



**The Growing Immensity  
of a “Cold Yet Active Archive”  
(~80% of the installed base)...**

**~21ZB in 2030**

**~72ZB in 2040**

**~163ZB in 2050...**

# **“Like Nothing We’ve Ever Seen Before”: *The Impacts of Generative AI on Archive Data Markets***

**New Forecasts, 2024-2050**

*Gen AI will drive solid double-digit expansions of enterprise data shipments through 2030, but 2031-2050 growth rates in excess of 25% cannot be feasibly sustained.*

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# OUR EXPANDING DATAVERSE



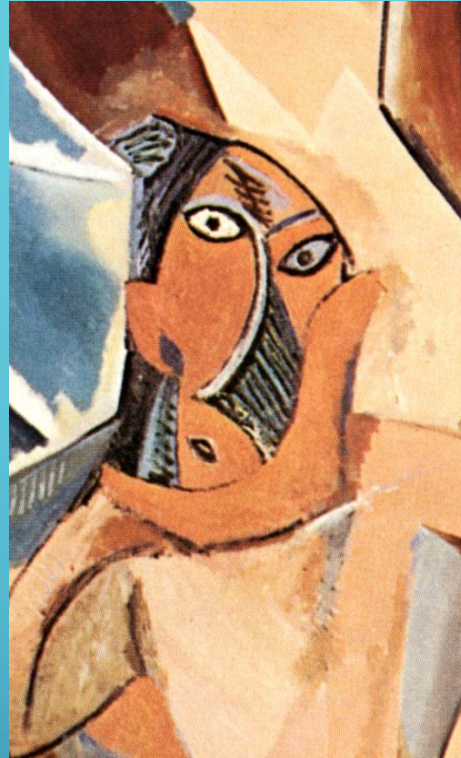
Not surprisingly, the potential global impacts of generative AI have engendered vastly inflated hype, as well as general and deep concerns about the enormous dangers and challenges lurking within immense possibilities.

There are colossal differences of opinion regarding the impacts of generative AI on enterprise data growth.

But one thing is certain: *The billions of people and systems and sensors connected in the global dataverse have generated and will continue to generate immense quantities of data...~80% of which will become “cool-cold-frozen” within 60 days of their creation ...*



# AGENDA



- Guiding Forecast Assumptions
- Shipment History and New 2024-2050 Forecasts
- The Active Archive Opportunity
- Nearline and Archive Technology Forecast Assumptions
- Inconclusive Conclusions

**Enduring Question:** *Will the Past be Prologue, or Will History Be Bunk?*

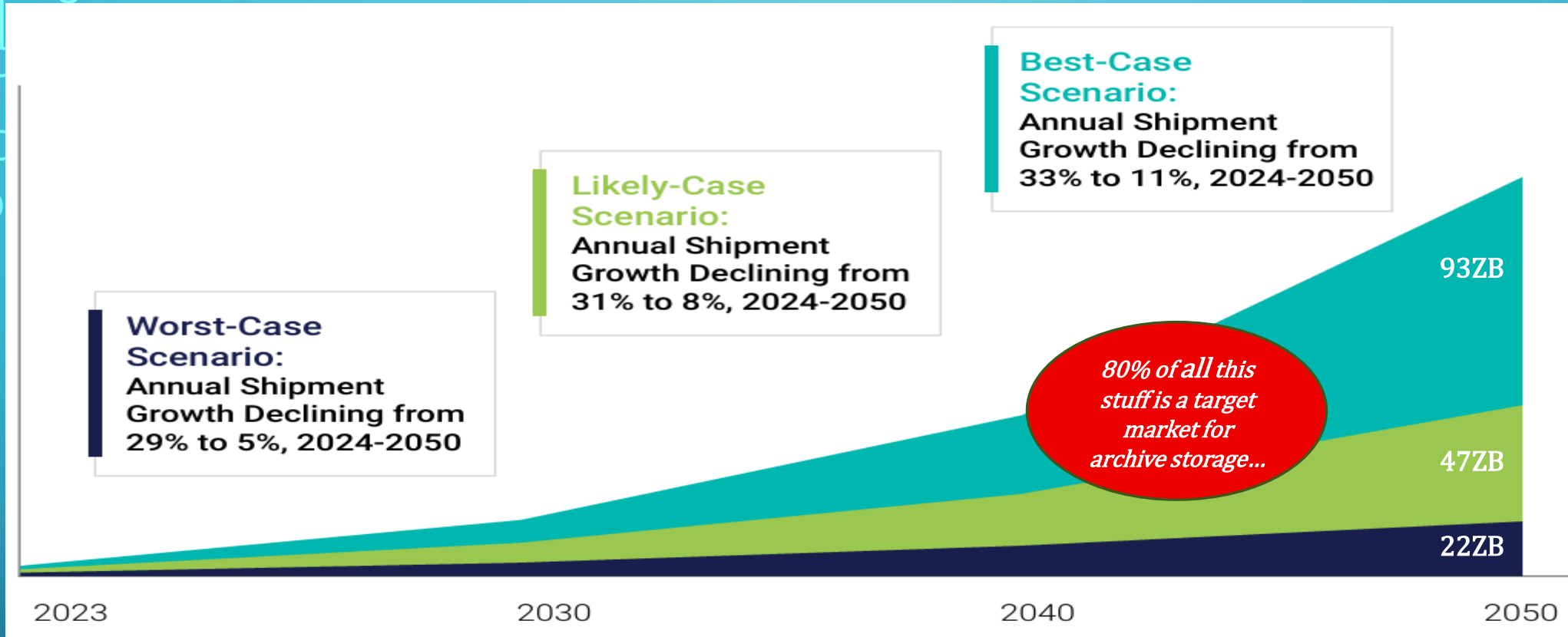
**Note:** My forecasts are always devised with these precautionary adages in mind:

- *The only thing we know with certainty about any forecast is that it will be wrong. —Anonymous*
- *He who foretells the future lies, even if he tells the truth. —Arab Proverb*

# GUIDING FORECAST ASSUMPTIONS

- **GenAI will help to drive shipment growth through 2030, resulting in at least 25%-30% annual increases from 2024-2030, but from 2031 onward, due to manufacturing and cost constraints, energy compliance regulations, and sustainability concerns, GenAI will of necessity be increasingly utilized to create greater storage efficiencies.**
- **After 2030, the >25% historic 2001-2020 growth rates cannot be feasibly sustained...**

# ALTERNATE SHIPMENT SCENARIOS, 2023-2050



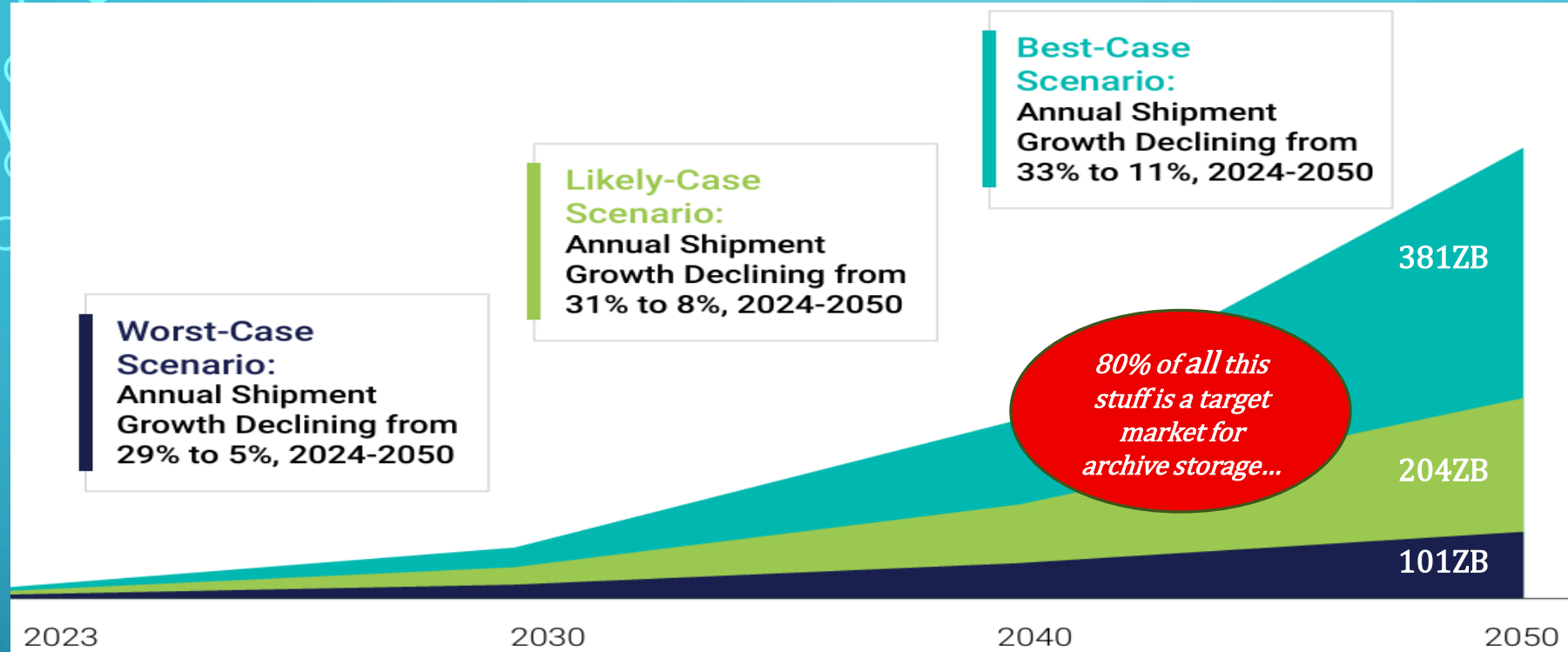
For the first time, we are predicting significant and variable 2031-2050 declines in annual shipment growth rates for all scenarios.

**Enterprise EB Annual Shipment Scenarios, 2001-2050**

	2001	2010	2020	2030	2040	2050
Worst-Case Scenario: Annual Shipment Growth Declining from 29% to 5%, 2024-2050	6.4	221.2	2,931.2	5,533.2	12,447.2	22,281.1
Likely-Case Scenario: Annual Shipment Growth Declining from 31% to 8%, 2024-2050	6.4	221.2	2,931.2	8,099.0	21,094.8	47,253.4
Best-Case Scenario: Annual Shipment Growth Declining from 33% to 11%, 2024-2050	6.4	221.2	2,931.2	9,302.9	31,981.1	92,871.4
<b>Unsustainable Shipment Scenario of a Consistent 25% CAGR, 2031-2050:</b>					<b>75,427.7</b>	<b>702,475.0</b>

Source: Furthur Market Research and Brad Johns Consulting (August 2024)

# ALTERNATE ACTIVE INSTALLED BASE SCENARIOS, 2023-2050



- The active installed base exceeded one zettabyte in 2016, grew to 5.7 zettabytes in 2023, and will likely expand to more than 200 zettabytes in 2050.
- Even in a worst-case scenario, with annual shipment growth gradually declining to 5% per year, we might see fresh shipments of 5.5ZBs in 2030, 12.4ZBs in 2040, and 22.9ZBs in 2050, creating an active installed base of 20.8ZBs in 2030, 53.6ZBs in 2040, and 101.3ZBs in 2050

Enterprise EB Active Installed Base Scenarios, 2006-2050

	2006	2010	2020	2030	2040	2050
Worst-Case Scenario: Annual Shipment Growth Declining from 29% to 5%, 2024-2050	-	-	-	20,764.1	53,631.7	101,288.8
Likely-Case Scenario: Annual Shipment Growth Declining from 31% to 8%, 2024-2050	94.6	252.3	2,962.3	26,598.1	89,225.5	203,762.6
Best-Case Scenario: Annual Shipment Growth Declining from 33% to 11%, 2024-2050	-	-	-	29,873.5	129,320.7	381,201.9
<i>Worst-Case Active Installed Base xChange Relative to 2006</i>				219.5	566.9	1,070.7
<i>Likely-Case Active Installed Base xChange Relative to 2006</i>	-	2.7	31.3	281.2	943.2	2,153.9
<i>Best-Case Active Installed Base xChange Relative to 2006</i>				315.8	1,367.0	4,029.6
<i>Unsustainable Active Installed Base Scenario of a Consistent 25% CAGR, 2031-2050:</i>				<b>773,796.6</b>	<b>2,361,439.9</b>	
<i>Unsustainable Scenario of a Consistent 25% CAGR, 2031-2050, xChange Relative to 2006:</i>				<b>8,179.7</b>	<b>24,962.4</b>	

Note: We began our tracking of the active installed base in 2006.  
 Source: Furthur Market Research and Brad Johns Consulting (August 2024)



# THE ACTIVE-ARCHIVE OPPORTUNITY, 2031-2040

## Enterprise EB Shipment Forecasts, 2031-2040

	2031	2032	2033	2034	2035	CAGR 2031-2035	2036	2037	2038	2039	2040	CAGR 2036-2040
Compressed* Enterprise SSD EB	1,334.7	1,985.4	2,790.8	3,353.7	3,705.9		4,319.8	5,156.3	5,760.4	6,390.9	7,130.2	
YoY Growth %	28.9	48.8	40.6	20.2	10.5	29.1	16.6	19.4	11.7	10.9	11.6	13.3
Raw, Uncompressed Mission-Critical Enterprise HDD EB	<b>Trillions of \$USD investments in new NAND fab capacity will be required...</b>											
YoY Growth %												
Raw, Uncompressed Business-Critical/Nearline Enterprise HDD EB	5,556.3	5,028.1	4,326.3	3,190.8	1,936.7		1,703.5	1,150.1	898.3	697.6	399.8	
YoY Growth %	1.0	-9.5	-14.0	-26.2	-39.3	-23.2	-12.0	-32.5	-21.9	-22.3	-42.7	-30.4
Total Raw, Uncompressed HDD Enterprise EB	5,556.3	5,028.1	4,326.3	3,190.8	1,936.7		1,703.5	1,150.1	898.3	697.6	399.8	
YoY Growth %	1.0	-9.5	-14.0	-26.2	-39.3	-23.2	-12.0	-32.5	-21.9	-22.3	-42.7	-30.4
Total SSD+HDD Enterprise EB	6,891.0	7,013.5	7,117.1	6,544.5	5,642.6		6,023.3	6,306.4	6,658.7	7,088.5	7,530.0	
YoY Growth %	5.5	1.8	1.5	-8.0	-13.8	-4.9	6.7	4.7	5.6	6.5	6.2	5.7
Compressed** LTO+IBM TS1100 "Active Archive" Tape EB	980.2	1,216.9	1,651.3	2,095.1	2,360.8		2,600.9	2,999.3	3,188.1	2,583.5	2,165.3	
YoY Growth %	25.0	24.1	35.7	26.9	12.7	24.6	10.2	15.3	6.3	-19.0	-16.2	-4.5
Enterprise Emerging Storage (2025 Onward)	1,190.9	1,836.5	2,398.5	3,656.1	5,510.7		6,128.7	6,905.8	7,898.8	9,681.3	11,368.8	
YoY Growth %	52.4	54.2	30.6	52.4	50.7	46.7	11.2	12.7	14.4	22.6	17.4	16.7
Total "Active-Archive" Storage Opportunity (Tape+Emerging)	2,171.1	3,053.4	4,049.8	5,751.2	7,871.5		8,729.6	9,905.1	11,086.9	12,264.8	13,534.1	
YoY Growth %	38.7	40.6	32.6	42.0	36.9	38.0	10.9	13.5	11.9	10.6	10.3	11.6
<i>Active-Archive prices will drop to \$0.10/TB during the 2030s...</i>												
Total Compressed Shipments of Enterprise EB	9,062.1	10,066.9	11,166.9	12,295.7	13,514.1		14,752.9	16,211.5	17,745.6	19,353.3	21,064.1	
YoY Growth %	11.9	11.1	10.9	10.1	9.9	10.5	9.2	9.9	9.5	9.1	8.8	9.3
SSD EB % of Total Annual Shipments	14.7	19.7	25.0	27.3	27.4		29.3	31.8	32.5	33.0	33.9	
HDD EB % of Total Annual Shipments	61.3	49.9	38.7	26.0	14.3		11.5	7.1	5.1	3.6	1.9	
SSD+HDD EB % of Total Annual Shipments	76.0	69.7	63.7	53.2	41.8		40.8	38.9	37.5	36.6	35.7	
Compressed** LTO+IBM TS1100 "Active Archive" Tape % of Total EB	10.8	12.1	14.8	17.0	17.5		17.6	18.5	18.0	13.3	10.3	
Enterprise Emerging Storage (2025 Onward) % of Total EB	13.1	18.2	21.5	29.7	40.8		41.5	42.6	44.5	50.0	54.0	
"Active-Archive" Storage (Tape+Emerging) % of Total EB	24.0	30.3	36.3	46.8	58.2		59.2	61.1	62.5	63.4	64.3	
Active Installed Base EB	32,586.3	38,728.7	44,855.4	50,691.3	56,105.7		61,796.5	67,941.1	74,519.8	81,577.4	89,127.4	
YoY Growth %	22.5	18.8	15.8	13.0	10.7	14.5	10.1	9.9	9.7	9.5	9.3	9.6

Note: This forecast closely reflects but does not exactly match the likely-case forecast scenarios depicted on Slide 7 of this presentation.

Source: Furthur Market Research and Brad Johns Consulting (August 2024)

# THE ACTIVE-ARCHIVE OPPORTUNITY, 2041-2050

## Enterprise EB Shipment Forecasts, 2041-2050

	2041	2042	2043	2044	2045	CAGR 2041-2045	2046	2047	2048	2049	2050	CAGR 2046-2050
Compressed* Enterprise SSD EB	7,790.6	8,193.8	8,875.6	9,332.4	9,909.8		10,356.8	11,073.4	11,771.9	12,250.6	12,972.1	
YoY Growth %	9.3	5.2	8.3	5.1	6.2	6.2	4.5	6.9	6.3	4.1	5.9	5.8
Raw, Uncompressed Mission-Critical Enterprise HDD EB												
YoY Growth %												
Raw, Uncompressed Business-Critical/Nearline Enterprise HDD EB	217.6	121.5										
YoY Growth %	-45.6	-44.2	EOL									
Total Raw, Uncompressed HDD Enterprise EB	217.6	121.5										
YoY Growth %	-45.6	-44.2										
Total SSD+HDD Enterprise EB	8,008.2	8,315.3	8,875.6	9,332.4	9,909.8		10,356.8	11,073.4	11,771.9	12,250.6	12,972.1	
YoY Growth %	6.4	3.8	6.7	5.1	6.2	5.5	4.5	6.9	6.3	4.1	5.9	5.8
Compressed** LTO+IBM TS1100 "Active Archive" Tape EB	1,860.2	882.3	503.8	321.9	108.7		50.6	25.5				
YoY Growth %	-14.1	-52.6	-42.9	-36.1	-66.2	-50.8	-53.4	-49.6	EOL			
Enterprise Emerging Storage (2025 Onward)	13,155.4	15,856.9	17,910.4	19,980.6	22,131.3		24,295.7	26,436.5	28,795.6	31,369.3	34,391.2	
YoY Growth %	15.7	20.5	13.0	11.6	10.8	13.9	9.8	8.8	8.9	8.9	9.6	9.1
Total "Active-Archive" Storage Opportunity (Tape+Emerging)	15,015.6	16,739.2	18,414.2	20,302.5	22,240.0		24,346.3	26,462.0	28,795.6	31,369.3	34,391.2	
YoY Growth %	10.9	11.5	10.0	10.3	9.5	10.3	9.5	8.7	8.8	8.9	9.6	9.0
Total Compressed Shipments of Enterprise EB	23,023.8	25,054.5	27,289.8	29,634.9	32,149.8		34,703.1	37,535.4	40,567.5	43,619.9	47,363.3	
YoY Growth %	9.3	8.8	8.9	8.6	8.5	8.7	7.9	8.2	8.1	7.5	8.6	8.1
SSD EB % of Total Annual Shipments	33.8	32.7	32.5	31.5	30.8		29.8	29.5	29.0	28.1	27.4	
HDD EB % of Total Annual Shipments	0.9	0.5	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	
SSD+HDD EB % of Total Annual Shipments	34.8	33.2	32.5	31.5	30.8		29.8	29.5	29.0	28.1	27.4	
Compressed** LTO+IBM TS1100 "Active Archive" Tape % of Total EB	8.1	3.5	1.8	1.1	0.3		0.1	0.1	0.0	0.0	0.0	
Enterprise Emerging Storage (2025 Onward) % of Total EB	57.1	63.3	65.6	67.4	68.8		70.0	70.4	71.0	71.9	72.6	
"Active-Archive" Storage (Tape+Emerging) % of Total EB	65.2	66.8	67.5	68.5	69.2		70.2	70.5	71.0	71.9	72.6	
Active Installed Base EB	97,398.3	106,241.3	115,785.5	126,067.1	137,152.8		148,832.1	161,313.0	174,590.7	188,575.7	203,789.2	
YoY Growth %	9.3	9.1	9.0	8.9	8.8	8.9	8.5	8.4	8.2	8.0	8.1	8.2

- Ever more trillions of \$USD investments in new NAND fab capacity will be required...
- Active-Archive storage technologies can add capacity far more quickly and cost effectively...and will achieve \$0.10/TB prices during the 2030s...

Note: This forecast closely reflects but does not exactly match the likely-case forecast scenarios depicted on Slide 7 of this presentation.

Source: Furthur Market Research and Brad Johns Consulting (August 2024)



# NEARLINE AND ARCHIVE TECHNOLOGY FORECAST ASSUMPTIONS

- An enduring universal driver of archive demand—*“Disposaphobia”*: We are generating more and more data and deleting less and less of it. And because “you don’t [yet] know what you don’t know about your data” and you don’t [yet] have any clear idea about its potential for monetizable “business intelligence” and “value efficiency,” your current fears about discarding any shred of “seemingly dead data” will “only be exacerbated by GenAI.” We are increasingly loathe to “sentence” any data to “deletion.”
- *HDDs*: Because of GenAI’s need for relatively quick access to large amounts of data for scrutiny and analysis, demand for the relative speed and cost-effective capacity of HDDs will remain unabated during the near term. But due to enlarging SSD and enterprise emerging technology incursions, HDD shipments will peak at ~5.6Zs in 2031 and decline to end-of-life (EOL) status by 2043. And due to more-costly areal density growth (limiting capacities to 50TB/drive), modulating ASP declines, and more-disciplined market management, it is unlikely that the HDD makers will ever deliver much more than ~5.5ZB/year. However, despite shipment declines, HDD ZB deliveries in 2036 will still exceed the HDD ZBs delivered in 2023 (~1.7ZBs vs. ~1ZB). Enterprise SSD ZB deliveries will not exceed enterprise HDD ZB deliveries until 2034.
- *Tape*: Assuming consistent execution through at least LTO 14 (with 1.4EB compressed capacities per cartridge), tape technology shipments will display great growth until 2039 but gradually decline to EOL status in 2048, largely due to incursions from more durable and cost-effective enterprise emerging storage technologies.
- *Enterprise Emerging Storage*: With initial shipments in 2025, enterprise emerging storage will expand rapidly, grow to exceed traditional tape shipments beginning in 2031, and increase to >30ZB/year during the 2040s.

# NEARLINE AND ARCHIVE TECHNOLOGY FORECAST ASSUMPTIONS

- Tape and enterprise emerging technology infrastructures will consume ~99% less power than SSD and HDD infrastructures and exceed SSD+HDD shipments beginning in 2035.
- The total “active archive” opportunity, including all tape and emerging enterprise storage shipments, will grow from 1.6ZB in 2030, to 13.5ZB in 2040, and to 34.4ZB in 2050. This opportunity could be much larger.
- There will be an increasingly immense appetite for the least-expensive costs per gigabyte combined with the greatest available capacities, and it is likely that SSD and HDD production capabilities will be limited.
- Tape and new breeds of enterprise storage will fill emerging gaps in required capacities, but this still may be insufficient to meet the explosively growing demand for a huge, active, “deep but accessible” archive.
- Despite the impacts of GenAI and its expansive high-speed need to summon and scrutinize increasingly gigantic chunks of data, not all data will need to be accessed and analyzed simultaneously, and at least 70% of all enterprise data will remain “cool” or “cold” or “frozen,” with access frequencies spanning minutes to years, with little or no need for the performance of SSDs and HDDs, but with greatly expanding needs for Sustainability, Immutability, and Security (SIS), which SSDs and HDDs—at least for the foreseeable future—can neither cost effectively nor power efficiently fulfill.
- As one of our survey respondents said in reference to the enduring virtues of tape and emerging storage media:  
*“Even with GenAI, you don’t need to plow a field with a Ferrari”—in most cases, oxen will suffice.*



# INCONCLUSIVE CONCLUSIONS

- To say the numbers in our new forecasts are staggering, even with our highly conservative 2031-2050 likely-case estimates of annual shipment growth, is an understatement of vast dimension.
- As we saw during the unprecedented downturns in 2022-2023 shipments, there must continue to be periodic perturbations that lead to curtailed production, more-limited growth rates, and more-profitable balances of supply and demand.
- Without these periodic downturns, enterprise storage growth—even at worst-case rates—cannot be feasibly sustained.
- In the end, the CFOs, with fervent approval from the CEOs and board members, will have the final say, and the most cost-effective technologies will inevitably prevail.

