Autonomous Drive Regeneration
Challenges, Opportunities & Best Practices
Autonomous Drive Regeneration

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Increasing storage capacity requires more components inside storage devices, HDDs or SSDs alike.

OPEN POSSIBILITIES.
What Happens with More Components?

Every head represents a smaller portion of drive capacity

More heads increase probability that at least one head encounters challenges (everything else equal)

Number of Heads: \( N \)

\[
\text{Prob.\{Single Head Issue\}} = p \\
\text{Prob.\{Single Head Healthy\}} = 1 - p \\
\text{Prob.\{All Heads Are Healthy\}} = (1 - p)^N
\]

With more heads, if the entire device is treated as a failure, due to a single head issue:
not only would it occur at a higher rate
but also discard more remaining capacity

OPEN POSSIBILITIES.
What Happens to Device Failures?

*Swapped*  
*Crushed*

**Hold Your Horses!**

70% of datacenter failures are caused by human errors per Uptime Institute. Crushed HDDs is a significant portion of global e-waste per International Solid Waste Association.

**OPEN POSSIBILITIES.**
Technical Solution to Assist with Deployment Robustness

Exos CORVAULT finds a way to minimize human intervention and reduce e-waste

Self-Healing
Autonomous Drive Regeneration (ADR)

Samsung SSDs implemented Fail-in-Place to address similar issues
CORVAULT Implementation of Autonomous Drive Regeneration

Reducing e-waste, increasing Sustainability

1. Drive alerts controller of issues
2. Controller offloads data to other drives and removes drive from logical volume
3. Drive & controller diagnose incidents and regenerate drive
4. Volume is rebalanced with renewed drive

Maximize Sustainability
CORVAULT self-healing capability (ADR) enable drives to continue functioning in-system when other systems require HDD return and replacement

OPEN POSSIBILITIES.
How Drives Support ADR?

Feature Set in **T10 & T13** Standards
- **Storage Element Depopulation**
- Collaboration of all major storage device suppliers

Command Set
- **REMOVE ELEMENT AND TRUNCATE**
- **RESTORE ELEMENTS AND REBUILD**

**OPEN POSSIBILITIES.**
Sustainability: A Clear Industry Trend

**aws** Sustainability in the Cloud

**DELL Technologies** Sustainability Lifecycle

**FACEBOOK** Building and Operating Sustainable Data Centers

**Google** Once is Never Enough

**HP Enterprise** Upcycling for the Bottom Line

**Microsoft** Circular Centers to Help Achieve Zero Waste

**INEMI** Value Recovery Per HDD Life Cycle

OPEN POSSIBILITIES.
TCO Benefits

Direct TCO benefits can be achieved with ADR
- TCO modeling on a 100EB system in two different modus operandi for two boundary conditions
  - On-site staff swapping drives ASAP
  - Unmanned system with drives kept in slots permanently

YMWV – TCO modeling requires numerous assumptions specific to systems

Key Message – TCO savings are achievable with ADR
A Snapshot of Field Returns

Among drives with true issues:

56% could be good ADR candidates

- No Issues with drive (no ADR necessary)
- Minor issues with single head (> 70% ADR success)
- Single head errors with mild signs on second head (20-70% ADR success)
- Single head severe errors with minor issues on second or more heads, or drive DNR (< 20% ADR success)
- Hard errors on multiple heads, or hardware issues (< 5% ADR success)
Interested to Implement ADR?

- `--showPhysicalElementStatus` to inquire drive for health status on each element (head)

- `--removePhysicalElement x` to depopulate element $x$ (head $x$)

- `--repopulateElements` to repopulate all elements (heads) with best attempt

We Are Here to Help!

Open Possibilities.
A Glimpse of Future Directions

Recording industry has been well aligned to support Storage Element Depopulation

Efforts are being made to ease implementation in storage systems
Can we expedite the process?

• Make background format optional
  – Handshake with hosts

Can we further simplify the process?
• Maintain data validity on heads not depopulated
  – How much would this help you?
Call to Action

- Treating a drive as failure due to single head issues has become less prudent and more costly in recent product generations
- Autonomous Drive Regeneration, supported by Storage Element Depopulation feature, enables recovery from issues associated with single heads (majority of drive returns) to allow continued usage
- By avoiding unnecessary swaps, benefits from ADR include less human intervention, reduced e-waste and direct reduction of TCO
- We promote wide adoption of Autonomous Drive Regeneration
- This is the time to let the industry know how you need the Storage Element Depopulation feature to be further enhanced
Open Discussion