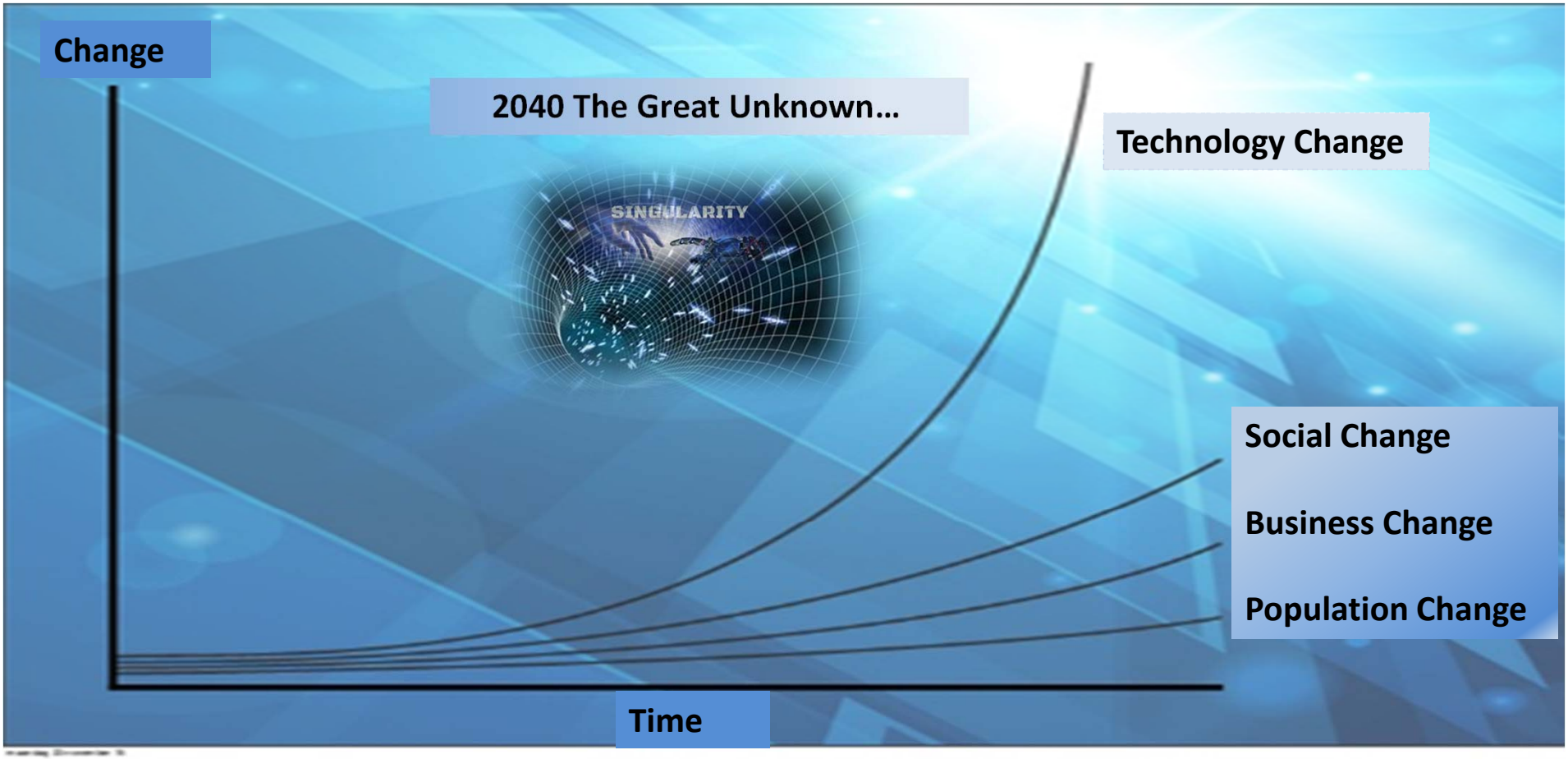
STORAGE OUTLOOK

Fujifilm 10th Annual Global IT Executive Summit
Sept. 19-22, 2018 Chicago

Fred Moore
President
Horison Information Strategies
Horison.com

Waves of Change



Digital Data Transformation

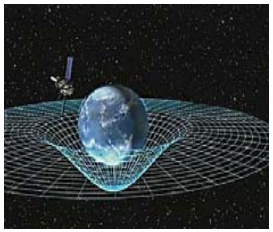
- **Constantly Pushing Compute, Bandwidth and Storage Architecture Limits.**
- **Data Protection Requirements Soar as Data Value Increases.**
- **New Formats and Architectures Needed as Storage Density Increases.**

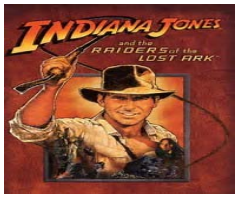
New Data

Traditional Data

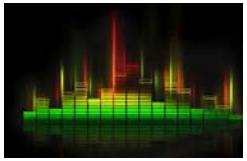
Hi-Res: 3D
50+ GB / object

4D..
Motion Vector:
100's GB/capsule





Video:
5 GB / movie



Audio:
5 MB / song

```
58674322
98323456
20419335
49567053
```

Numbers:
5 KB / record

The quick brown fox jumped over the lazy brown dog.

Text:
500 KB / record

Images: 2D
2 MB / picture

Three Storage Access Modes

Block	File	Object
Specific location on disks / memory	Specific folder in fixed logical order	Flexible container size
Tracks	File path	Data and Metadata
Sectors	File name	Unique ID
	Date	

Source: Horison, Inc.

IT Performance Gap Grows

Computing and I/O Speeds *Diverge*

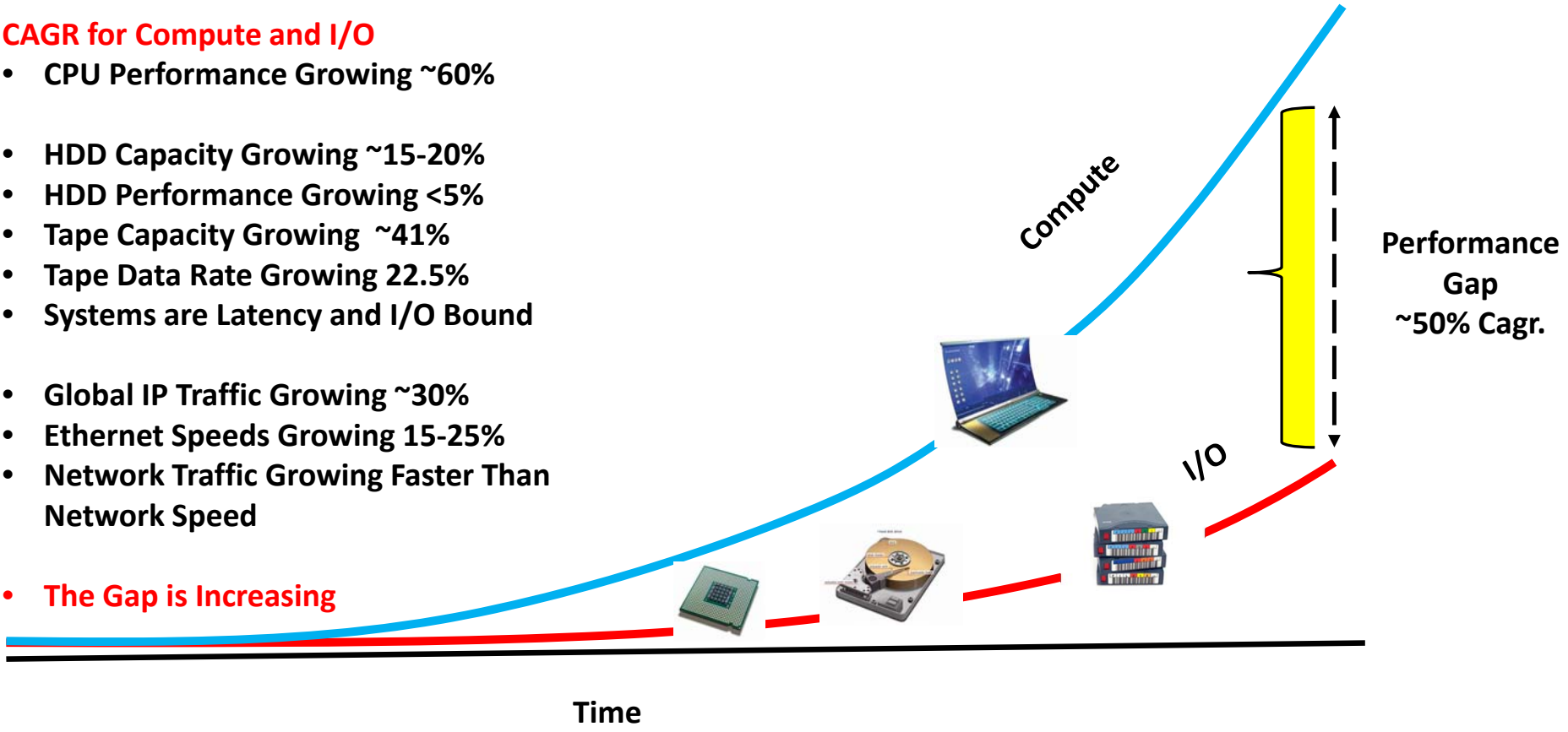
CAGR for Compute and I/O

- CPU Performance Growing ~60%

- HDD Capacity Growing ~15-20%
- HDD Performance Growing <5%
- Tape Capacity Growing ~41%
- Tape Data Rate Growing 22.5%
- Systems are Latency and I/O Bound

- Global IP Traffic Growing ~30%
- Ethernet Speeds Growing 15-25%
- Network Traffic Growing Faster Than Network Speed

- The Gap is Increasing



Source: Horison, Inc.

Storage Outlook
2018 - 2020

HDDs

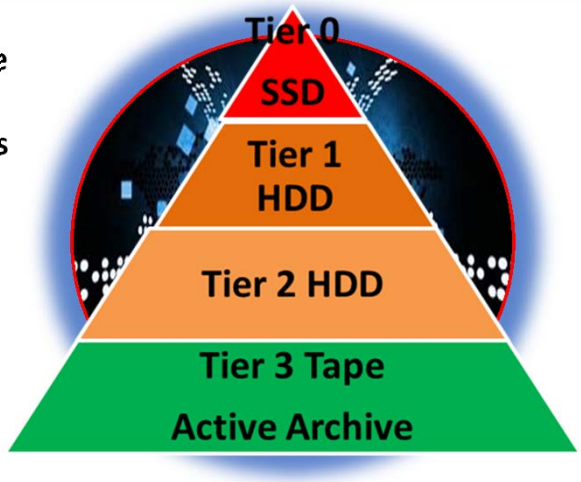
- Areal Density and Performance Are Extremely Difficult to Increase.
- Can Only Add More Helium Filled Disks Now Reaching 14 Tb in 3.5".
- Hamr to Arrive In 2018 (Seagate).
- Mamr (Microwave Assisted Magnetic Reversal WD) - 2019.
- Much Pressure On Roadmap.

Tape

- Capacity Shipped Up 12% In 2017 (LTO).
- New Focus on Performance, Access Time and Faster Robotics.
- Plays Key Roles for Cybercrime, Archival, DR And Big Data.
- Unlimited Density/Capacity Potential.
- Well-defined Roadmaps For 10+ Years.

Holographic disc, Glass disc, Atoms, DNA, Quantum Computing…

- Years Away for Data Center Usage.



IoT

- Market Is Here - $772B In 2018, IPTV.

Ransomware

- Protection Will Be Added to More Backup Software.

Object Storage

- Has Had Less Overall Impact Than Expected.
- S3 Will Continue To Attract Cloud Users.

SSD (Memories and Flash)

- Continued Very Strong Demand.
- Impact On HDD Sales (50x Faster Than HDD).
- Price to Go Down This Year With New Fabs.
- Massive Move From 2D To 3D NAND, Then 3D Xpoint (~500x Faster Than Flash).
- AFA's Dominate Growth, NVMe Boosts Perf.

Artificial Intelligence (AI), Machine Learning (ML)

- Storage Management - Predictive Analytics.
- Getting Much Smarter, Recommend Actions
- Control Operations, Manage Tiered Storage.
- Will Enable "Edge Storage" Solutions.

Cloud Market Surge – But What's After Cloud?

- Expected to Reach $97.4 Billion by 2022.
- CAGR of 24.8%.

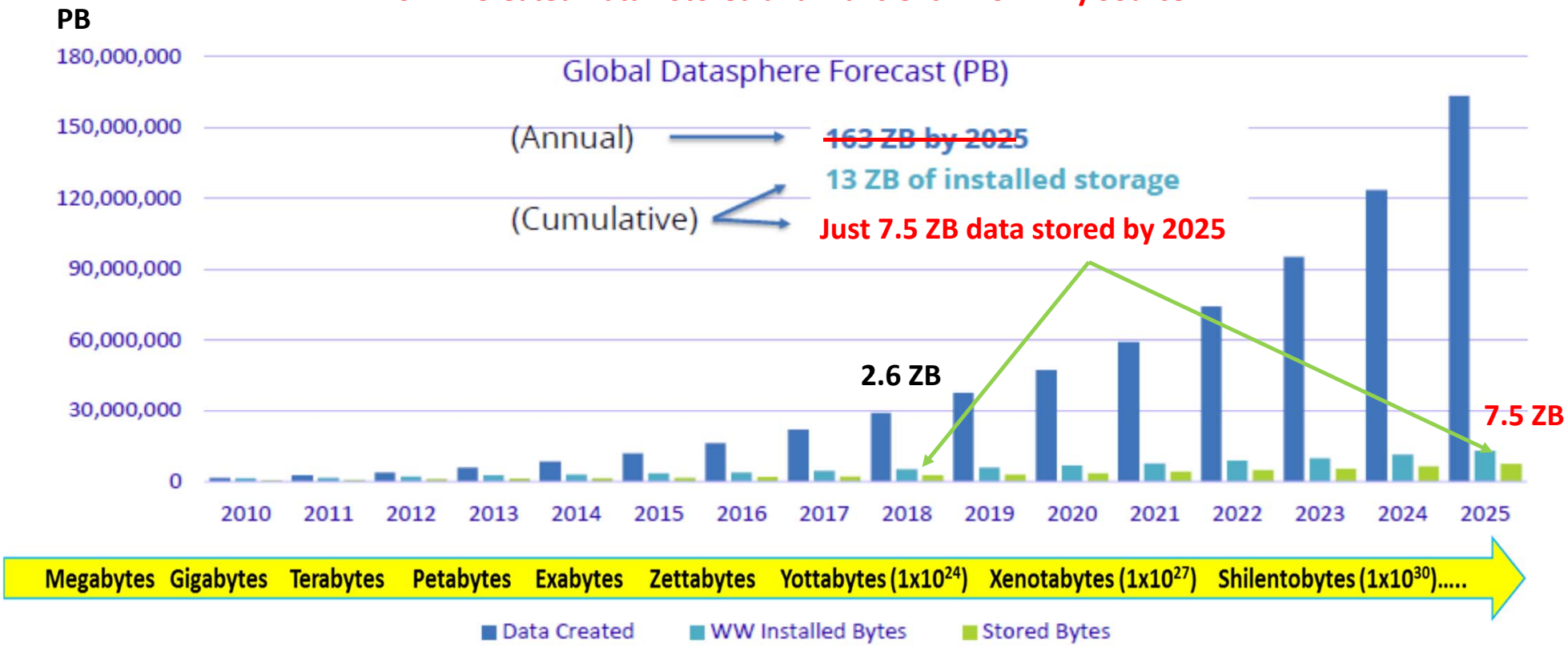
Impact TBD …

- SDS, SEDs, Erasure Coding vs. RAID, GDPR, Blockchain, Blockweave, Shards….

What Happened to All the Data Created?

Global Datasphere Forecast of 163 ZB to be Created in 2025 - by IDC

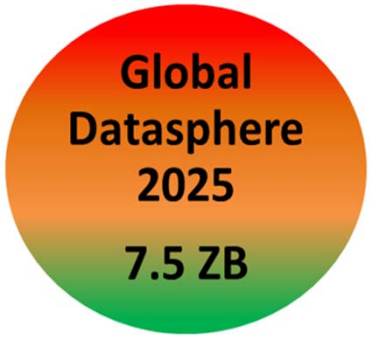
For All Created Data - Stored and Transient - From Any Source.

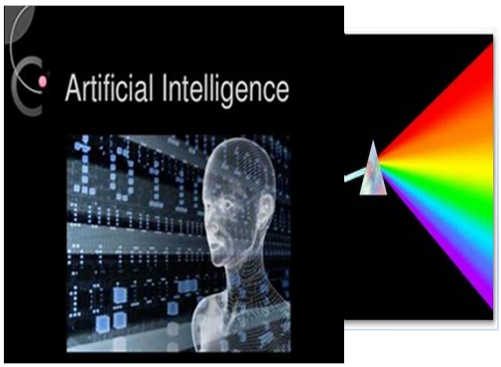


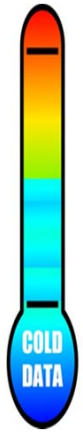
Global Datasphere by Data Class and Storage Tier

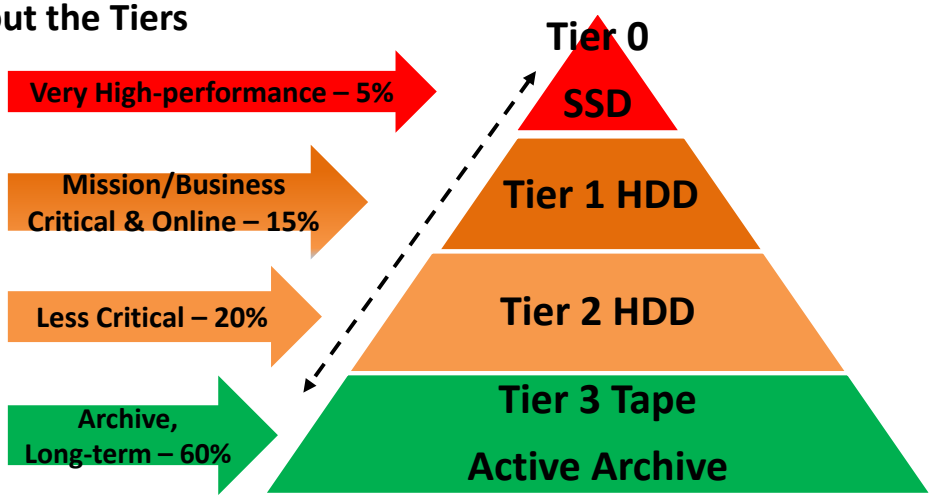
WW Digital Data Stored in 2025 est.

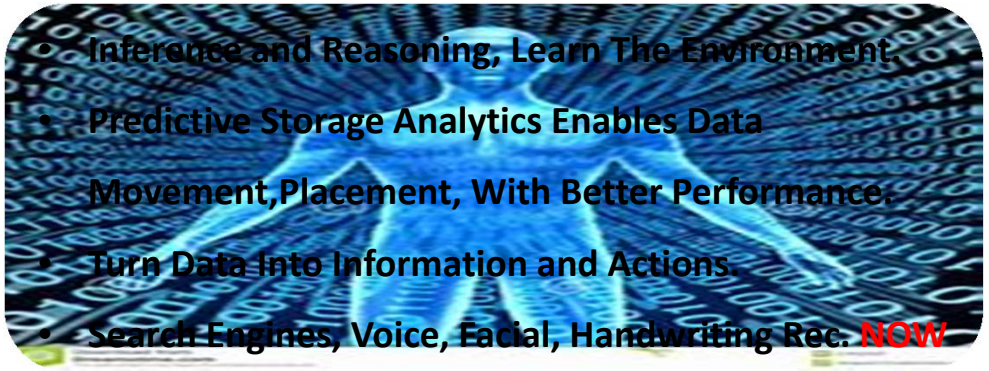
AI Will Enable Dynamic Data Classification, Mapping and Movement Throughout the Tiers











Source: Horison, Inc. The Digital Universe IDC

The Data Lifecycle Classification Model

Tier 0 and Tier 1

Primary Storage

SSD, Enterprise HDD, Mission-critical, OLTP, DBs, Hi-perf. apps

Tier 2

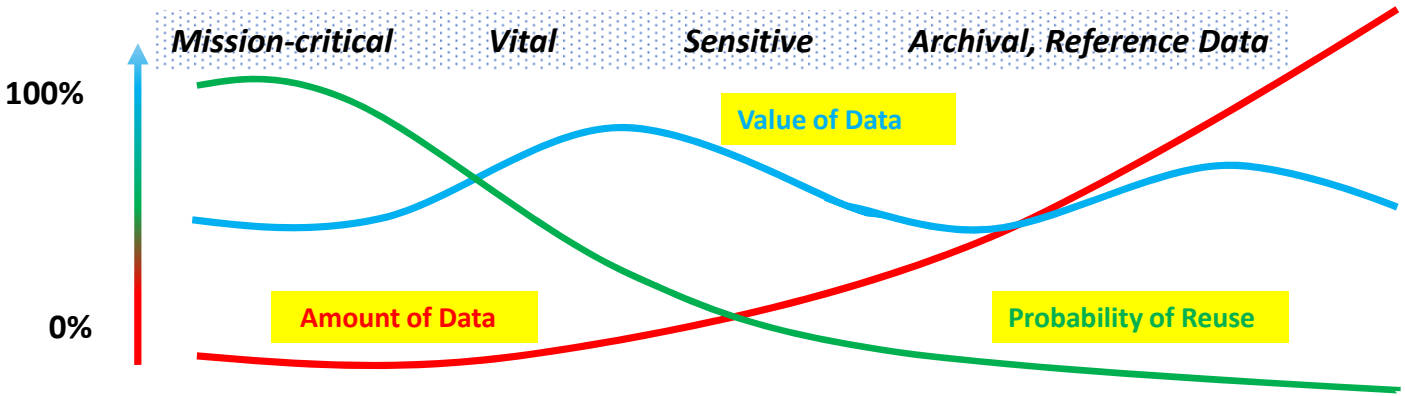
Secondary Storage

Midrange HDD, Backup/recovery, Moderate Perf. Apps, Test and Development, Big Data

Tier 3 (Archives – TB, PB,EB, ZBs..)

Long-term Retention

Tape, Offsite vaults, Archives, Clouds, Permanent Copies, Big Data, Compliance, Video, RIM, Cold Data…

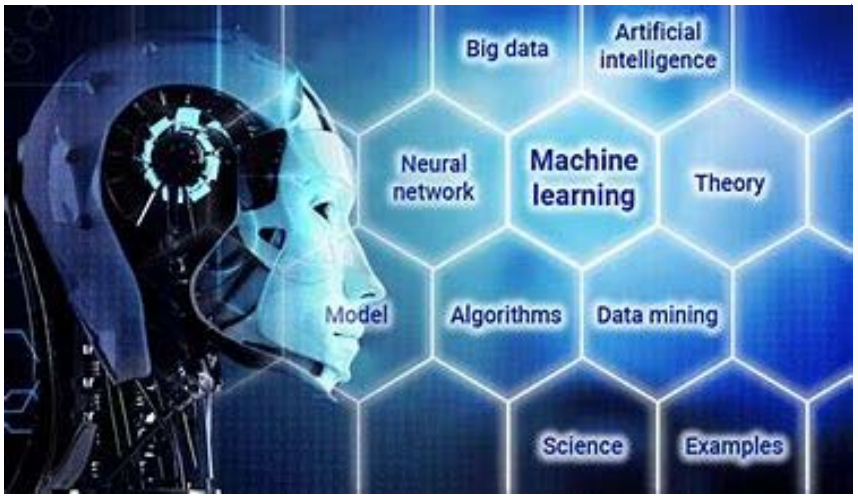


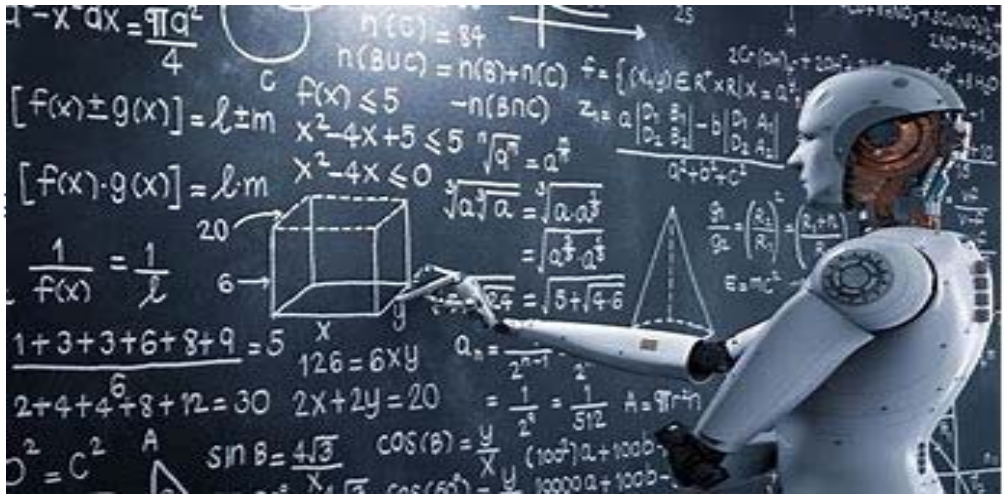
Days Since Data Creation	0 days	30+ days	90+ days	1+ years	Permanent and Infinite Storage
Response Time	ms.	ms. -secs.	Minutes	Hours	Hours-days
Components, Challenges	Policy engine, Tiered storage, Availability, BUR, Data Security		Data movers, Active archive	Re-mastering, Enormous Data Migrations	

Creation — Security/encryption — Long-term Storage, archive — Destruction

Source: Horison, Inc.

Storage *Integrates* Artificial Intelligence





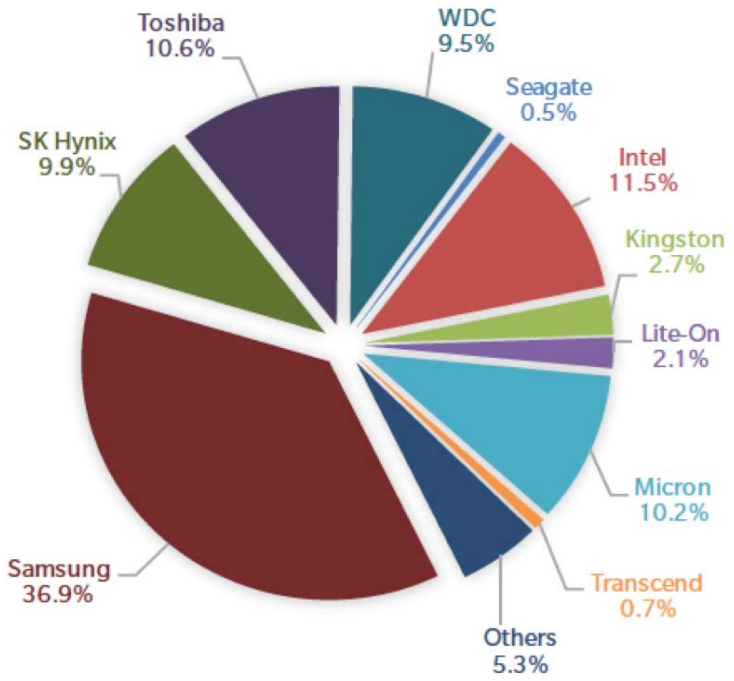
- **AI Can Learn the I/O Pattern and Architect the Optimal Tiered Storage Solution.**
- **Learn Data Lifecycles to Create a "Predictor Factor" About How Data Will Likely be Used In the Future.**
- **Build Data Classification Engine To Learn When to Move Data From Higher-performance and More Expensive Storage, To Less-expensive Storage - Decide When To Archive and Delete.**
- **Deploy Algorithms to Detect and Destroy Cyber Crime and Malware Threats.**
- **AI Expected to Lower Storage Management Software Costs.**

Source: Horison, Inc.

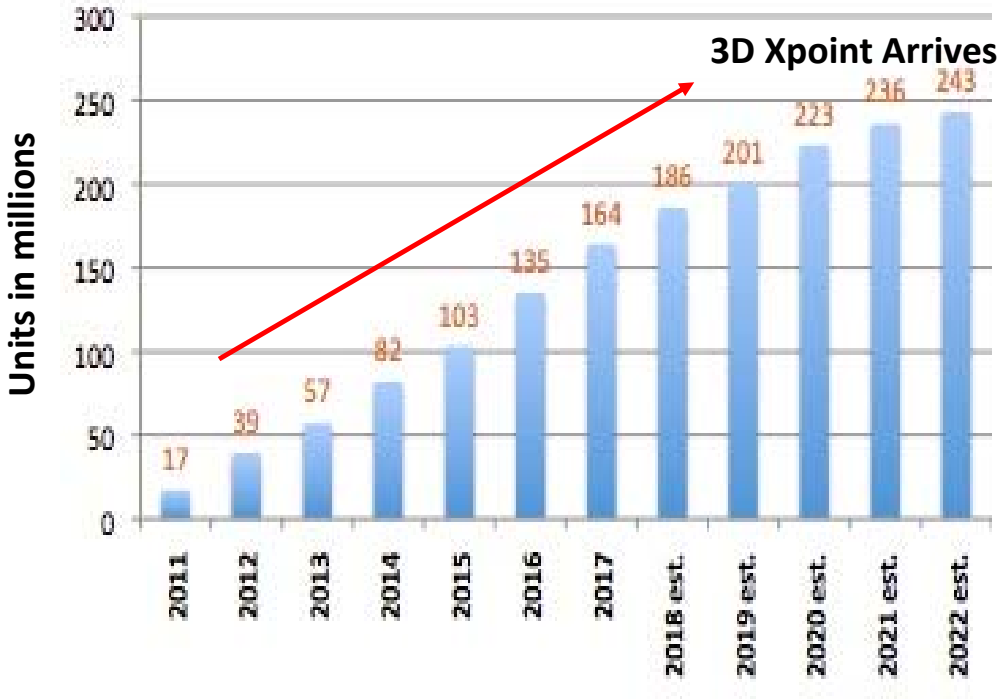
Trendline - SSD Market

2Q 2018

21.85 EB Capacity and 47.76 M Units
Primary Flash SSD Suppliers



Flash SSDs Shipped From 2011 to 2022 - 25% CAGR
Exabyte Growth 21% for 2017

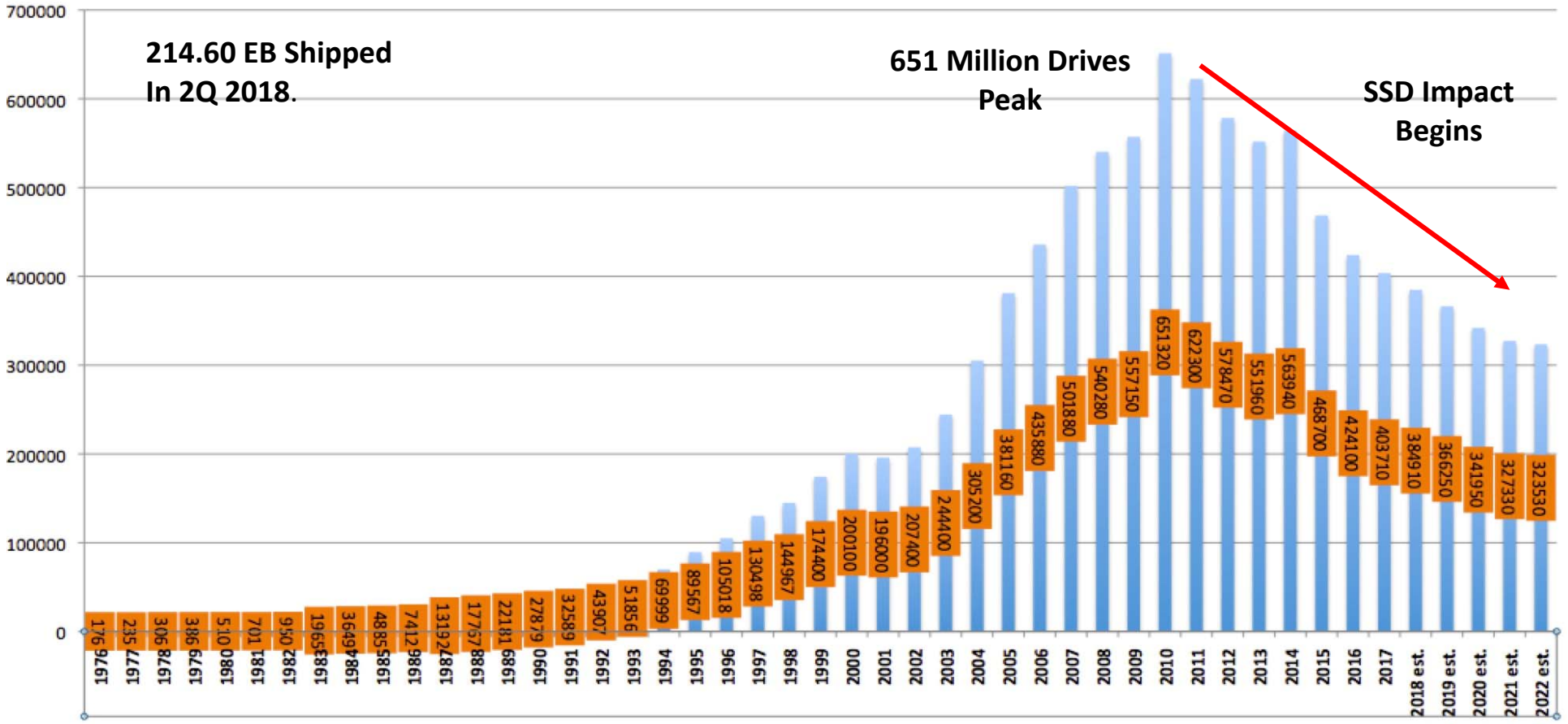


SSD Market - Data Center, Desktop and Consumer
3D NAND is 73% of 2Q Shipments

Source: Trendfocus

Trendline - HDD Market

Yearly HDD Shipments Since 1976 in Thousands

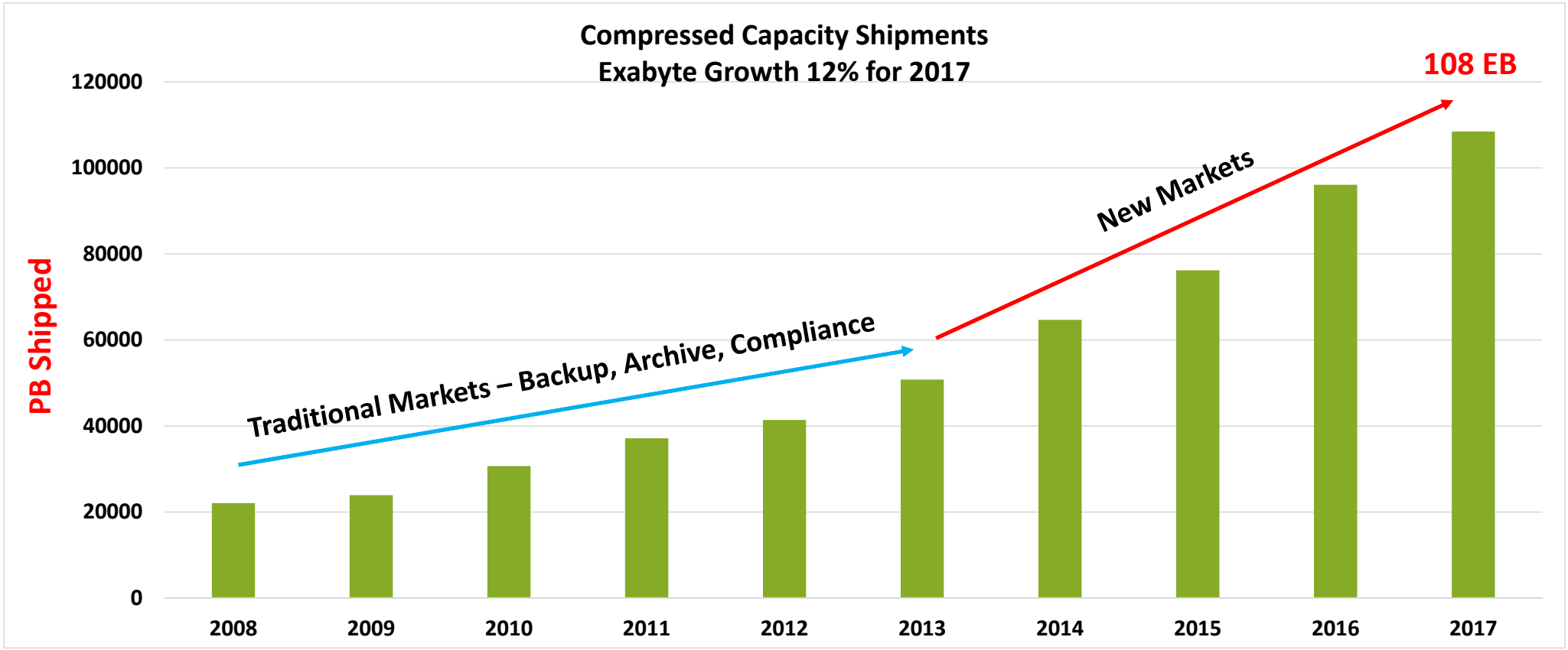


HDD Market - Data Center, Desktop and Consumer

Sources: Disk/trend, IDC, Trendfocus, compiled by StorageNewsletter.com

Trendline - Tape Market

Total LTO Tape Capacity Shipped in 2017

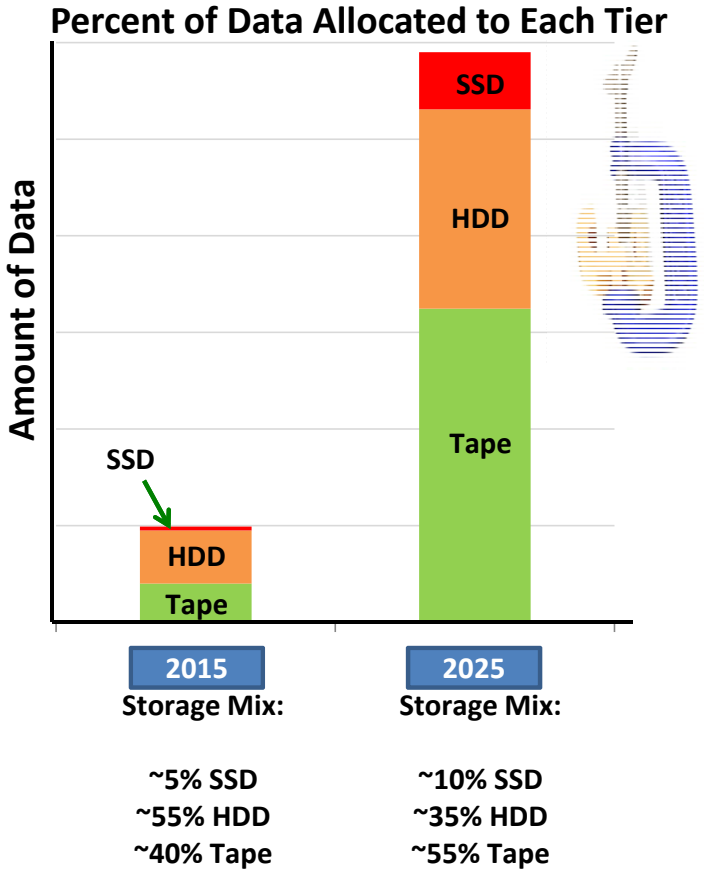


Tape Market - Data Center

Source: The LTO Program Technology Provider Companies (TPCs), Hewlett Packard Enterprise, IBM Corporation and Quantum

Storage Squeeze Play – HDD Caught in Middle

SSD and Tape *Squeezing* HDD Market



HDD Challenges are Mounting

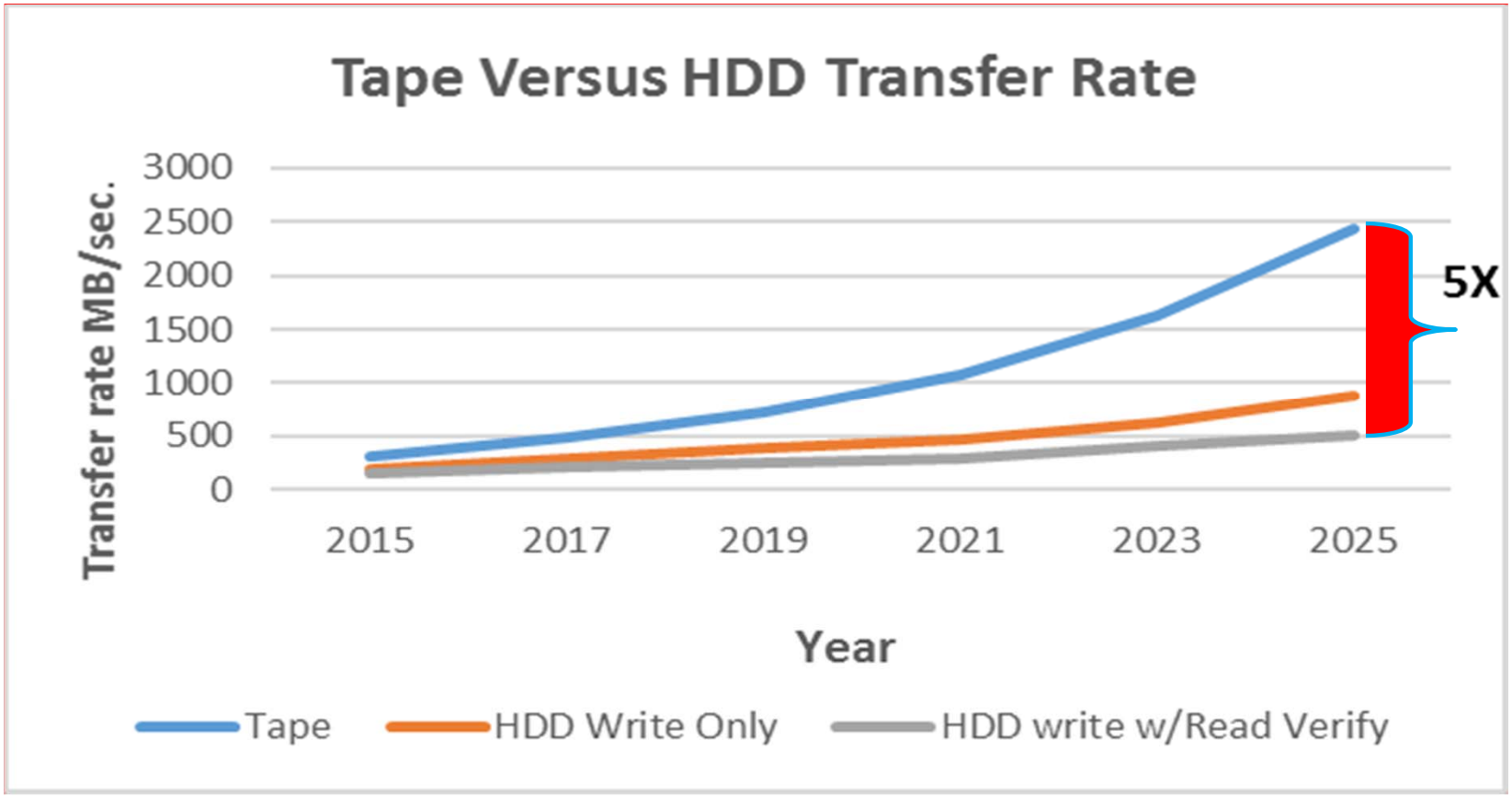
- HDD Shipments Down 35% Since 2010
- Any Further HDD Performance Gains Minimal
- Tape Data Rates Faster Than HDD (~2x – 5x)
- HDD Re-build Times Excessive (*n* * days)
- HDD Adding Platters to Increase Capacity
- HDD TCO Higher Than Tape (4-15x)
- HDD Data Main Target for Hackers
- Tape Reliability ($1x10^{19}$) Has Surpassed HDD
- Tape is Much Greener Than HDD
- Tape Media Life is 30 Years or More

Old way: Keep adding more disk
New way: Optimize SSD, disk and tape

Source: Horison, Inc.

Tape Addresses the IT Performance Gap

Tape Data Rates to Exceed HDD by 5X



Source: TSC State of the Tape Industry Memo 2016, INSIC

Tape Performance Accelerates

New Access Time and Throughput Improvements

Robotics	Drive Load	Drive Access	∑ Positioning Time	Throughput/Data Transfer
Tape Library Mount Time	Tape Drive Load Time	File Access Time Locate the File	Total Time to 1st Byte of File	Sequential Transfer For a File
4 - 10 secs	11 sec	10 - 100 secs	25 – 121 secs	*What About Data Transfer Time?*

Active Archive	Provides HDD-like Cache Access Time to 1st Byte of Tape Files (cache hit ratio ~60-90%)
RAO – Recommended Access Order (Enterprise Tape)	Order Tape Requests to Optimize Tape Movement Time to 1st Byte. Reduces Drive and Media Wear.
TAOS - Time-based Access Order System (LTO)	Order Tape Requests to Optimize Tape Movement Time to 1st Byte. Reduces Drive and Media Wear.
High Performance Transporter	Faster Robotic Moves.
Media IQ	Sorting Move Commands to Optimize Move Sequence Based on Robot Location.
Slot IQ	Take Advantage of Empty Library Slots Nearest Tape Drives to Reduce Movement.

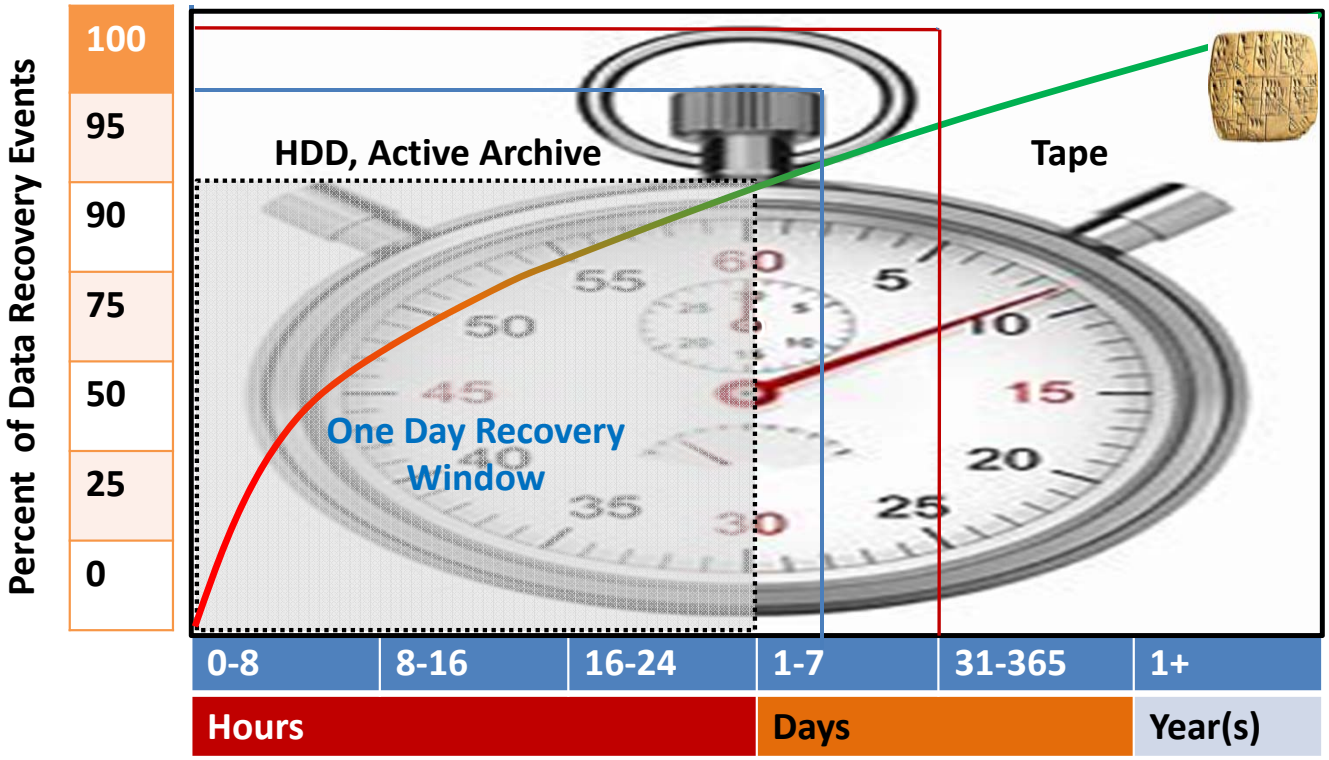
Faster Data Rates *Today*	Tape Data Rates Are 2-3x Faster Than HDD.
Faster Data Rates *Tomorrow*	Projected to be 5X Greater than HDD by 2025.
RAIT	Striping Multiplies Tape Drive Data Rates. Ultra-High-performance File Transfers. Increases Availability With Fault-tolerance.

Source: Horison, Inc.

Backup Recovery Guidelines

Backup Data Activity Profile

90% of Data Recoveries Occur Within 24 Hours After Backup
95% of Data Recoveries Occur Within 1 Week After Backup
99% of Data Recoveries Occur Within 1 Month After Backup



Guidelines

- For Backup Data Kept Over 1 Month, Store on Tape *P(a)* < 1%.
- Use Active Archive (HDD + Tape) for Backup, Then Migrate to Tape Automatically (Air Gap).
- Recovery is Usually Faster on Tape for Files >10-15 GB.
- HDD Best for Smaller Files.
- AI to Make Decisions on Best Device to Use for RTO/RPO.

"Backup is Important, Recovery is Everything".

Source: Horison, Inc.

The Cause and Cost of Downtime and Data Loss

Causes of Unplanned Downtime and/or Data Loss

% of Incidents Reported

- Hardware, Network, System Malfunction, Power and Electrical Outages 44 %
- Human Caused, Terrorism, Theft 32 %
- Software & Corruption 14 %
- Cybercrime/Malware Attacks 7 %
- Natural Disasters 3 %

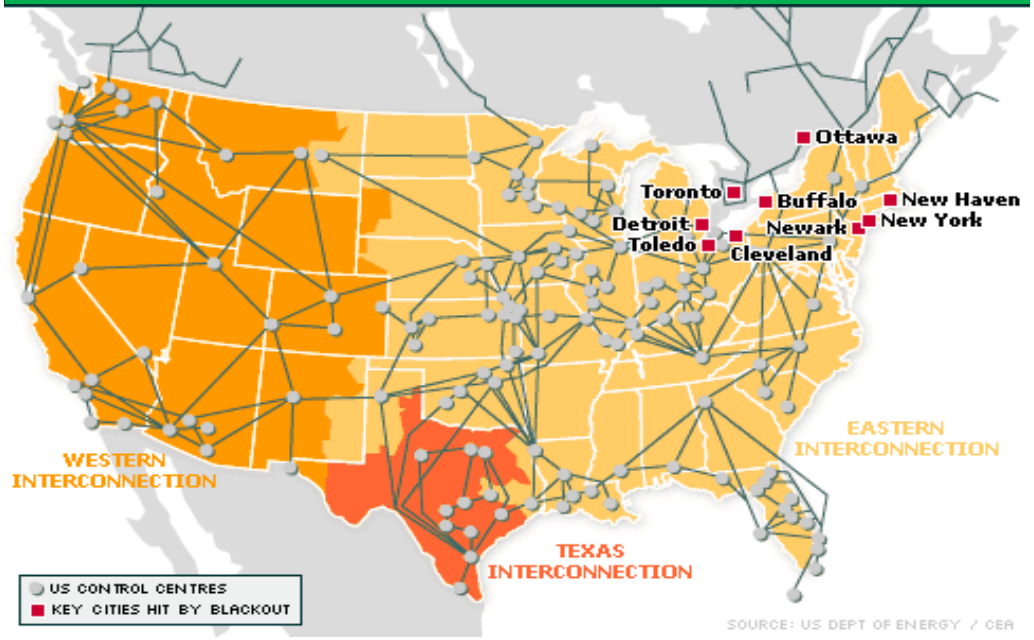
Industry	Downtime Cost /Hour (max. est.)
Energy	$5.0 M
Telecom	$4.0 M
Financial	$2.8 M
Retail	$2.2 M
Transportation	$1.4 M
HealthCare	$1.4 M

Source: Horison Inc.

Without Electricity There is NO IT Industry

Electricity is the Lifeblood of the Information Age

North American Electricity Grid – East, West and Texas Grids

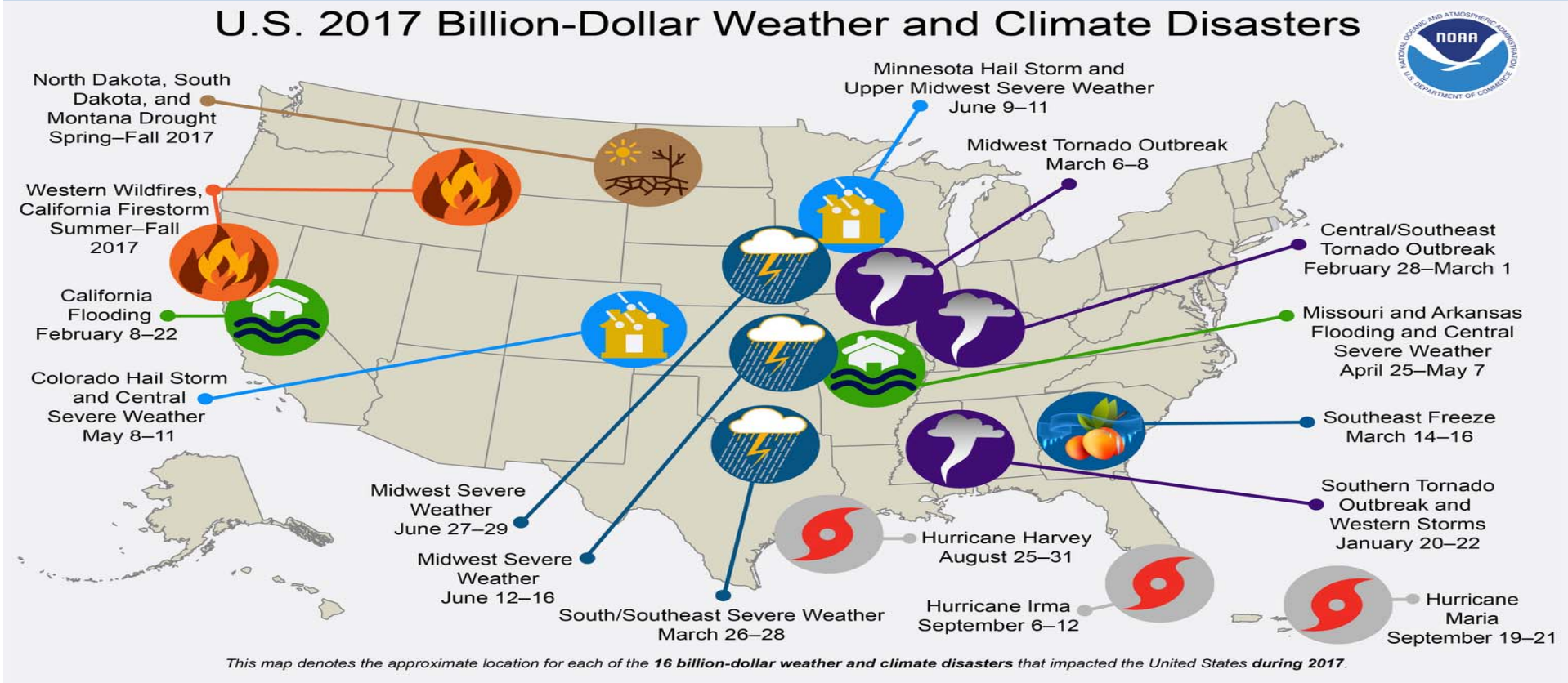


- America's Electric Grid Consists Of More Than 450,000 Miles Of High Voltage Transmission Lines.
- These Grids Supply More Than 140 Million Customers In Industries, Businesses and Residences With Electricity – High Exposure for IT.
- Removeable Media Key in Many DR Scenarios.

Data Center Electricity Consumption Rises

TeraWatt hour (TWhr) = one trillion (10^{12}) watts.

Natural Disasters Take Heavy Toll



- **Since 1980, The U.S. Has Sustained 219 Weather and Climate Disasters.**
- **The Cumulative Costs For These 219 Events Exceed $1.5 Trillion – Total IT and Data Center Impact?**
- **Removeable Media Key in Many DR Scenarios.**

Natural Disasters Fuel Removeable Media Backup Revival

Data Transfer Performance Model

Chicago to Indianapolis
185 miles

3h 39m Drive Time @50.4 mph

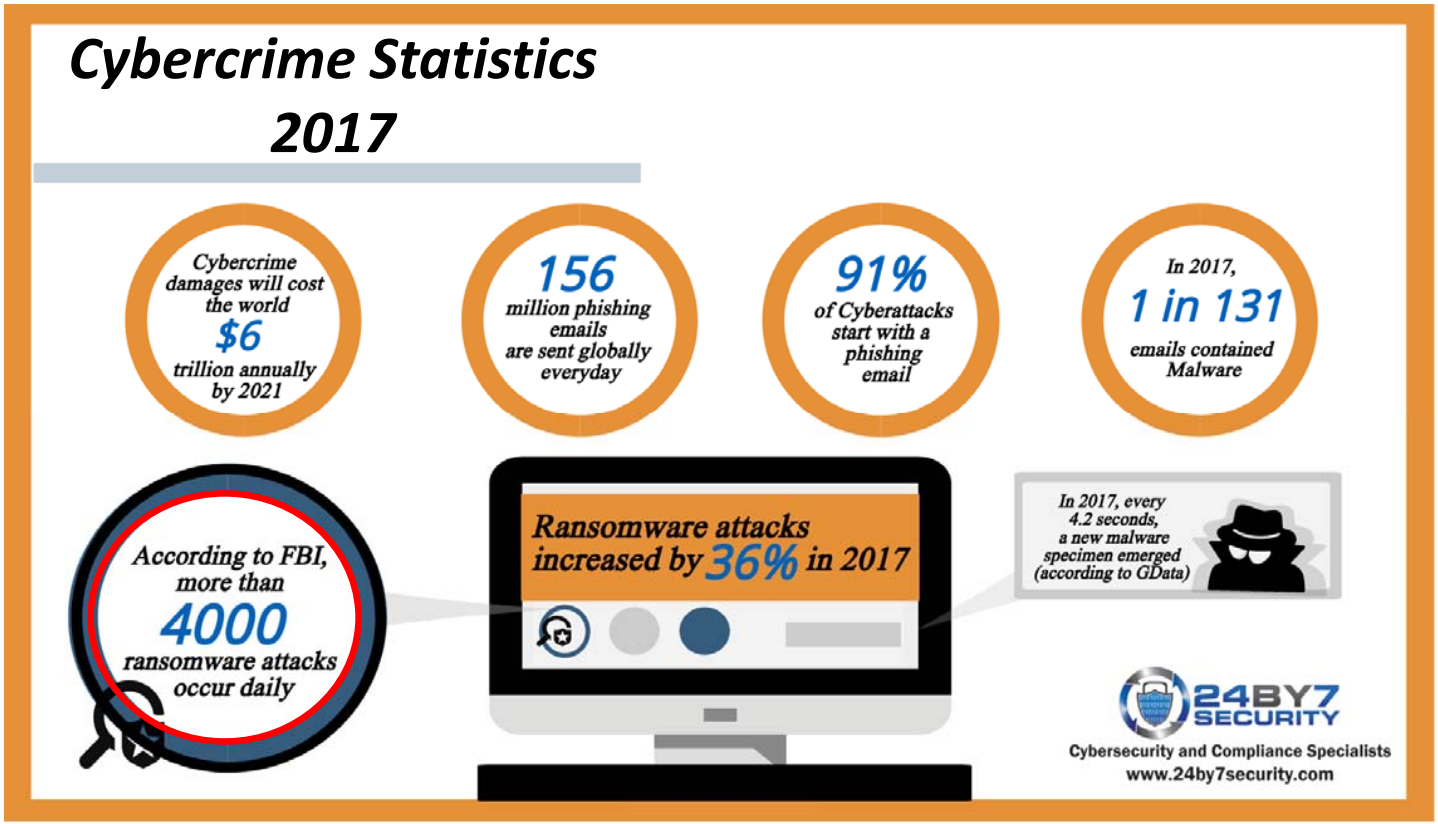
Removeable media (tape) has faster transfer times for larger amounts of data (offsite).

- 100 GB file size packetized for TCP/IP = 800 Gbits.
- Add 40% TCP/IP packet framing ovhd. = 1,120 Gb for 100 GB.
- Data rate of 10 Gig E = 10 Gbits/sec. = 112 sec. for 100 GB.
- LTO-8 cartridge 12 TB native, 30 TB compressed.

	500 GB	1 TB	100 TB	500 TB	1 PB
10 Gig E	560 s 9m 20s	1,120 s 18m 40s	112,000 sec 31hr 6m	560,000 sec 155h 30m	1,120,000 sec 311hr 6m
40 Gig E	140 sec 2m 20s	280 sec 4m 40s	28,000 sec 7h 46m	140,000 sec 38h 53m	280,000 sec 77h 47m
100 Gig E	56 sec	112 sec 1m 52s	11,200 sec 3h 6m	56,000 sec 15h 30m	112,000 sec 31h 6m
Truck 50.4 mph	3H 39 min				
Helicopter 130 mph	1H 32 Min				
Airplane 530 mph	52 min				

Source: Horison, Inc.

Cybercrime Impact Soars



- **In 2017, the U.S. employed nearly 780,000 workers in cybersecurity positions.**
- **Approximately 350,000 current cybersecurity job openings in 2018.**

- **There Were 90 Million Cyber Attacks in 2016.**
- **The Average Total Cost Of a Data Breach Was $3.79 Million in 2016.**
- **Cybercrime Will Become a $6 Trillion Problem By 2021!**

Let's Learn How to Hack!!

DEFCON 26

August 9-12, 2018 At Caesars Palace In Las Vegas!

$280 For All Four Days! Cash Only At The Door, There Is No Pre-registration.

Contests, Awards, Prizes!

Over 16,000 Attendees In 2017.

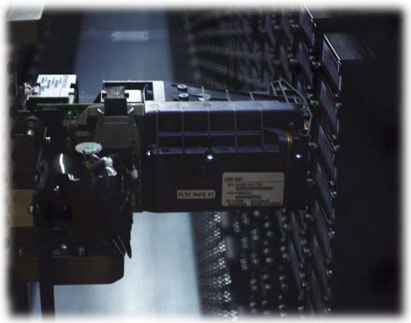
And FBI And NSA Agents Looking To Recruit Potential and Up-and-coming Cyber-culture Hackers.

DEF CON China May 11-13, 2018 in Beijing, China!

The Tape Air Gap = Data Protection

- The Average Total Cost Of a Data Breach Was $3.79 Million In 2016.
- Estimated 4,000 Ransomware Attacks Each Day.
- Tape Air Gap Prevents Unauthorized Electronic Access – Data Protection.

Online Tape Access



Manual

Robotic

A I R G A P

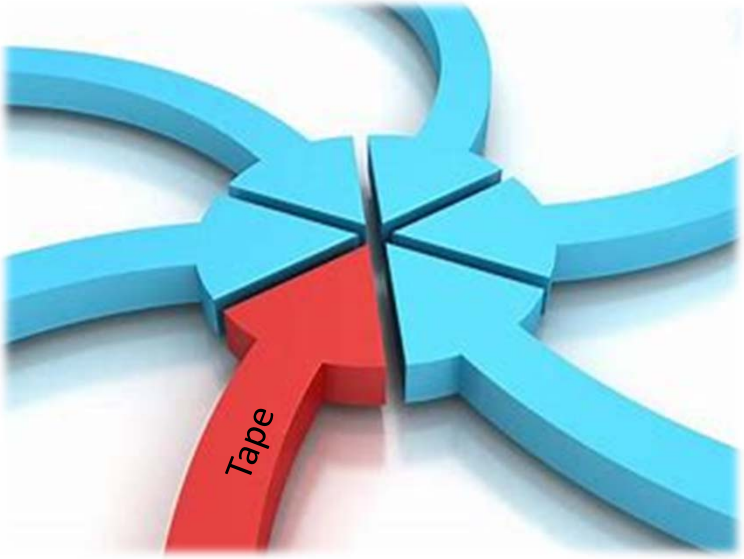
	Catfish	Drive-by Download	Ghosting	Hash Busters
Keylogger		Man-in-the-middle attack	Pharming	
Ransomware	Scareware	Skimming		Spear-fishing
Spoofing		Vishing	Whaling	WikiLeaks… Human leaks

The Convergence of Cybersecurity and Data Protection

Is Underway

Backup
Copy(s) of Data

Malware Protection,
Anti-virus Tools
Hackers, Cybercrime



Replication, CDP, Snapshot
Data Consistency, Recovery

Firewall
Networks, Web

Tape Air Gap Protection
Hacker-proof Storage,
Removeable Media

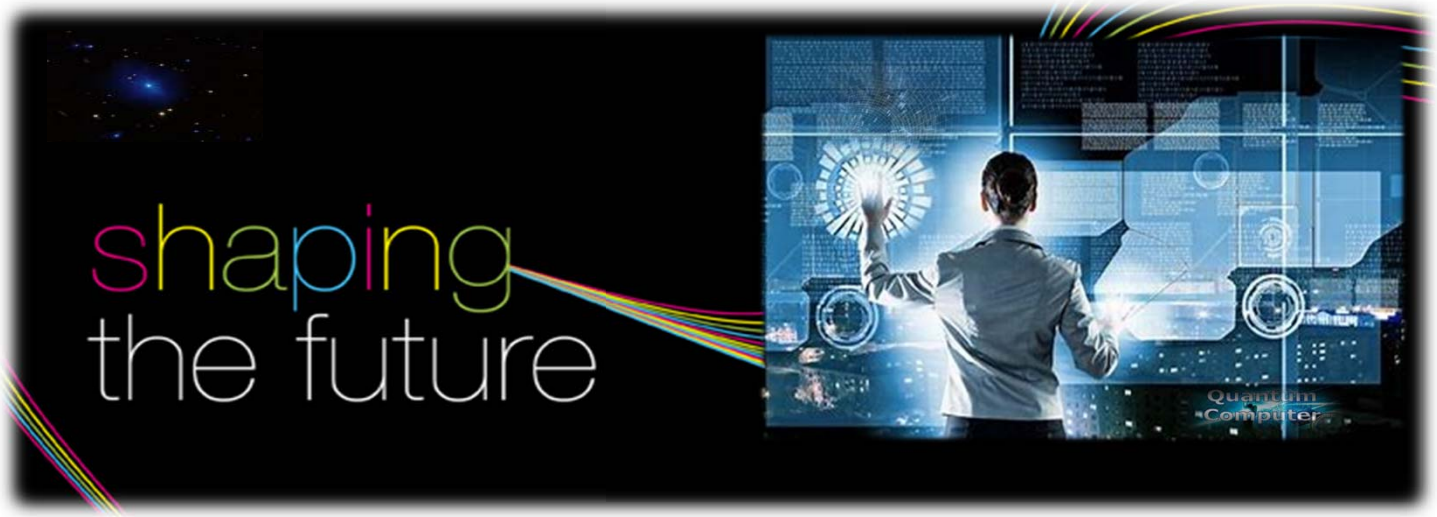
Disaster
Recovery
IT Systems,
Data Centers

Backup/Recovery → **Replication** → **HA Infrastructure** → **Disaster Recovery** → **Secure Vault** → **Cyber Security**

Tape Value Proposition - 2018

Function	Remarks - Current State of the Tape Industry
Price/TCO	Tape Has the Lowest Acquisition Price $/GB, HDD TCO 4-15x Higher Than tape.
Performance	Much Improved - Active Archive, Fastest Data Rates, RAIT, Smarter and Faster Robotics, Access Time to 1st Byte Features (RAO, TAOS) Have Arrived.
Recovery	Fast Recovery for Large Data Sets and Files.
Capacity	Tape Cartridge Capacity Max. @15TB (45TB compressed) with 200X More Area, HDD @14TB. Lab Demos Demonstrate Native Cartridge Capabilities to Reach 100s of TBs.
Scalability	Tape Adds capacity by Adding Media, HDDs Add Capacity by Adding Drives.
Reliability	Tape (BER) $1x10^{19}$ HDD (BER) $1x10^{16}$ Tape BER is 1000x Higher Than HDD.
Energy Usage	Tape Uses Much Less Energy Than HDDs, Can Move Tape Data w/o Electricity.
Portability	Tape Media Easily Portable, HDDs Difficult to Move.
Encryption/WORM	All Tape Drives offer Encryption, Option on Some HDDs But Seldom Used.
Cybersecurity	Tape Air Gap Prevents Cybercrime Attacks, Strong Defense Against Malware.
Media Life	>30 Years for all Modern Tape, Avg. ~4-5 Years for HDDs.
Recording Limits	No Foreseen Limits for Tape, HDDs Facing Areal Density and Performance Limits.
Cloud Storage	Tape Improves Cloud Reliability and Security, Lowers Storage Costs, Unlimited Capacity Scaling.

Source: Horison, Inc.



Remember …

Things Are Changing So Fast…

Even the Future is Obsolete