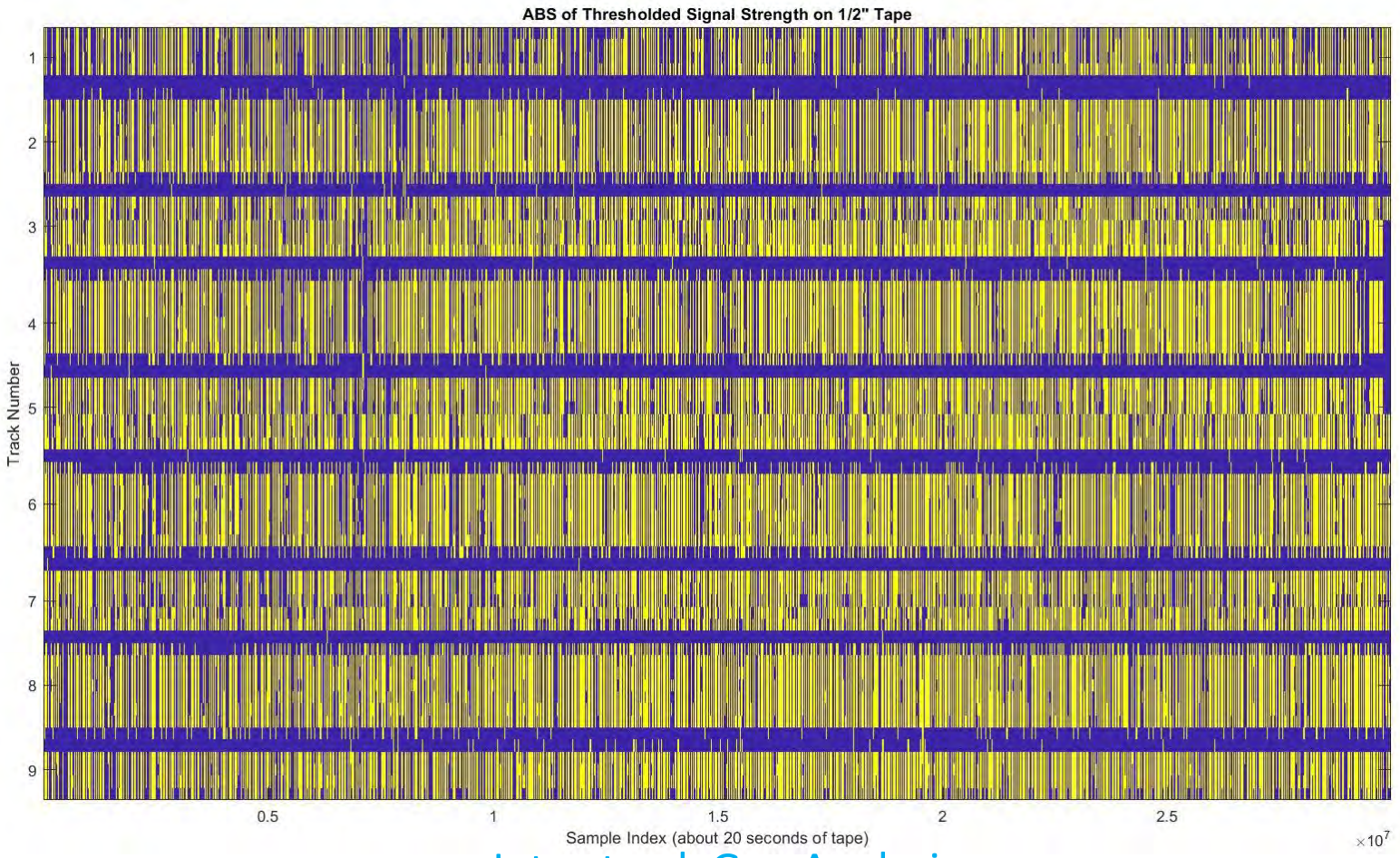
Landau Capabilities:
Readback Waveforms from Vintage ½” 9-track Tape



Inter-track Gap Analysis

Unprecedented Erasure Verification!

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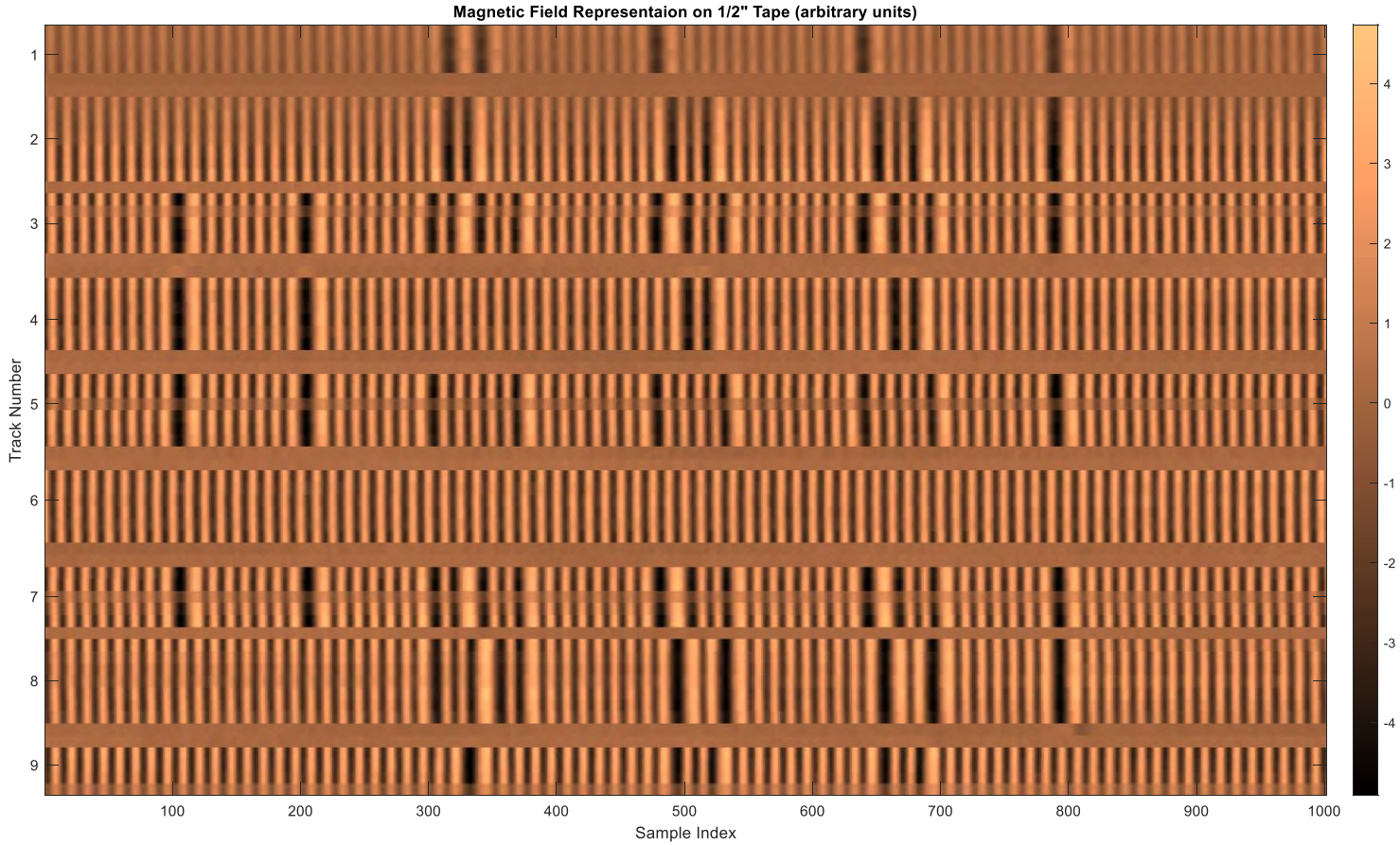
Landau Capabilities: Magnetic Force Microscope (MFM) like Resolution of Individual Magnetic Patterns



"Freeze" the Magnetic State of at-Risk Tapes

Unprecedented "Preservation Master" ("Digital Surrogate")!

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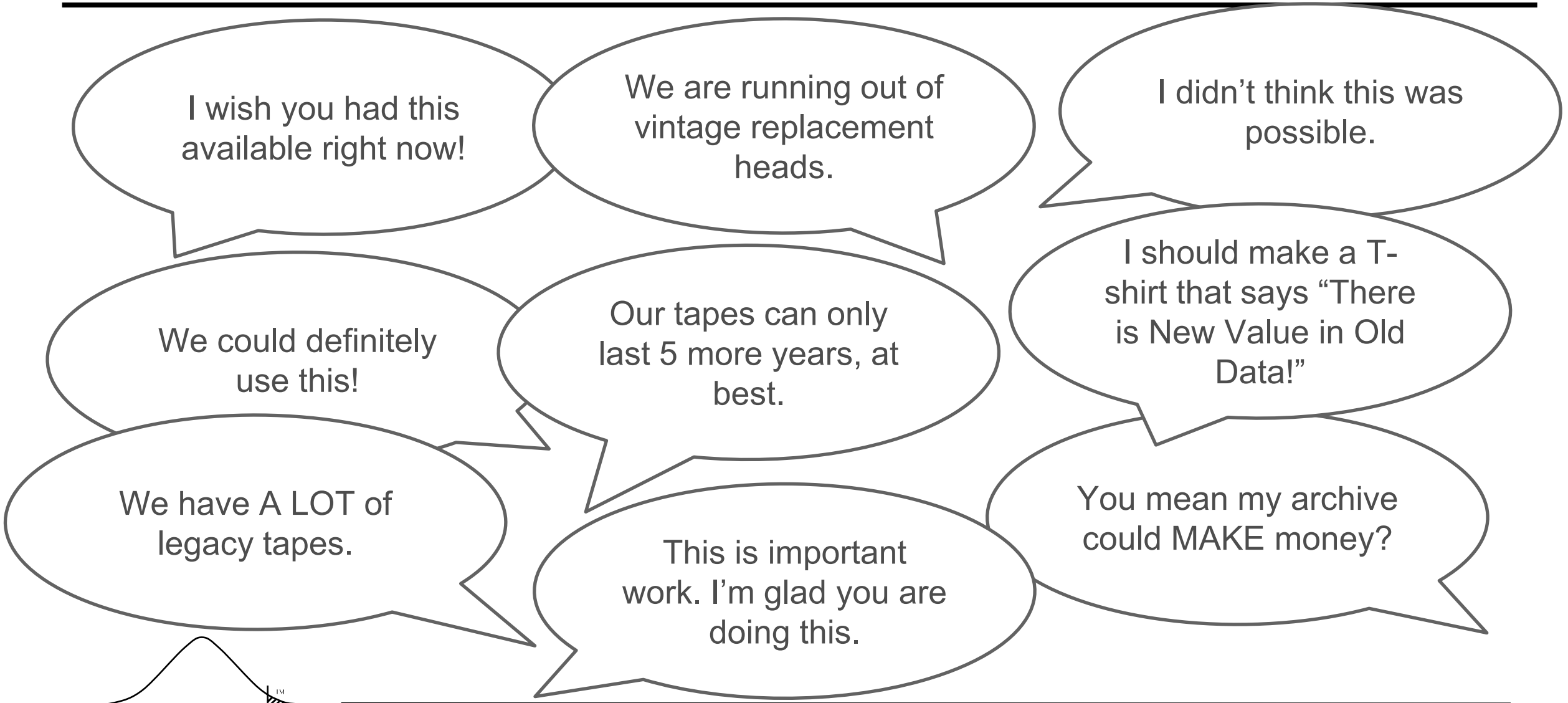
What We are Hearing in Interviews



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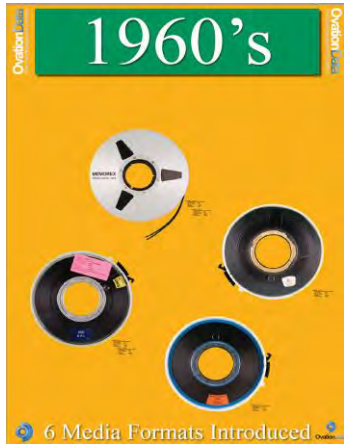
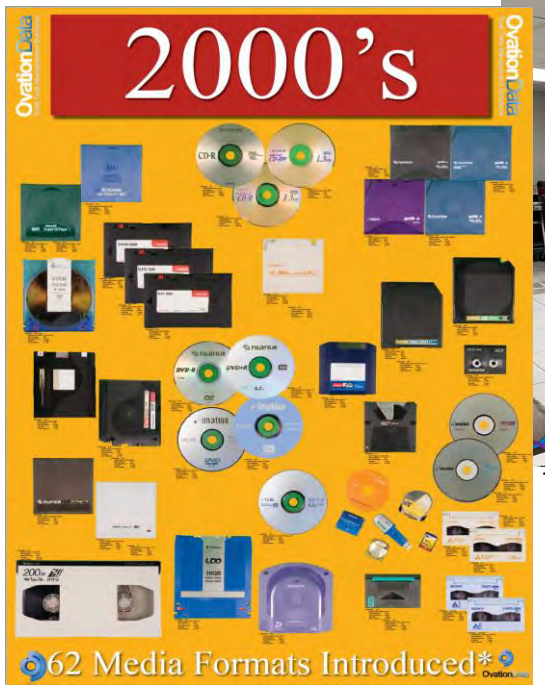
Opportunity: Recovery Market has 275+ Different Removable Formats





Tape recovery labs must keep dozens of old-format drives up and running to satisfy demand. They are working museums!

Courtesy: Ovation Data Services

Recovery of each format requires
- Refurbished drives
- Replacement heads
- Skilled technicians and operators

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Legacy Tapes Were Used Around the World!

Eastern Bloc 1” Wide Tapes

- Seismic data from nuclear tests
- Institute of Geophysical Research of Kazakhstan

Access to our technology can be used as a diplomatic tool

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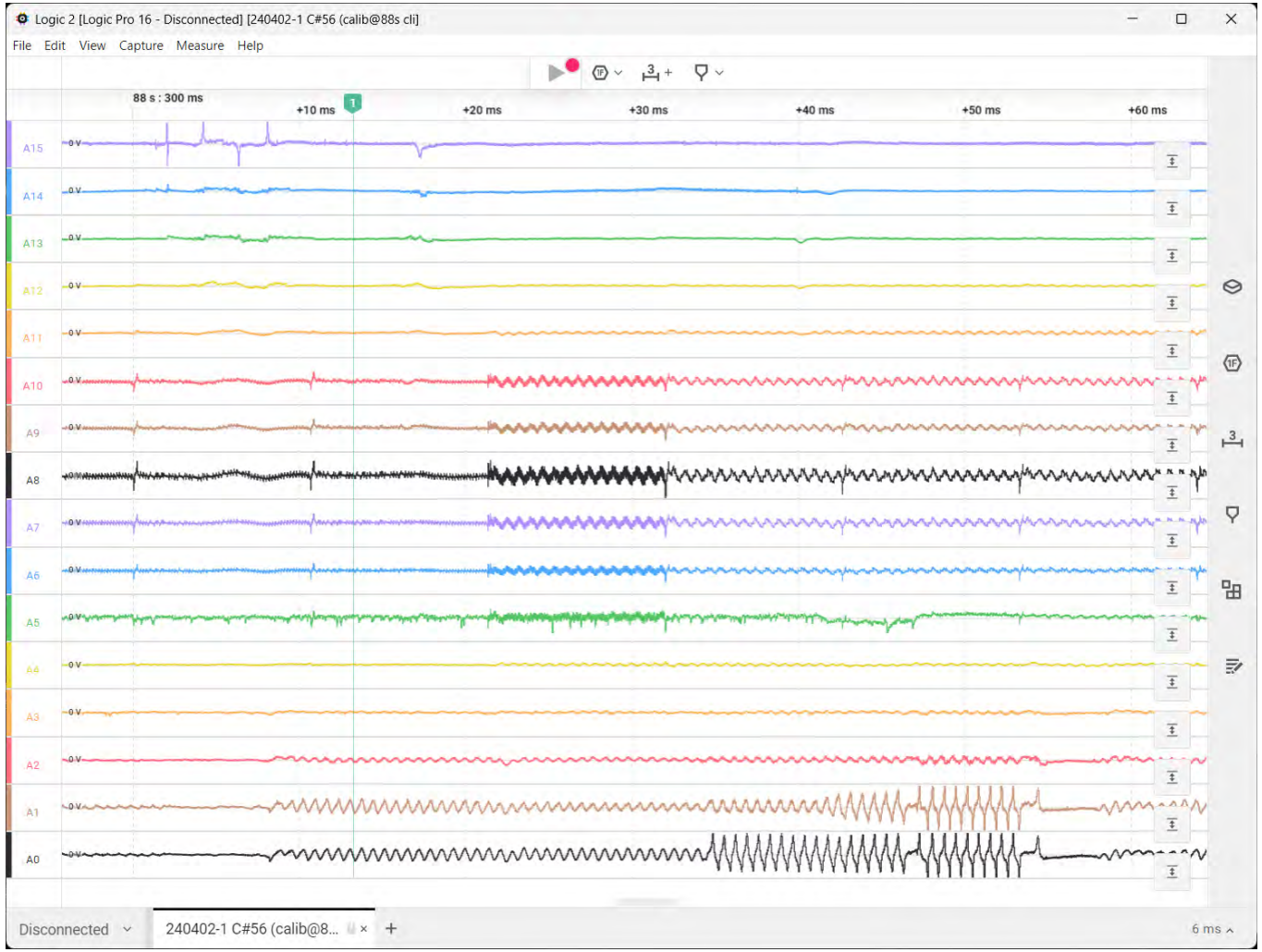
1” Analog Seismic Data
Clock Track and Sensor Calibration Signal



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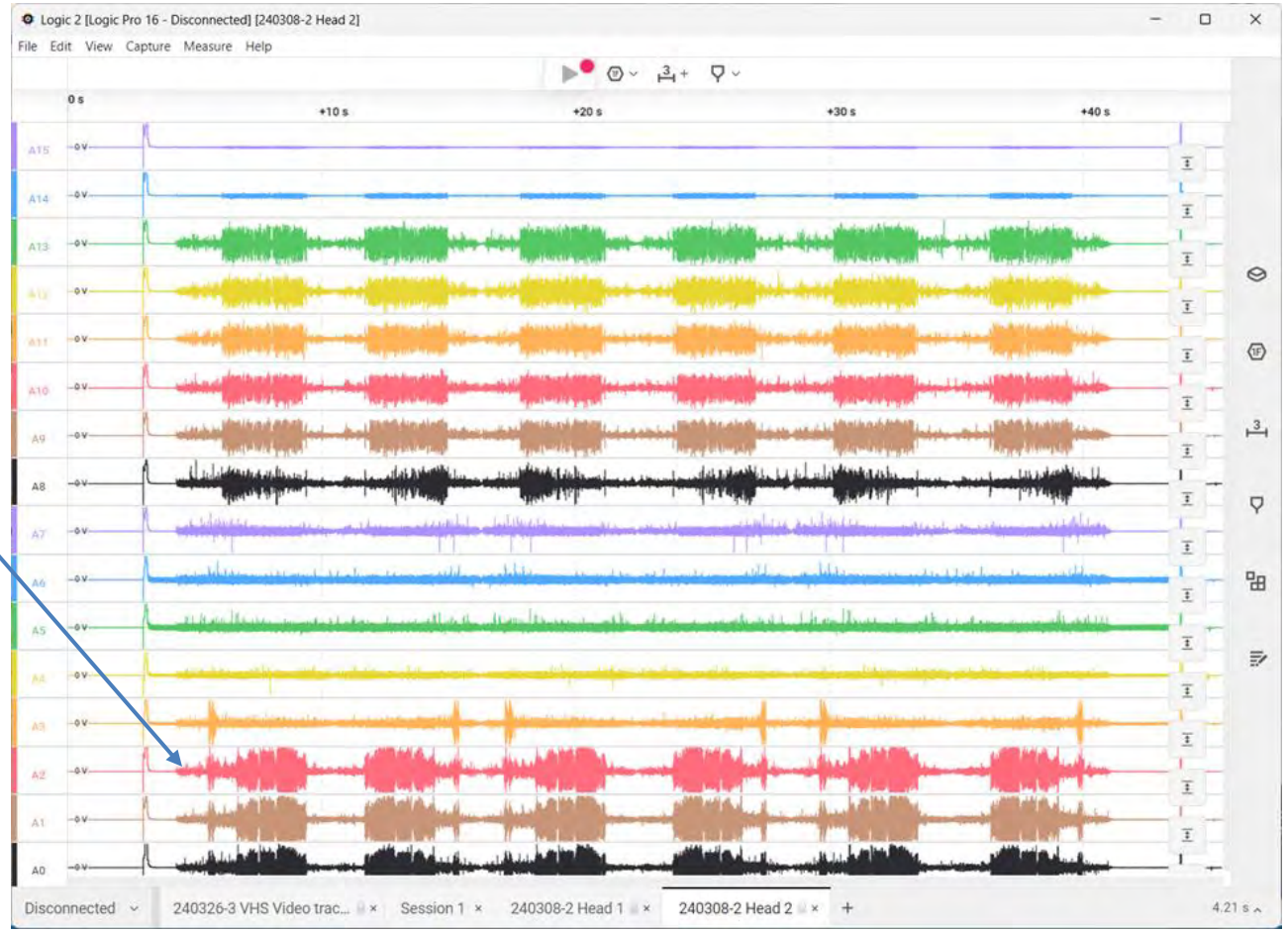
Experimenting with Audio – No Effects/Processing

¼” analog 4-track recording of unknown origin and quality – probably originally recorded off of the radio

Prairie Home Companion



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Let's Expand What is POSSIBLE for Magnetic Data Preservation

Change the Economics of Legacy Data

- Lower recovery/migration costs
- Monetize data (prepare it for AI/ML)
- Modern, robust hardware with AI-assist can address underserved markets worldwide
- Data management companies can differentiate with value-added migrations
- Legacy tapes might become a reliable part of a 3:2:1 preservation strategy

Create New Opportunities

- Sovereign AI (use access to capability as diplomatic tool)
- Digital Surrogate (Digital Twin / Preservation Master)
- Consulting to improve emerging long-term archival technologies (DNA, ceramic, …)
- Analog: Instrumentation, audio, helical scan video

Collaborations for Acceleration

- Fund new capabilities
- Define raw data formats and APIs
- Opensource projects for additional formats; Competitions
- Embed in university programs (University of North Texas)
- Technology licensing; Service partnerships
- User groups; Conferences like FMS – the Future of Memory and Storage

MVP: Modern Tape Cleaner

In addition to tape drives, vintage tape cleaners are in demand

High speed tape transport

- Variable to low speeds for delicate tapes

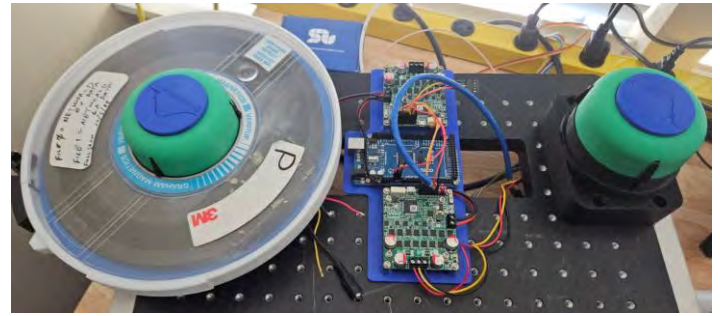
Precise, programmable tension control

- "Archival Rewind" option

Retractable ceramic burnisher

In beta testing

- Would you like to try it?



https://www.next-archive.com/product/rti-6120-cl/

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Partner with Us!

Join our Early Access Program to be the first customers in line for

- Tape Cleaners
- Digital Surrogate/Validator Systems
- Multiformat Legacy Tape Readers

https://forms.gle/UHMhtL9W2kocQX9C6

Take this survey to tell us what features your ideal tape machine would have

https://forms.gle/Rti4P55KE2xSZhG28

We are looking for pilot projects, open-source contributors, and partners

We offer consulting for developing archival technologies and policies, based on what we are learning about vintage tapes

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Appendix

The Business We are Creating

Product Offering (Business Thesis)

- *Product description: Multi-format, "do-no-harm" magnetic tape reader for legacy formats (We will sell Hardware, Software, Maintenance, and NRE/Consulting)*
- *Target customers: Tape recovery companies, National Labs, Government Agencies, eDiscovery, Digital Preservationists, Data Scientists, Data Brokers, Cloud Ingestion Service Providers, Cloud Storage and Archiving Providers*
- *Customer problems being addressed: Legacy tapes are deteriorating and are expensive to recover; Some "erased" tapes still contain proprietary data*
- *Why they would buy our solution: Faster, less-destructive, cheaper, automated, and better performing than original equipment*

Minimum Viable Product (MVP) Progression

1) Tape Cleaner; 2) "Digital Surrogate" Creator; 3) Multiformat ½" Tape Reader

TCO, Environment, Supply Chain

- Total Cost of Ownership
  - One platform to maintain
  - Amortize over multiple formats/jobs
  - Faster and more reliable recoveries
- Environmental Impact
  - Eliminate climate-controlled storage for migrated tapes
  - Utilize vintage tapes as a reliable media type in 3:2:1 preservation?
  - Recycle vintage hardware and reduce warehouse space
- Supply Chain (Shortages and Security)
  - No single-sourced component
  - Can use different generations of heads
  - Team can design around part shortages
  - Technicians and engineers work with modern technology, not 1970s tech

Commercialization

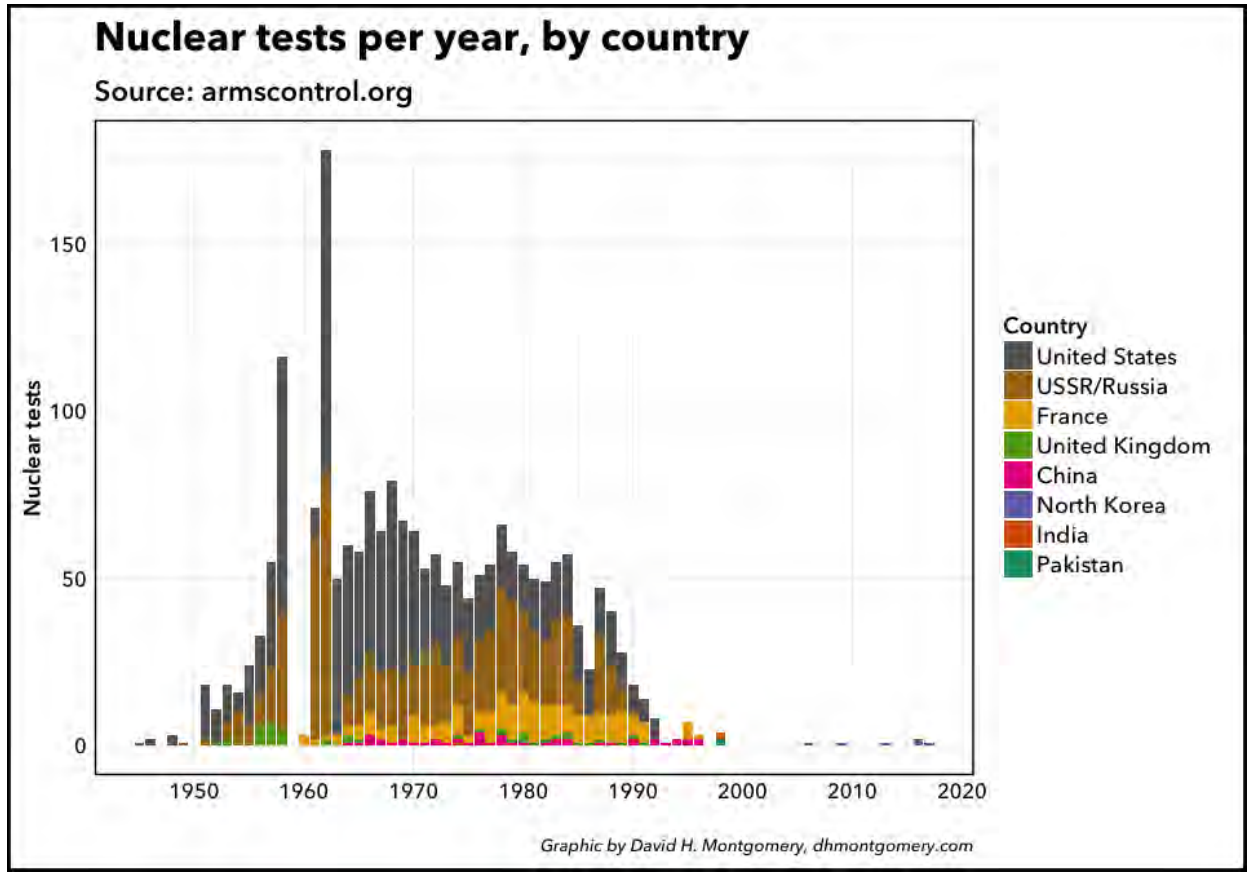
Completed Energy i-Corps program for lean startup training

Completed inaugural Phase Shift II training for commercialization

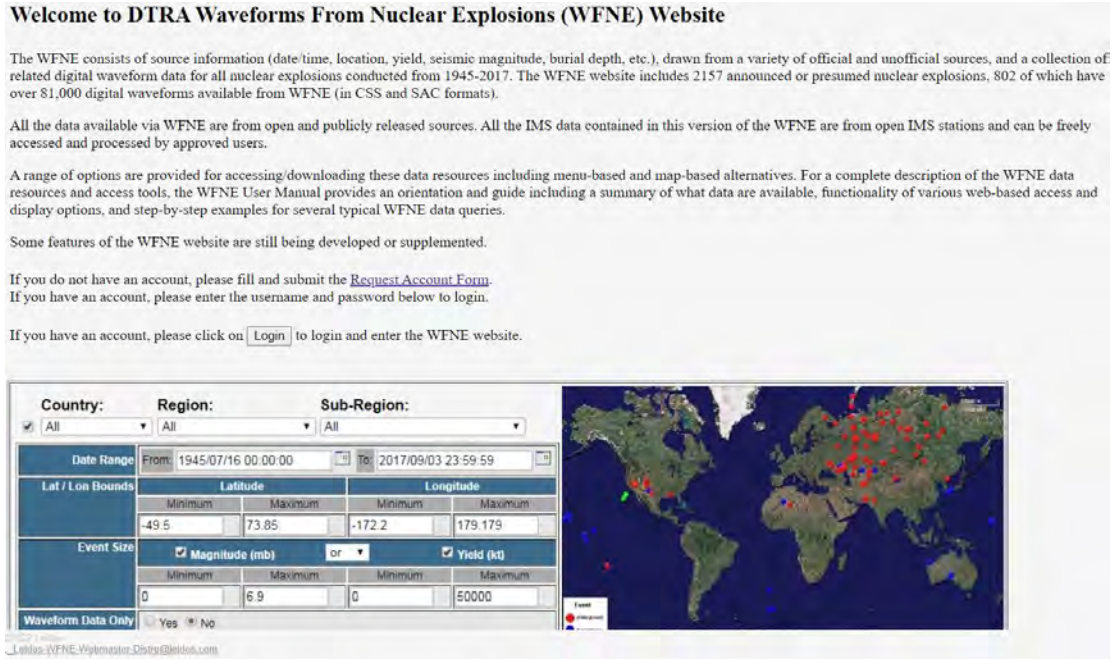
Completed over 120 interviews to test business hypotheses

Current member of Carnegie Mellon University's Project Olympus at the Swartz Center for Entrepreneurship

AI/ML: Irreproducible Scientific Data Can Now Be Analyzed Efficiently, at Scale



Number of nuclear tests per year by country from 1945 to 2017. This figure is based on publicly available data at: http://dhmontgomery.com/2018/02/nuclear-tests/



https://www.wfne.info/
https://www.ctbto.org/our-work/detecting-nuclear-tests

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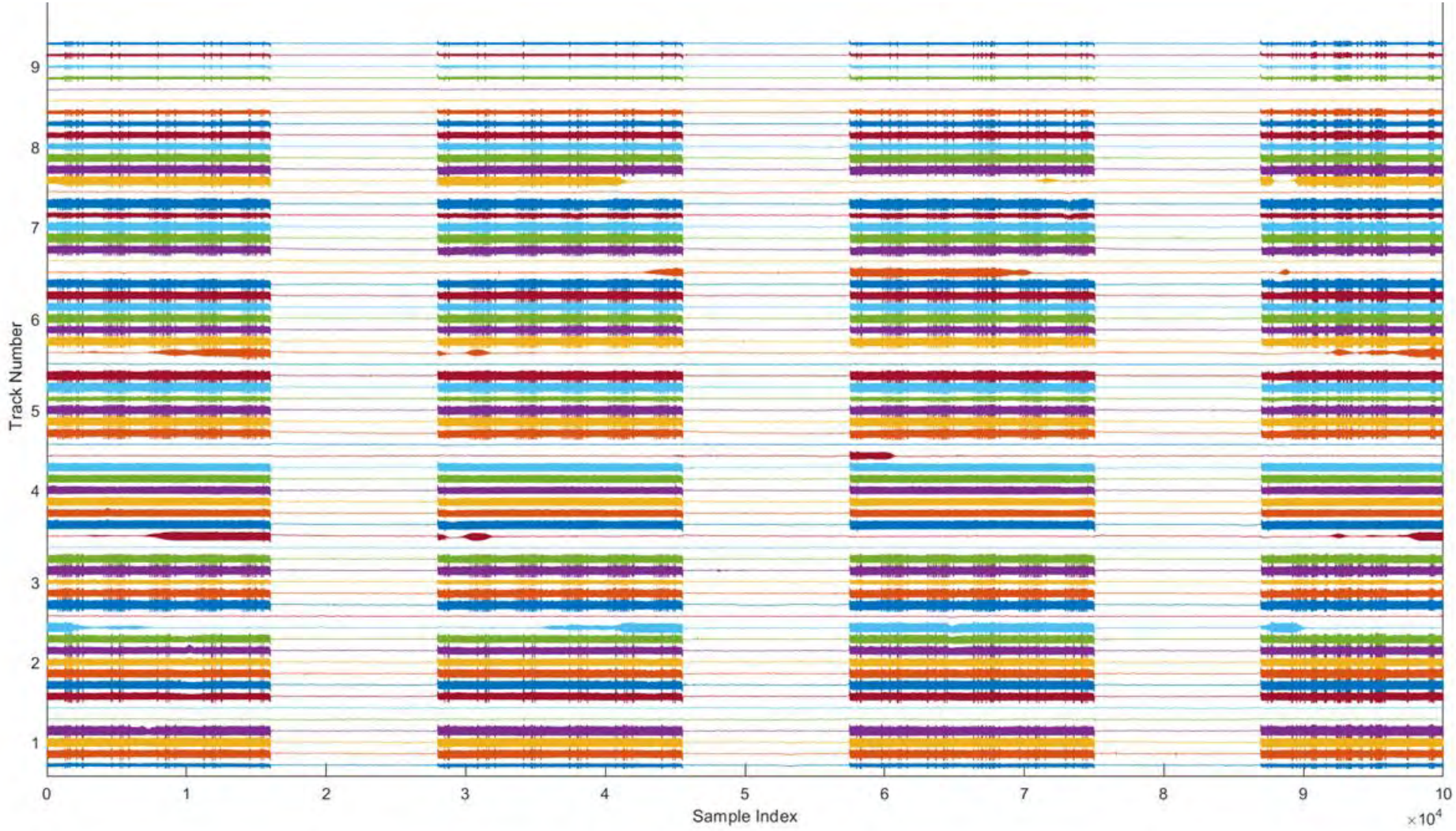
One-pass Scanning of ½” Tape



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