Technical Objectives

• Evaluate possibility of an Archival drive capable of 10 year operation & storage
Longevity of the Storage Device

Key Technical Issues

• Drive Lifetime
  – Thermal Stability
  – HDI Reliability (css, stiction, tribology)
  – Lubricant Lifetimes
  – Corrosion (media, internal parts)
  – Head( Reader ) Lifetime
  – Electronics/PCBA Lifetime

• Handling/Transportability
  – Non-Op Shock
  – Op Shock & vibration
  – Weight
Usage Model & Environment for 10-Yr Life

• Usage Model
  – MAID system to reduce power consumption
  – Power on approx. 12X/day for duration of 2-3 minutes, otherwise powered off

• Environment Expected
  – Temperature Range: 20-35°C
  – Relative Humidity Range: 20-60%
  – Handling: gentle; install once & leave in system for entire life
Thermal Stability Modeling

RMO Model for Longitudinal Media Stability, applied to Tonka2 media with Archival conditions

**NOTE that even 100 years for Cases C & D degrade BER by less than 0.5 decades !!**

- **Case A:** 50°C disk temp, 100% duty cycle (always on)
- **Case B:** 26°C disk temp, 100% duty cycle (always on)
- **Case C:** 26°C disk temp, 2% duty cycle
- **Case D:** 26°C disk temp, 0.3% duty cycle
Analysis of 10 yr Archive

• HDI Reliability, Long-Term
  – Contact Stop Starts:
    • Max number of css would not exceed 50kcss in 10-year life of archival drive.
    • This is normal spec limit for drives, so probably not a reliability risk.
    • Archival tape specs for css-equivalent much smaller: (load/unloads of the cartridge into the drive) of 20k (LTO-3) and 30k (SAIT-1)
  – Stiction:
    • Risk of unknown magnitude if the drives are shut OFF for extended periods
    • If the drive is stored in power off condition for years at a time, we have no data on the stiction risk. It is probably significant.
    • Solution requires drive to be powered on an regular intervals
• Drive Longevity
  – Corrosion and Lube Puddling
  • The relative humidity inside the drive is ideally held in the range of 20% to 60%. Environments encountered could have humidity as high as 80% for limited times (up to approx. 3 months)
  • Studies show that HDD by itself will readily exceed 60% RH when in a 35C/80% environment.
  • For long-time storage, all the underground facilities (such as Iron Mountain) have rooms with virtually any temperature and humidity desired, from <0°C to >40°C and 0% ≤ RH ≤ 80%. Hard drives could be specified to be stored in low temp and RH<60%
Evaporation is a function of Lube Vapor Pressure

- **Spin Motor Lubricant**
  - Hydrocarbon Ester
  - Vapor Pressure: $2.8 \times 10^{-6}$ mmHg

- **Actuator Pivot Lubricant**
  - Hydrocarbon Grease
  - Vapor Pressure: $5 \times 10^{-8}$ mmHg

- **Disc Lubricant**
  - Perfluoropolyether
  - Vapor Pressure: $2 \times 10^{-8}$ mmHg

- **Evaporation rate of lube doubles every 10°C, so for two temperatures it goes like:** $2^{(T_2-T_1)/10}$

- Hence, if $T_1 \sim 65°C$ (normal hdd specs) and $T_2 \sim 35°C$ (archival drive spec) then

- Relative lube evaporation rate of archival drive is $\sim 2^{-3} = 1/8$ as fast, implies 8X lifetime

- 8X lifetime would mean 40 years instead of 5 yrs
Interim Technical Conclusions

- **Thermal decay** will be less than 0.2 decades of BER degradation & is therefore within the limits of BER loss.
- **Lubricants/Oils** are well within evaporation limits.
- **Drive** must be maintained in an environment with controlled humidity.
- **Maximum number of CSS in 10-year life** does not exceed normal spec limit.
- **Stiction risk** exists, if drive is stored in power-off state for years at a time.
- **Shock & handling** may be an issue.
On the other hand

- Not clear that drive life is the right way to attack the problem of longevity
  - If a drive is used for 10 years, it will last through 2-4 generations
  - Power, floor space would probably be more valuable after 5 years
  - Drives already designed to last 5 years
  - Assume areal density CAGR of 27%

<table>
<thead>
<tr>
<th>Capacity</th>
<th>30 GB</th>
<th>200 GB</th>
<th>500 GB</th>
<th>2 TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: while designing drives for longer life is technically feasible, it won’t happen; too much of the market gets more benefit from regular transitions to newer technology.