

Computational Methods of Signal Decoding for Recovering Recorded Data

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Computational Methods of Signal Decoding for Recovering Recorded Data



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April 14, 2004 MSST 2004, WIP Presentation

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Professional Data Recovery

- *Professional Data Recovery* is the process of obtaining usable data from downed computers and backups and corrupted or deleted file sets.
 - Very labor intensive, highly technical.
 - Usually performed in a controlled lab environment
 - Each case is unique
 - Logical and Physical methods
- Different from “Disaster Recovery”
 - Usually means retrieving data from backups

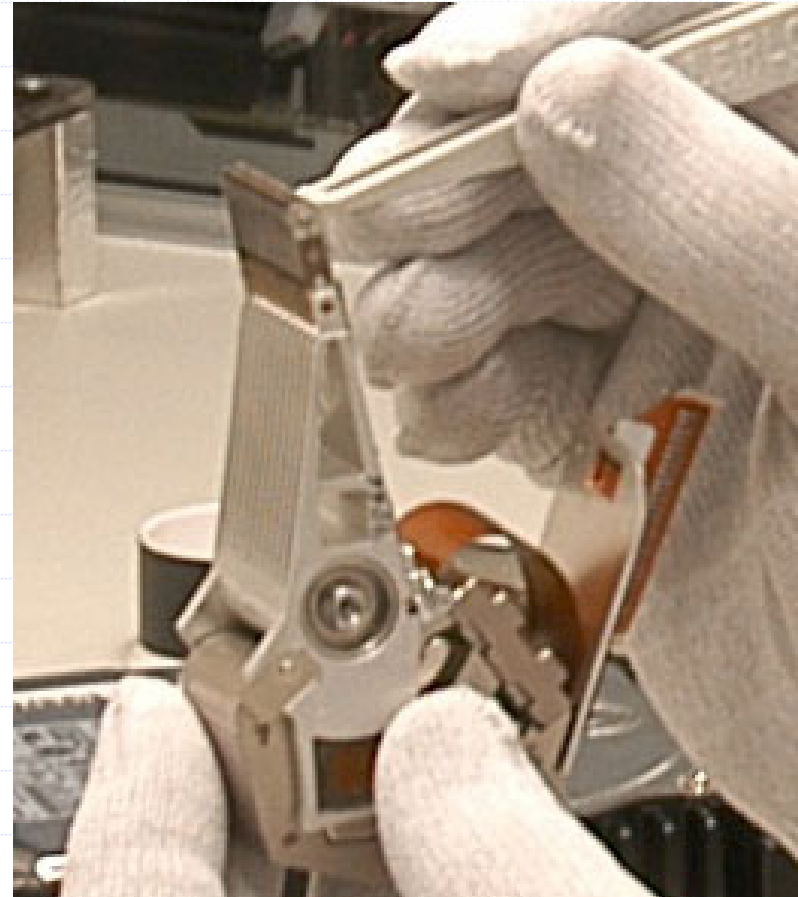
These "Disasters" Need "Data Recovery"

Damaged PCB
(Printed Circuit
Board)



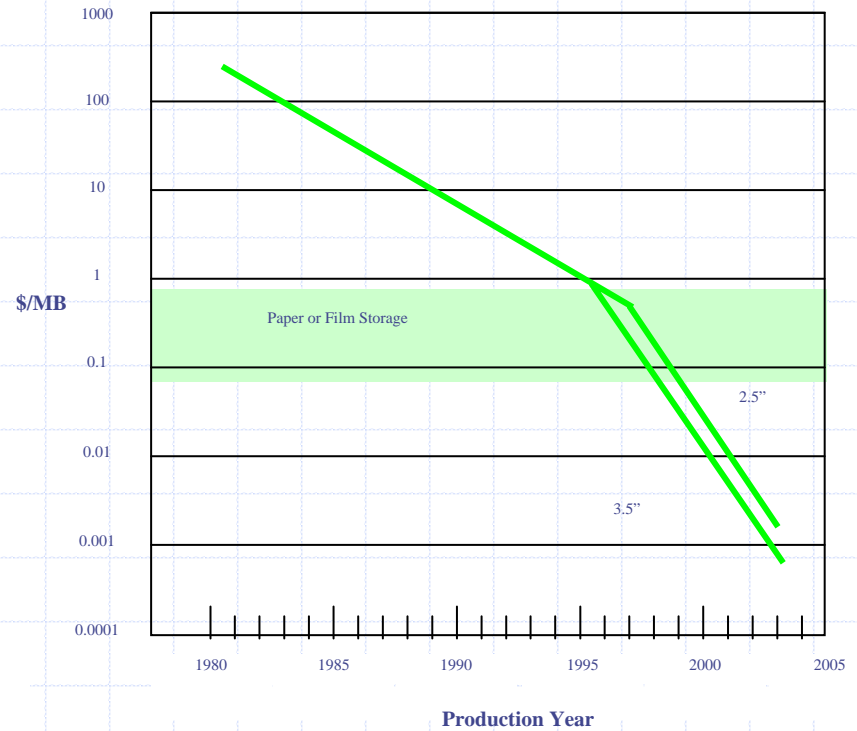
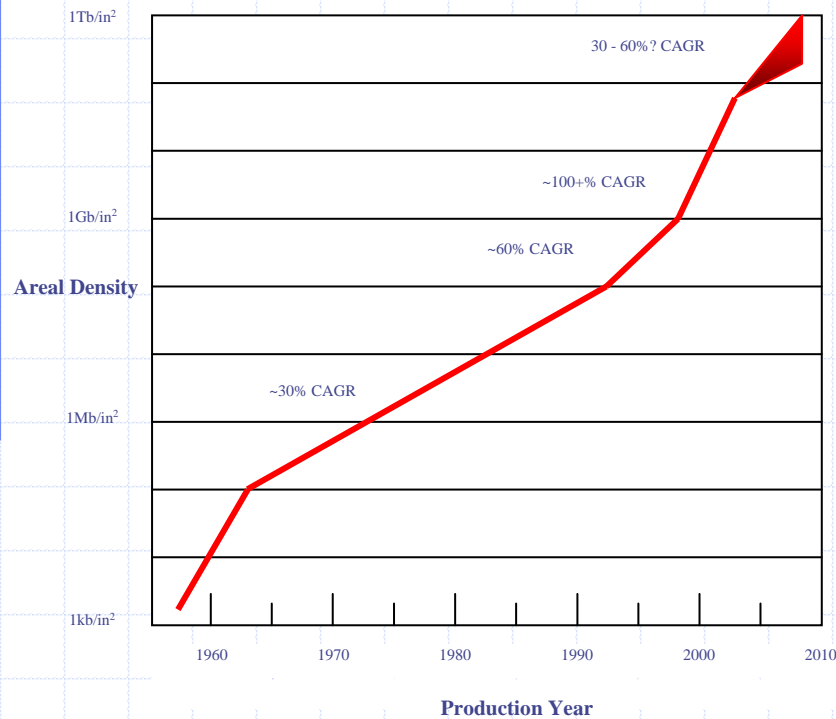
The Current State-of-the-Art Recovery Technique

- Careful part-replacement
- In a controlled environment
- Some failed drives are currently unrecoverable, ...
- Why?



High Capacity High Technology

Low Cost High Yields



Hyper-Tuned Hard Disk Drives

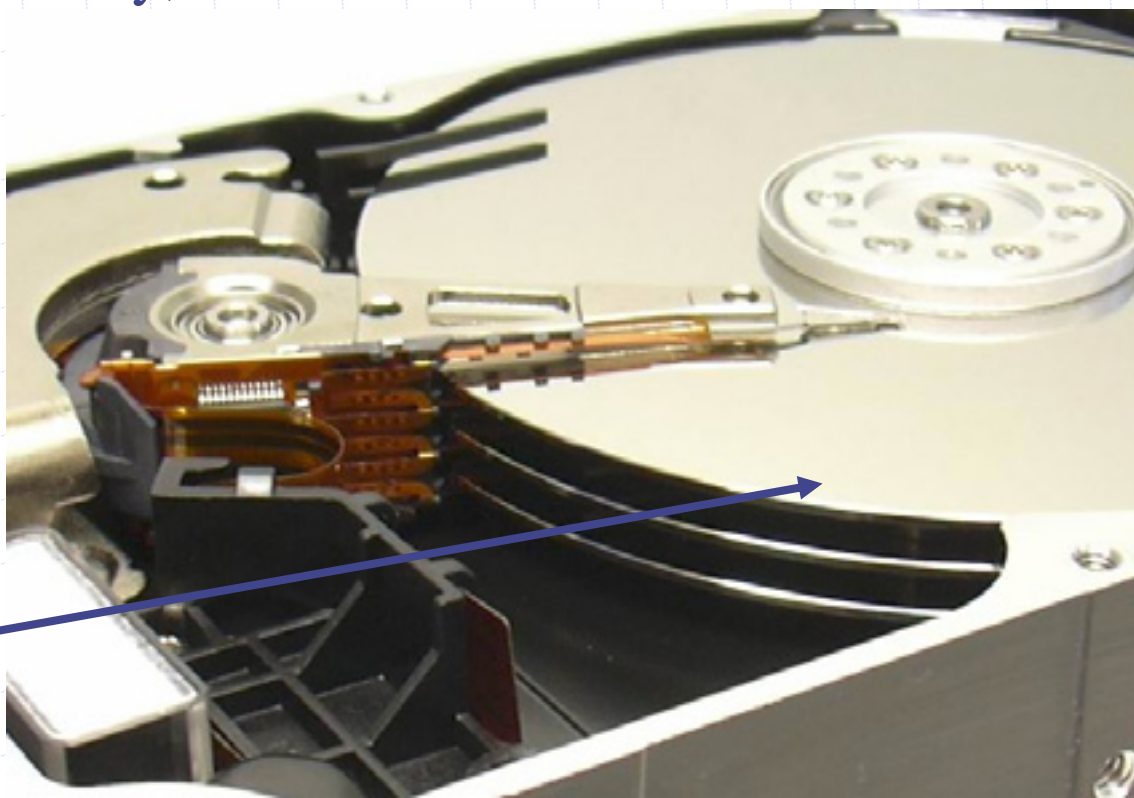
Tuned During "Burn-in" in the Manufacturing Process

Variable Parameters must be Optimized, Leading to “Hyper-Tuned” Drives

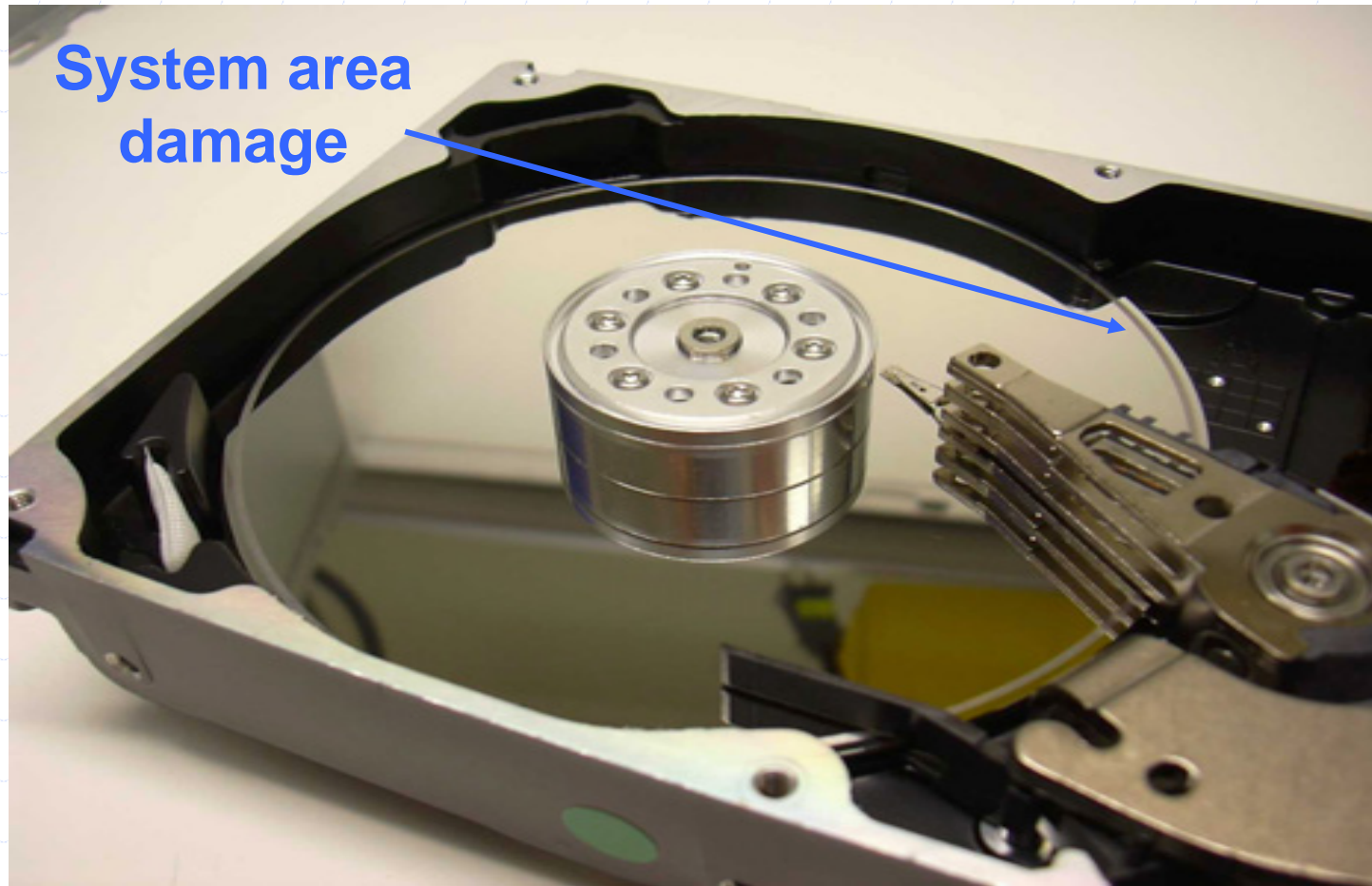
The hyper-tuned parameter settings must be stored in a non-volatile memory, **for the life of the drive**

Where?
ROM
Disk

**Typically,
Right Here!**



Now What?

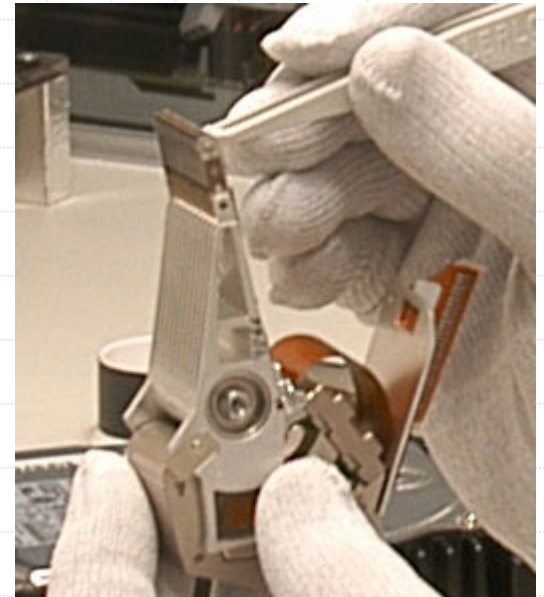


When Hyper-tuning Information is Lost, ...

- The drive might not be able to
 - Seek to a track
 - Locate a sector
 - Identify remapped defective sectors
 - Read data with sufficient raw bit error rate (before ECC correction) to provide data integrity

When Hyper-tuning Information Does Not Match the Components ...

- It is almost the same as being lost
- Current state-of-the-art in data recovery is careful part-replacement
- Head transplants can be successful, but if the tuning parameters are wrong for this new head/disk/electronics combination seeking and data integrity can fail



The Need for Drive-Independent Data Recovery

- Needed Now; plus, ...
- Trend: More hyper-tuned parameters
- Trend: Lower success rates for component repair/replacement method
- Trend: Higher density (smaller bits) leads to more rapid thermal decay of data

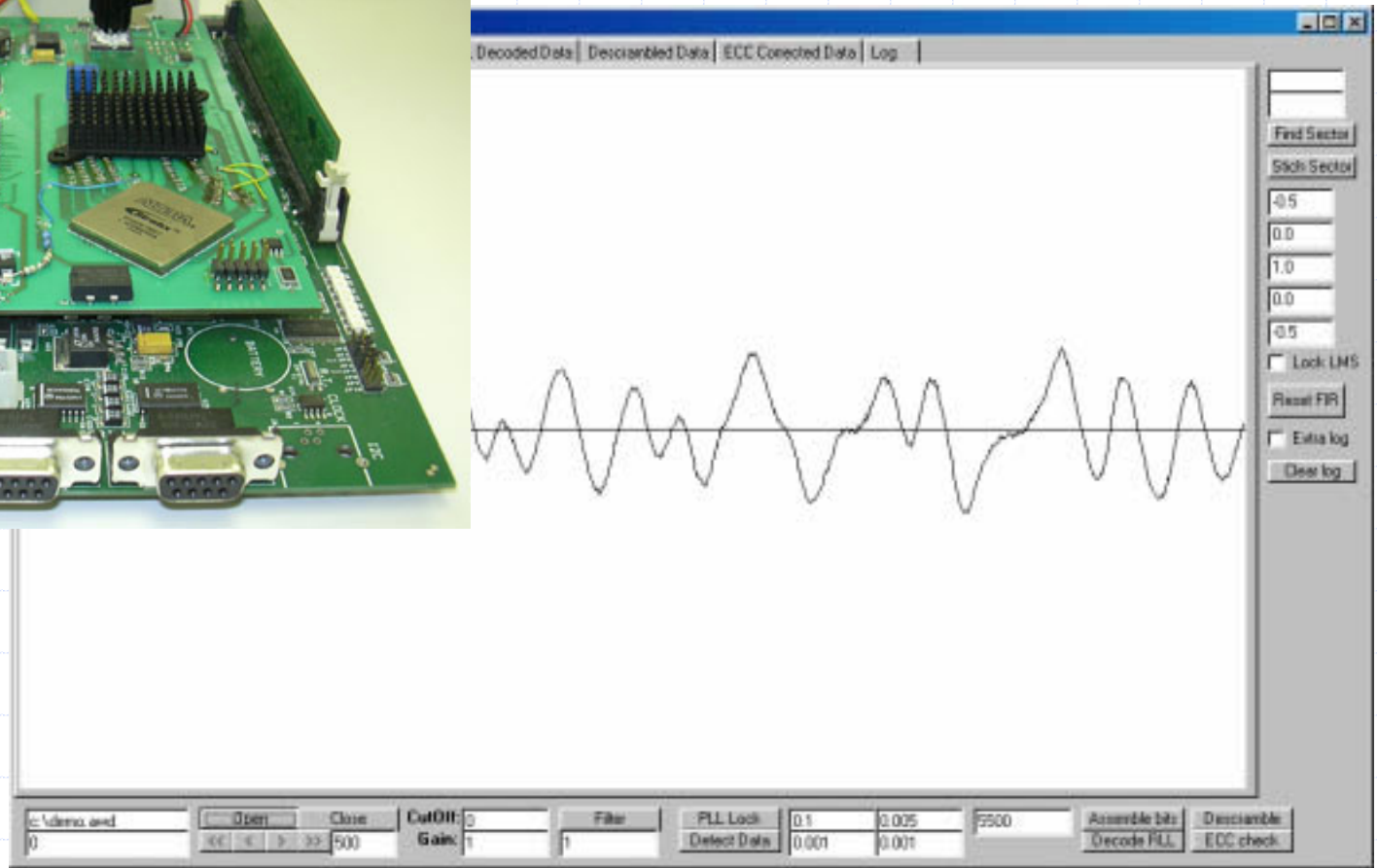
Drive-Independent Data Recovery Requirements

- Economical & timely
- Read data sectors from anywhere on disk surface
- Continually, incrementally improve to work at the lower SNRs of newer drives
- Flexible to accommodate the differences between the signal processing and coding used by each drive manufacturer, each drive model, and even each drive
- Compatible with other methods of acquiring signals from deliberately damaged disks as an aid to worldwide counter-terrorism activities of law enforcement.

Parameter Determination Through SignalTrace™ Technology

- Servo layout and pattern
- Zone table
- PRML/NPML read channel parameters
- Synchronization
- RLL codes, descrambling, and error correction codes (ECC)

ActionFront Data Recovery Labs' SignalTrace™ Prototype Implementation



Filter and Detect Data

The image displays two overlapping windows of the MSSST 2004 Demo software. The top window shows a waveform plot of a signal, with a horizontal line indicating a threshold. The bottom window shows the same data as a binary stream of 0s and 1s. The software interface includes a menu bar with options like 'Raw Signal', 'Filtered Signal', 'Detected Bits', 'PLL Codewords', 'PLL Decoded Data', 'Decompressed Data', 'ECC Corrected Data', and 'Log'. A 'Find Sector' button is visible in the top right of the top window. The bottom window has a 'Find Sector' button and a 'Raw Sectors' list on the right side. The bottom status bar shows various parameters: 'CutOff: 550000', 'File: 1', 'PLL Lock: 0.1', 'Dected Data: 0.001', '0.001', '500', 'Available bits: Decode PLL', and 'ECC correct'.

Decode the Recording Code, Descramble the Data, and Make ECC Corrections

The screenshot displays the MSST 2004 software interface, which is used for data recovery. The main window is titled "MSST 2004 Data" and shows a grid of data with columns labeled "Raw Signal", "Filtered Signal", "Detected Bits", "PLL Codewords", "PLL Decoded Data", "Descrambled Data", and "ECC Corrected Data". The "Detected Bits" column contains hexadecimal values, and the "PLL Decoded Data" column contains the text "123456789ABCDEF". The "Descrambled Data" column contains the text "This drive has been prepared for the first public demonstration of the ActionPro at Data Recovery Lab's Signalrac technology at the 2004 IEEE NSR Maxx Storage Systems and Technologies Conference...". The "ECC Corrected Data" column contains the text "1234567890...".

The interface also includes a "Connected Data Log" window on the right, which shows a list of data blocks with their addresses and sizes. The "Data Log" window has a search bar and a "Find Sector" button. The "Data Log" window also has a "Lock LMS" checkbox and a "Reset FPI" button.

The bottom of the interface has a status bar with the following information: "c:\data.pwd", "Open", "Data", "CutOff: 66000000", "Filter", "PLL Lock: 0.1 0.005 9500", "Assemble bits", "Descramble", "G4005", "1 1 3 3 500", "Gain: 1", "Detect Data: 0.001 0.001", "Decode PLL", "Data Log".

Successful Drive-Independent Recovery Using SignalTrace™

The screenshot displays the SignalTrace software interface, titled "M55T2004 Demo". The main window shows a hex dump of data with the following columns: Raw Signal, Filtered Signal, Detected Bits, PLL Codewords, PLL Decoded Data, Descrambled Data, and ECC Corrected Data. The data is organized into rows with hexadecimal addresses (e.g., 00 11 22 33) and corresponding hex values. The decoded data column contains the following text:

```

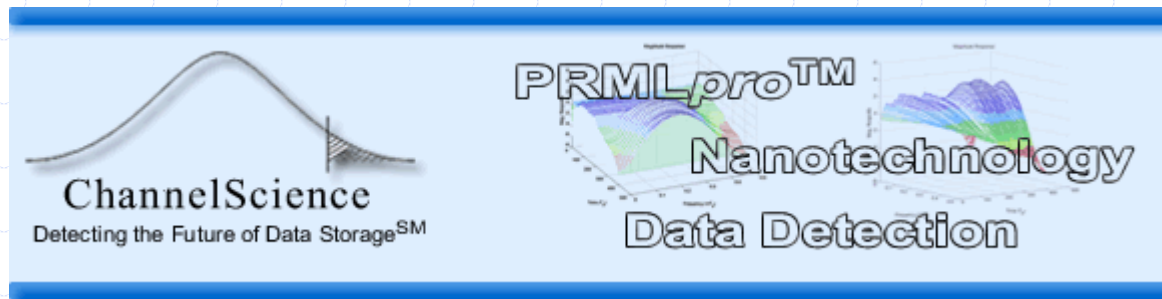
M123456789ABCDEF
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: jkl;"zxcvbnm.../.
: .....
: Drive # 1.....
: .....
: .....
: LBA 000002632134
: ..x..G/.Rtt5....
: ..8Y
  
```

At the bottom of the interface, there are several control panels:

- File Panel:** Includes "Open", "Close", "CutOff" (set to 6000000), "Filter", "Gain" (set to 1), and "File" buttons.
- PLL Lock Panel:** Includes "PLL Lock" (set to 0.1), "Detect Data" (set to 0.001), and "ECC check" buttons.
- Assembly Panel:** Includes "Assemble bits" and "Decode PLL" buttons.
- Navigation Panel:** Includes "Find Sector" (set to 40), "Skip Sector" (set to 50), "Reset FIR", "Extra log", and "Clear log" buttons.

A New White Paper Now Available: *Recovering Unrecoverable Data*

- ChannelScience (www.ChannelScience.com) white paper, commissioned by ActionFront



- Provides a rare overview of data recovery techniques, identifies the need for drive-independent data recovery, and describes the results obtained with the prototype SignalTrace™ system.

ActionFront Data Recovery Labs

The SignalTrace™ prototype is the only solution known to-date, that can recover data from (previously) un-recoverable media.

We invite you to see a demonstration of SignalTrace™ and preview the white paper at the ActionFront booth.



Recovering Unrecoverable Data

The Need for Drive-Independent Recovery



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Data Recovery Methodology from Damaged Drives

- Logical recovery from corruption or deletion & formatting errors.
- Physical external recoveries:
 - Swapping firmware
- Physical internal recoveries:
 - Repair/replace components in HDA
 - Most difficult

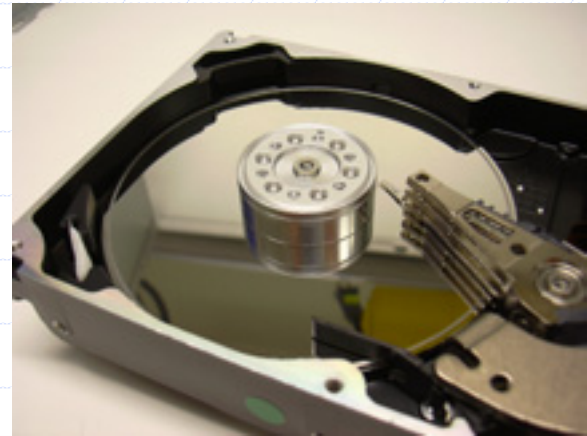
Some damaged drives are currently
un-recoverable.

Hyper-tuning is a Proprietary Process for Each Manufacturer

- Currently there is no universal way to trigger a re-optimization of parameters in the field
- Even if there were, the parameters must be optimized for the currently written data – not for the data written by transplanted heads
- This includes bpi/tpi information (adaptive formatting) and recording code used

Some Damaged Drives Currently Un-Recoverable.

- Head crash on park zone:
 - Severe damage but not to actual data.
 - Good chance for recovery.
- Head crash affecting track 0 and data zone:
 - Even slight damage in data zone means lower chance for recovery.
 - This area also contains larger firmware programs used by the drive to control itself after spin-up.



Fixed Parameters Become Variable

Achieving high manufacturing yields, combined with high capacity, requires the head, medium, and electronics – and how they interact – to be precisely matched.

For example,

- Data rate (bpi) varies as a function of radius

- Magnetic spacing *ceases* to vary with radius

- Sector location varies with defect

- Write current

- Read bias current

- PRML/NPML Read Channel Parameters

- Recording code

- Adaptive formatting (bpi/tpi optimization)

... and how these parameters change over time, ...