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INTRODUCTION

This is the November 2020 issue of this newsletter and the third issue in the 2020-2021 annual volume.

This year marks the 35rd year of this newsletter, formerly called the Rigid Disk Heads and Media Newsletter (and originally published by Peripheral Research, Inc.).

Here are some **top items impacting digital storage in the third calendar quarter of 2020 (and the first month of CQ4 2020)**:

- Seagate and Western Digital have both changed their release of HDD shipment information during their quarterly announcements making it more difficult to figure out their actual unit shipments. WD started with their CQ3 2018 announcements while Seagate starting doing this in CQ1 2017. The latest quarterly numbers from Seagate only give quantitative information for mass capacity (mostly nearline and surveillance HDDs) and legacy HDDs. Western Digital's latest number give similar information. Also, Toshiba has changed their data presentation, starting in 2020, although there is still more detail available than for Seagate and Western Digital. This has made it more difficult to report actual shipments of various categories of HDDs. Thus, the numbers reported here are our best guess estimates.
- Total HDD shipments in C3Q 2020 were up 8.3% compared with C2Q 2020 (63.5M versus 58.7M), down 13.5% in C2Q from C1Q 2020, down 12.8% in C1Q 2020 from C4Q 2019, down 5.5% in C4Q from C3Q3 2019 and up 5.8% in C3Q from C2Q 2019.
- Notebook HDD shipments are estimated to be up 29.6% from the prior quarter while desktop HDD shipments are up by 17.2% Q2Q.
- CE HDD shipments were up 1.8% while branded shipments were up 23.5% Q2Q.
- High performance enterprise HDDs were up 12.9% while near line enterprise HDDs were down 15.8% Q2Q.
- 3.5-inch HDDs are estimated to have declined by 1.7% Q/Q. 2.5-inch HDDs increased by 23.4% Q2Q.
- Total 2020 HDD shipments through C3Q 2020 total 190M. We project C4Q 2020 shipments will be between 60 and 65M units, resulting in 250-255M total HDD shipments for the calendar year, down 19-21% from 316.3M shipped in 2019. Total decline in HDD shipments between 2018 and 2019 was 15.7%.
- There was an 7.6% ASP decrease from C3Q to C2Q 2020 compared to an 2.1% ASP increase from C2Q to C1Q 2020, an 8.9% ASP increase from C4Q 2019 to C1Q 2020, an 2.4% ASP increase from C3Q to C4Q 2019 and an 6.0% ASP increase from C2Q to C3Q 2019. The ASP decline in C3Q 2020 was due to declining nearline HDD shipments.
- In C2Q Seagate, WDC and Toshba had 44.3%, 39.4% and 16.3% market share. In C3Q these companies had 40.9%, 36.2% and 22.9% market

share. Toshiba gained market share from both Seagate and WDC QoQ. Toshiba gained 7% market share in nearline HDDs in C3Q and also gained market share in legacy drives QoQ.

- There was no growth in HDD areal density in CQ3 2020 and the growth of capacity-oriented Near Line drives for enterprise and hyperscale applications will result in more components per drive out to 2025. We project that total shipments of heads and media will exceed the peak in 2014 by 2024-2025 largely due to the growth of high capacity (many heads and media) hard disk drives.
- The industry is in a period of extended product and laboratory areal density stagnation, exceeding the length of prior stagnations.

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This issue has several guest articles by various friends of the Entertainment Storage Alliance including Steve Daniel, Jim Handy and Andy Marken. It also includes sales flyers for the **2020 Digital Storage in Media and Entertainment Report** and the **2020 Emerging Memory Report.**

Please let your friends know about this newsletter. There is a subscription form at the end of the report. Feel free to pass this newsletter to your friends in the industry.

Thanks for being a customer!

Tom Coughlin

SYSTEMS / SUBSYSTEM STORAGE PRODUCTS

CXL Consortium Releases Compute Express Link 2.0 Specification (Organization PR, 11/10/20)
The CXL Consortium, an industry standards body dedicated to advancing Compute Express Link (CXL) technology, announced the release of the CXL 2.0 specification. CXL is an open industry-standard interconnect offering coherency and memory semantics using high-bandwidth, low-latency connectivity between host processor and devices such as accelerators, memory buffers, and smart I/O devices. The CXL 2.0 specification adds support for switching for fan-out to connect to more devices; memory pooling for increased memory utilization efficiency and providing memory capacity on demand; and support for persistent memory – all while preserving industry investments by supporting full backwards compatibility with CXL 1.1 and 1.0.

"Datacenter architectures continue to evolve rapidly to support the growing demands of emerging workloads for Artificial Intelligence and Machine Learning, with CXL technology keeping pace to meet the performance and latency demands," said Barry McAuliffe, president, CXL Consortium. "Designed with breakthrough performance and easy adoption as guiding principles, the CXL 2.0 specification is a significant achievement from our dedicated technical work group members."

Key Highlights of the CXL 2.0 Specification:
- Adds support for switching to enable device fan-out, memory scaling, expansion and the migration of resources.
- Includes memory pooling support to maximize memory utilization, limiting or eliminating the need to overprovision memory.
- Introduces standardized fabric manager specification for inventory and resource allocation to enable easier adoption and management of CXL-based switch and fabric solutions.
- Provides standardized management of the persistent memory interface and enables simultaneous operation alongside DDR, freeing up DDR for other uses.
- Introduces managed hot-plug support to take a CXL device online or offline from the system.
- Adds link-level Integrity and Data Encryption (CXL IDE) to provide confidentiality, integrity and replay protection for data transiting the CXL link.
- Supports a wide variety of industry interconnect form factors and standardized management interfaces to ease implementation.
- Includes Compliance and Interoperability specifications and in-system testing to enable a robust and interoperable multi-vendor ecosystem.

Traditional PC Market Delivers Another Quarter of Double-Digit Growth in Q3 2020, According to IDC (IDC PR, 10/12/20)
As the global pandemic rages on and many countries around the world enter the second wave of COVID-19 infections, continuity of business and online schooling remain at the forefront of every economy. This led to double-digit growth in the traditional PC market, comprised of desktops, notebooks, and workstations, as global shipments grew 14.6% year over year to 81.3 million units in the third quarter of 2020 (3Q20), according to preliminary results from the International Data Corporation (IDC) Worldwide Quarterly Personal Computing Device Tracker.

"Consumer demand and institutional demand approached record levels in some cases," said Jitesh Ubrani research manager for IDC's Mobile Device Trackers. "Gaming, Chromebooks, and in some cases cellular-enabled notebooks were all bright spots during the quarter. Had the market not been hampered by component shortages, notebook shipments would have soared even higher during the third quarter as market appetite was yet unsatiated."

Unfortunately, shortages of multiple components, such as processors, panels, and other subcomponents, led to missed opportunity for many vendors. "The PC industry rode into the third quarter with a sizeable backlog of unfulfilled orders," said Linn Huang, research vice president, Devices and Displays at IDC. "And it appears the quarter will end under the same auspices. Given that the shortages have been due more to a shortfall of business planning than a technical glitch, we do not anticipate a sudden surge in capacity. Consequently, this backlog will likely carry into 2021."

Regional Highlights

Asia/Pacific (excluding Japan) (APeJ): The Traditional PC market posted a single digit increase in the region with results coming in above IDC's forecast. Shipments were driven by inventory replenishments and strong demand for notebooks as end users across the region continued to purchase devices for work from home, online learning, and entertainment purposes.

Canada: The Traditional PC market remained extremely active, posting the 17th consecutive quarter of gains. This is the second quarter where COVID-19-related restrictions were in effect, continuing to boost demand from Canadian households and from organizations looking to ensure business continuity through stay-at-home situations. The need for computing devices in Canada should remain high throughout the winter but spending might be impacted by the macro-economic situation, increasing pressure on average selling prices for the foreseeable future.

Europe, Middle East, and Africa (EMEA): Traditional PC shipments achieved high single-digit growth in 3Q20 as another exceptional quarter of growth for notebook outweighed heavy desktop declines. The ongoing lockdowns continued to drive high demand for notebooks to enable entertainment, working, and studying

from home. However, with offices largely remaining closed there was limited demand for stationary devices.

Japan: The GIGA project through which students all over the country receive PCs and tablets for online learning, as well as strong work-from-home demand helped maintain flat growth in the traditional PC market. The consumer segment declined year over year due to the high baseline set last year by the consumption tax hike and Windows 10 migrations.

Latin America: The traditional PC market posted double-digit growth for first time in five years. Despite price increases and economic contractions in many countries, the demand for portability continues to rise. Higher notebook demand due to work-from-home and online learning sustained the region's growth, which is expected to continue in most countries into early 2021.

USA: The traditional PC market witnessed yet another extraordinary quarter posting strong double-digit shipment growth. Preliminary results reflect continued strong buyer sentiment fueled by stay-at-home PC needs and resultant inventory replenishment. While notebook shipments strengthened further due to sustained demand from the consumer and education segments, the desktop market declined year over year but found some respite as gaming systems remained in demand.

Top 5 Companies, Worldwide Traditional PC Shipments, Market Share, and Year-Over-Year Growth, Q3 2020 (Preliminary results, shipments are in thousands of units)

Company	3Q20 Shipments	3Q20 Market Share	3Q19 Shipments	3Q19 Market Share	3Q20/3Q19 Growth
1. Lenovo	19,272	23.7%	17,310	24.4%	11.3%
2. HP Inc.	18,690	23.0%	16,805	23.7%	11.2%
3. Dell Technologies	11,996	14.8%	12,098	17.1%	-0.8%
4. Apple	6,890	8.5%	4,959	7.0%	38.9%
5. Acer Group	6,005	7.4%	4,644	6.6%	29.3%
Others	18,419	22.7%	15,091	21.3%	22.1%
Total	**81,272**	**100.0%**	**70,907**	**100.0%**	**14.6%**

Source: IDC Quarterly Personal Computing Device Tracker, October 12, 2020

Notes:
- Some IDC estimates prior to financial earnings reports. Data for all companies are reported for calendar periods.
- Shipments include shipments to distribution channels or end users. OEM sales are counted under the company/brand under which they are sold.
- Traditional PCs include Desktops, Notebooks, and Workstations and do not include Tablets or x86 Servers. Detachable Tablets and Slate Tablets are

part of the Personal Computing Device Tracker but are not addressed in this press release.

Hard Disk Drives and Tape

Backblaze Hard Drive Stats for Q3 2020 (Company PR, 10/20/20)
As of September 30, 2020, Backblaze had 153,727 spinning hard drives in our cloud storage ecosystem spread across four data centers. Of that number, there were 2,780 boot drives and 150,947 data drives. This review looks at the Q3 2020 and lifetime hard drive failure rates of the data drive models currently in operation in our data centers and provides a handful of insights and observations along the way. As always, we look forward to your comments.

Quarterly Hard Drive Failure Stats for Q3 2020

At the end of Q3 2020, Backblaze was using 150,974 hard drives to store customer data. For our evaluation we remove from consideration those drive models for which we did not have at least 60 drives (more on that later). This leaves us with 150,757 hard drives in our review. The table below covers what happened in Q3 2020.

Observations on the Q3 Stats

There are several models with zero drive failures in the quarter. That's great, but when we dig in a little we get different stories for each of the drives.

Backblaze Annualized Hard Drive Failure Rates for Q3 2020
Reporting period: July 1, 2020 through 30 September 2020 inclusive

MFG	Model	Drive Size	Drive Count	Avg Age	Drive Days	Drive Failures	AFR
HGST	HMS5C4040ALE640	4TB	3,023	53.8	274,923	0	0.00%
HGST	HMS5C4040BLE640	4TB	12,737	47.5	1,171,895	7	0.22%
HGST	HUH728080ALE600	8TB	1,032	33.2	92,702	2	0.79%
HGST	HUH721212ALE600	12TB	2,600	12.1	238,966	2	0.31%
HGST	HUH721212ALE604	12TB	1,909	1.5	67,002	2	1.09%
HGST	HUH721212ALN604	12TB	10,838	18.0	997,546	10	0.37%
Seagate	ST4000DM000	4TB	19,024	59.4	1,753,271	69	1.44%
Seagate	ST6000DX000	6TB	886	65.9	81,512	1	0.45%
Seagate	ST8000DM002	8TB	9,801	48.1	901,933	28	1.13%
Seagate	ST8000NM0055	8TB	14,425	38.4	1,328,845	51	1.40%
Seagate	ST10000NM0086	10TB	1,200	36.0	110,396	3	0.99%
Seagate	ST12000NM0007	12TB	28,867	26.9	2,944,060	65	0.81%
Seagate	ST12000NM0008	12TB	18,339	7.2	1,557,673	42	0.98%
Seagate	ST12000NM001G	12TB	6,139	3.8	547,693	10	0.67%
Seagate	ST14000NM001G	14TB	2,400	0.7	21,120	0	0.00%
Seagate	ST16000NM001G	16TB	60	9.9	5,428	0	0.00%
Seagate	ST18000NM000J	18TB	60	0.4	300	0	0.00%
Toshiba	MD04ABA400V	4TB	99	64.3	9,108	0	0.00%
Toshiba	MG07ACA14TA	14TB	17,318	5.9	1,186,511	32	0.98%
	TOTALS		**150,757**		**13,290,884**	**324**	**0.89%**

BACKBLAZE

● The 18TB Seagate model (ST18000NM000J) has 300 drive days and they've been in service for about 12 days. There were no out of the box failures which is a good start, but that's all you can say.

● The 16TB Seagate model (ST16000NM001G) has 5,428 drive days which is low, but they've been around for nearly 10 months on average. Still, I wouldn't try to draw any conclusions yet, but a quarter or two more like this and we might have something to say.

● The 4TB Toshiba model (MD04ABA400V) has only 9,108 drive days, but they have been putting up zeros for seven quarters straight. That has to count for something.

● The 14TB Seagate model (ST14000NM001G) has 21,120 drive days with 2,400 drives, but they have only been operational for less than one month. Next quarter will give us a better picture.

● The 4TB HGST (model: HMS5C4040ALE640) has 274,923 drive days with no failures this quarter. Everything else is awesome, but hold on before you run out and buy one. Why? You're probably not going to get a new one and if you do, it will really be at least three years old, as HGST/WDC hasn't made these drives in at least that long. If someone from HGST/WDC can confirm or deny that for us in the comments that would be great. There are stories dating back to 2016 where folks tried to order this drive and got a refurbished drive instead.

If you want to give a refurbished drive a try, that's fine, but that's not what our numbers are based on.

The Q3 2020 annualized failure rate (AFR) of 0.89% is slightly higher than last quarter at 0.81%, but significantly lower than the 2.07% from a year ago. Even with the lower drive failure rates, our data center techs are not bored. In this quarter they added nearly 11,000 new drives totaling over 150PB of storage, all while operating under strict Covid-19 protocols. We'll cover how they did that in a future post, but let's just say they were busy.

Lifetime Hard Drive Failure Rates

The table below shows the lifetime AFR for the hard drive models we had in service as of September 30, 2020. All of the drive models listed were in operation during this timeframe.

The lifetime AFR as of Q3 2020 was 1.58%, the lowest since we started keeping track in 2013. That is down from 1.73% one year ago, and down from 1.64% last quarter.

Backblaze Lifetime Annualized Hard Drive Failure Rates
Reporting period: April 20, 2013 through 30 September 2020 inclusive

MFG	Model	Drive Size	Avg Age	Drive Count	Drive Days	Drive Failures	AFR
HGST	HMS5C4040ALE640	4TB	53.8	3,023	12,476,131	170	0.50%
HGST	HMS5C4040BLE640	4TB	47.5	12,737	23,069,669	270	0.43%
HGST	HUH728080ALE600	8TB	33.2	1,032	1,113,086	20	0.66%
HGST	HUH721212ALE600	12TB	12.1	2,600	908,168	10	0.40%
HGST	HUH721212ALE604	12TB	1.5	1,909	67,002	2	1.09%
HGST	HUH721212ALN604	12TB	18.0	10,838	5,891,093	75	0.46%
Seagate	ST4000DM000	4TB	59.4	19,024	57,835,040	4,029	2.54%
Seagate	ST6000DX000	6TB	65.9	886	3,145,481	86	1.00%
Seagate	ST8000DM002	8TB	48.1	9,801	14,491,613	414	1.04%
Seagate	ST8000NM0055	8TB	38.4	14,425	17,133,800	569	1.21%
Seagate	ST10000NM0086	10TB	36.0	1,200	1,335,422	28	0.77%
Seagate	ST12000NM0007	12TB	26.9	28,867	30,486,342	1,739	2.08%
Seagate	ST12000NM0008	12TB	7.2	18,339	3,909,226	108	1.01%
Seagate	ST12000NM001G	12TB	3.8	6,139	685,622	18	0.96%
Seagate	ST14000NM001G	14TB	0.7	2,400	21,120	-	0.00%
Seagate	ST16000NM001G	16TB	9.9	60	15,895	1	2.30%
Seagate	ST18000NM000J	18TB	0.4	60	300	-	0.00%
Toshiba	MD04ABA400V	4TB	64.3	99	261,874	5	0.70%
Toshiba	MG07ACA14TA	14TB	5.9	17,318	2,983,751	84	1.03%
	TOTALS			150,757	175,830,635	7,628	1.58%

BACKBLAZE

We added back the average age column as "Avg Age." This is in months and is the average age of the drives used to compute the data in the table and is based on the amount of time they have been in operation. One thing to remember is that our environment is very dynamic with drives being added, being migrated, and leaving on a regular basis and this could impact the average age. For example, we could retire a Storage Pod with mostly older drives and that could lower the average age of the remaining drives of that model while those remaining drives got older.

Looking at the average age, the 6TB Seagate drives are the oldest cohort, averaging nearly five and a half years of service each. These drives have actually gotten better over the last couple years and are aging well with a current lifetime AFR of 1.0%.

Flash Memory and DRAM

3D NAND Market to Grow to $81 Billion in 2025 (Storage Newsletter, 11/10/20)
Article *extracted from:*

- *Equipment and materials for 3D NAND manufacturing 2020, Yole Développement, 2020*
- *NAND quarterly market monitor, Yole Développement, 3Q20*
- *YMTC's 3D NAND flash memory, System Plus Consulting, 2020*

3D NAND equipment market: a long-term growth

Highlights:
• 3D NAND has become a mainstream technology because of its excellent scalability that allows increased bit density and lower cost-per-bit via vertical stacking of memory cells.
• Advances in the field of 3D NAND manufacturing are enabled by both equipment and material developments.
• Market figures:
3D NAND market is expected to grow to $81 billion in 2025 with a 11% CAGR between 2019 and 2025. The 3D NAND equipment market including etching, deposition and lithography, will grow to $17.5 billion by 2025, showing a 9% CAGR during the same period.
• Technology status: 3D NAND memory manufacturers will adopt different strategies to increase the number of layers and the overall bit density per die.
• Competitive landscape: The equipment market is dominated by USA, followed by Japan and Netherland. Four companies, ASML, Applied Materials, Tokyo Electron and Lam Research – hold more than 70% of the overall equipment market. In the 3D NAND business, Samsung is the clear technology leader with fierce competition from WD-Kioxia, followed by SK hynix and Micron-Intel.

Leading the NAND memory market in China, YMTC looms on the horizon and threatens to disrupt the status-quo.

DRAM & NAND process mix evolution in 300mm wafer units production

(Source: Status of the Memory Industry 2020 report, Yole Développement, 2020)
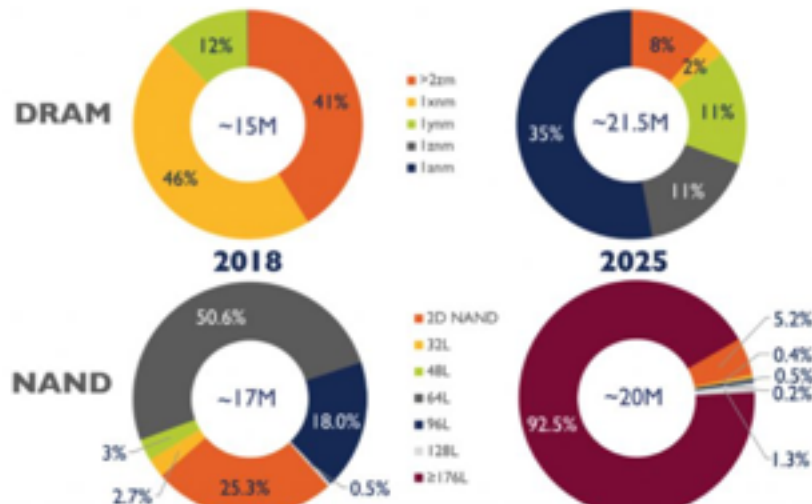
2019 – 2025 stand-alone memory market revenue forecast with breakdown by technologies

(Source: Status of the Memory Industry 2020 report, Yole Développement, 2020)
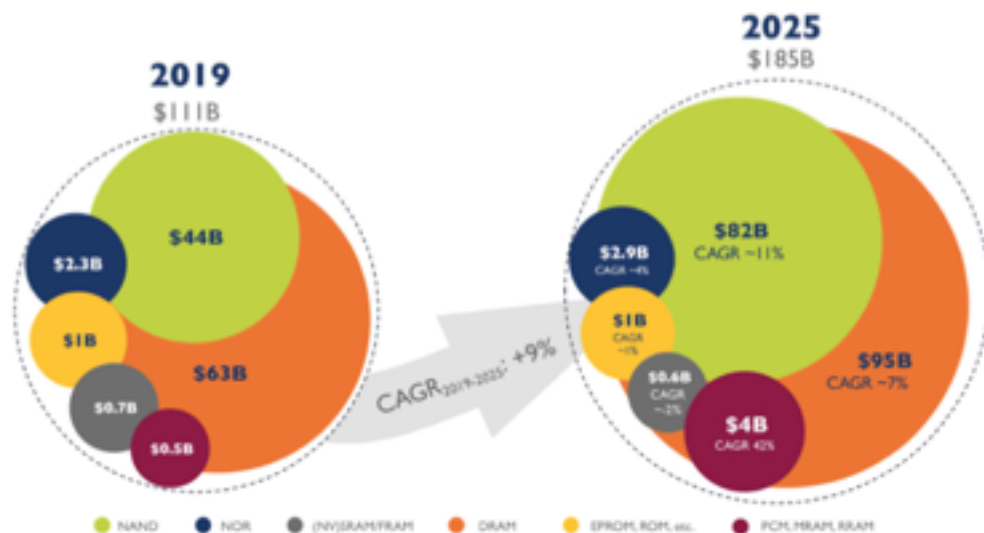
3D NAND & DRAM: timeline and time-to-market of technology generation by key players

(Source: Status of the Memory Industry 2020 report, Yole Développement, 2020)
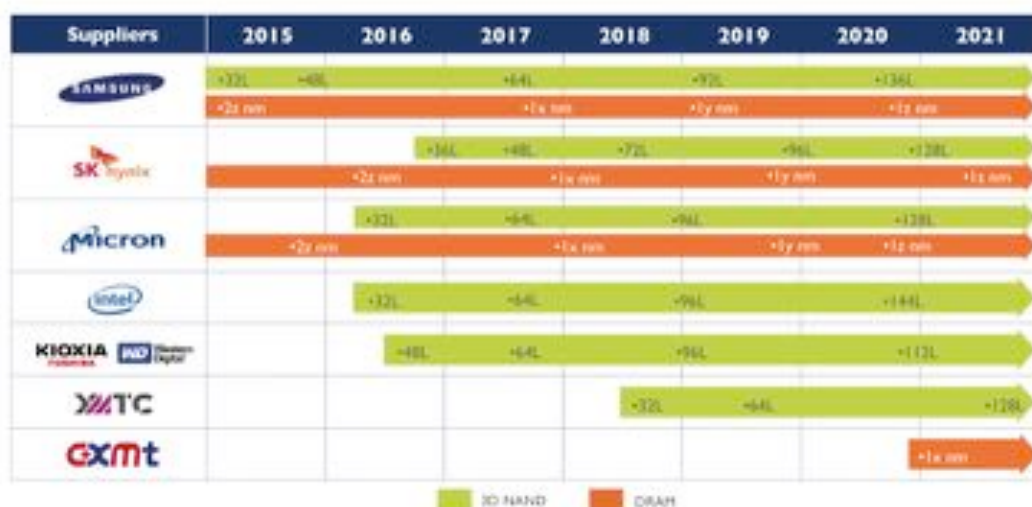
"*The 3D NAND manufacturing equipment market will keep growing, propelled by robust long term NAND-bit demand and ever-increasing manufacturing complexity,*" asserts Simone Bertolazzi, PhD, technology and market analyst with the semiconductor and software division, Yole.

The 3D NAND equipment market spanning etching, deposition and lithography equipment is expected to grow from $11 billion in 2019 to $17.5 billion by 2025. This industry will be driven by the etching market segment, with a CAGR around 10%, and deposition, with a CAGR around 9%, between 2019 and 2025.

Four companies are leading this market: Applied Materials, ASML, Tokyo Electron and Lam Research.

For the 3D NAND business, market figures are significant: analysts announce a 9% CAGR between 2019 and 2025 with a growth from $11 to $17.5 billion at the end of the period.

"*3D NAND does not require advanced lithography, but it is highly demanding in terms of deposition and etching, as sophisticated HAR (High Aspect Ratio) dry etching tools are needed for processing deep and narrow structures in dielectric stacks*," comments Bertolazzi.

In the *NAND Quarterly Market Monitor, 3Q20*, analysts affirms that NAND's competitive landscape remains incredibly dynamic. Samsung is utilizing its massive new Pyeongtaek site and expanding its facilities in Xi'an, China; Kioxia and its partner Western Digital continue to expand their footprint in Japan; Micron and SK Hynix remain competitive despite smaller manufacturing capacities; and

Intel has emerged as a stand-alone supplier with capacity in China. In addition, it is also important to notice SK Hynix acquisition of Intel's NAND business that took place on October 20.

Meanwhile, a new entrant looms on the horizon: China's YMTC, which threatens to disrupt the status-quo. Indeed, YMTC is the leading NAND memory maker in China.

According to Walt Coon, Yole: "*The company is currently shipping 64-layer NAND in low volumes domestically, including SSDs, with 128-layer production under development (shipments expected in 2021). YMTC's 2020 ramp has been hampered by Covid-19, with delays in equipment deliveries/installations at its Wuhan manufacturing site.*"

Belinda Dube, technology and cost analyst, System Plus Consulting, comments: "*CMOS periphery and NAND array wafer are manufactured separately. Wafers are connected by copper to copper hybrid bonding. And the bonding technique needs a high level of accuracy and alignment precision to perfectly join the metal layers from different wafers. YMTC's Xtacking process allows the company to increase its die density.*"

YMTC's memory enters the NAND flash market as a solution to cater for higher I/O speed because of the use of advanced CMOS that can be manufactured on a different wafer from the NAND array. Consequently, this memory provides the combination of high speed and large density characteristics.

In the highly competitive 3D NAND business, there is need for ad hoc tools capable of addressing complex challenges:
• Etching tools must drill deep channel holes from the top of the device to the bottom substrate.
• Deposition tools must produce high-quality defect-free thin films with nm thicknesses.
• Metrology/inspection tools are also becoming essential to monitor the processes and maintain high yields. Ideally, these challenging tasks need to be accomplished in the fastest possible time and lowest cost.

"*In this framework, the competition among equipment suppliers to deliver the best solutions is growing fierce,*" comments Bertolazzi. "*Besides equipment technology development, a great deal of R&D effort has to be focused on finding new material solutions.*"

In this context, specific technical strategies are needed for next-gen 3D NAND products.

Three focus areas have been identified by Yole's memory team:
• **String-stacking:** whereas all players have already adopted a double-stack

approach, Samsung, the industry leader, is the only player to develop the 128-layer gen with a single-string approach and thus enjoys higher margins on NAND than other chip makers. For the following gen, Samsung is expected to adopt double stacking.

• **Cell Architecture**: all the manufacturers except Intel have adopted the CT (Charge Trap) solution for their 1xx 3D NAND technologies. Intel has recently announced the sale of its 3D NAND business to SK Hynix, and Yole expects they could shift from FG (Floating Gate) to CT as the deal with SK Hynix moves forward. The transfer of the NAND business is expected to be completed by 2025.

• **Logic circuit position:** besides Micron, with CUA (Circuit-Under-Array), SK Hynix, with 4D-NAND, and YMTC, with Xtacking, all players need to implement specific solutions to minimize the silicon-area consumption of the CMOS logic circuit. Nowadays, all major 3D NAND manufacturers are carrying out R&D activities to explore the use of wafer-to-wafer stacking approaches based on hybrid bonding. Samsung has not yet disclosed an approach to minimize the CMOS logic circuit area and a has strong know∂ci -how in bonding technologies stemming from its CIS (CMOS image sensor) and HBM (High-Bandwidth Memory) businesses. It could be a potential candidate for the adoption of hybrid bonding for 3D NAND. SK hynix could follow Samsung

Capital Equipment

300mm Fab Spending to Boom through 2023 with Two Record Highs, SEMI Reports (SEMI Press Release, 11/3/20)
300mm fab investments in 2020 will grow by 13% year-over-year (YoY) to eclipse the previous record high set in 2018 and log another banner year for the semiconductor industry in 2023, SEMI reported today in its *300mm Fab Outlook to 2024*. The COVID-19 pandemic has sparked the 2020 surge in fab spending by accelerating digital transformations worldwide, and the increase is expected to stretch into 2021.

Powering the growth is rising demand for cloud services, servers, laptops, gaming and healthcare technology. Fast-evolving technologies such as 5G, Internet of Things (IoT), automotive, artificial intelligence (AI) and machine learning that continue to fuel demand for greater connectivity, large data centers and big data are also behind the increase.

"The COVID-19 pandemic is accelerating a digital transformation sweeping across nearly every industry imaginable to reshape the way we work and live," said Ajit Manocha, SEMI president and CEO. "The projected record spending and 38 new fabs reinforce the role of semiconductors as the bedrock of leading-edge technologies that are driving this transformation and promise to help solve some of the world's greatest challenges."

Growth in semiconductor fab investments will continue in 2021 but at a slower rate of 4% YoY. Mirroring previous industry cycles, the report also predicts a mild slowdown in 2022 and another slight downturn in 2024 following a $70 billion record high in 2023. See figure 1.
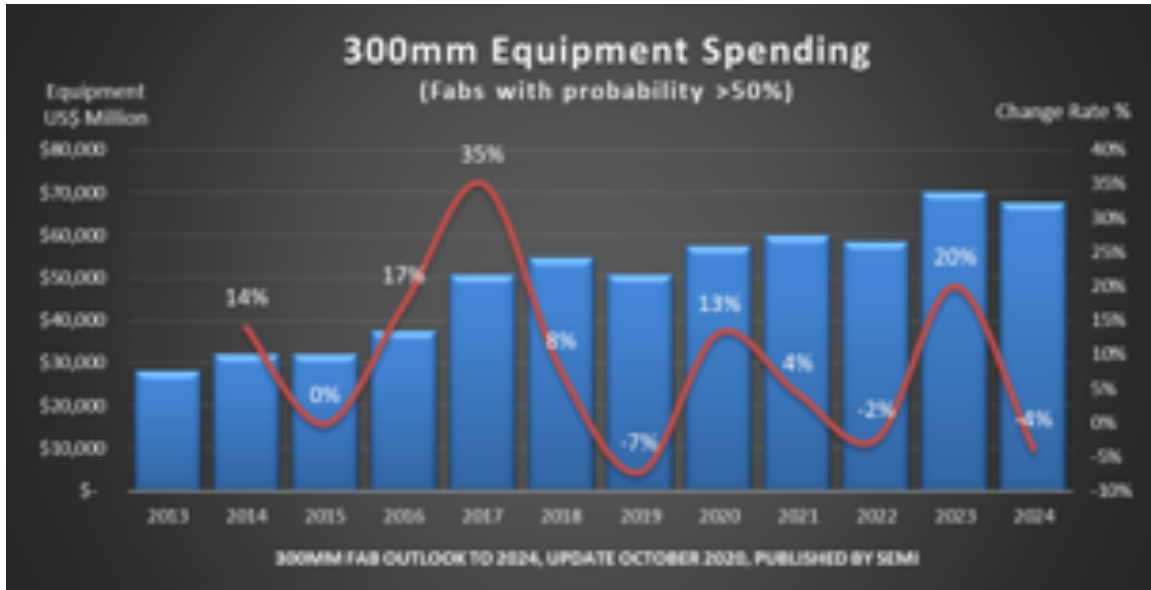
Figure 1: 300mm fab equipment spending from 2013 to 2024

Adding 38 New 300mm Fabs

The SEMI *300mm Fab Outlook to 2024* shows the chip industry adding at least 38 new 300mm volume fabs from 2020 to 2024, a conservative projection that does not factor in low-probability or rumored fab projects. During the same period, per-month fab capacity will grow by about 1.8 million wafers to reach over 7 million. See figure 2.

Under a high-probability project forecast, the industry will add at least 38 new 300mm volume fabs from 2019 to 2024. Taiwan will add 11 volume fabs and China eight to account for half of the total. The chip industry will command 161 300mm volume fabs by 2024.
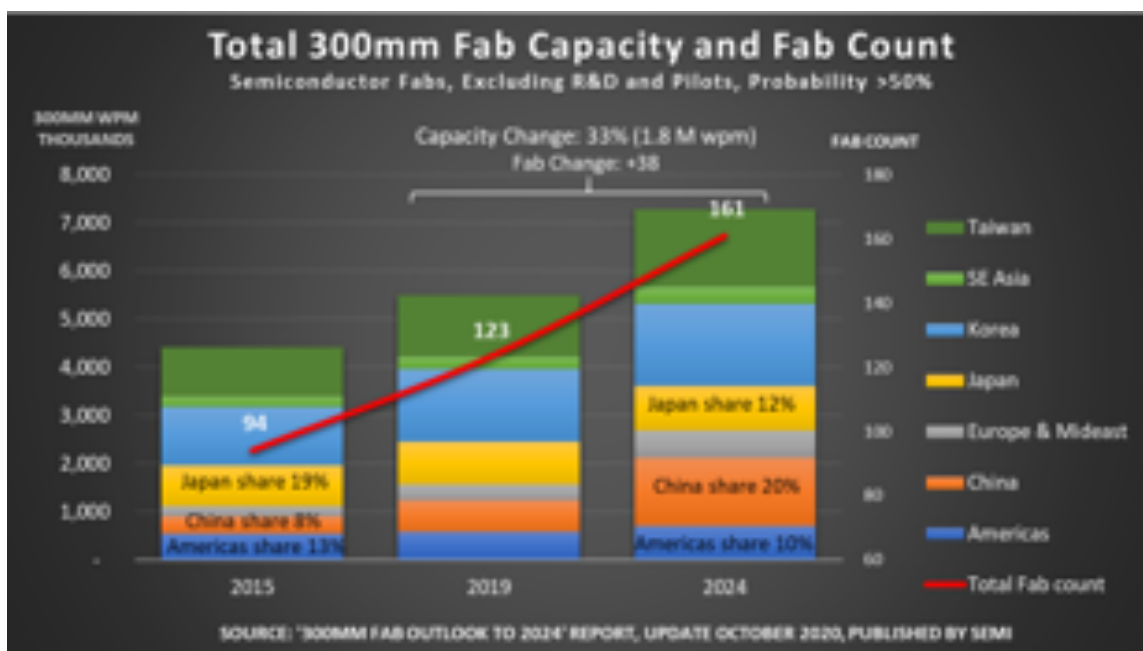
Figure 2: Total 300mm fab capacity and fab count for 2015, 2019 and 2024

Capacity and Spending Growth by Region

China will rapidly increase its global share of 300mm capacity, from 8% in 2015 to 20% in 2024, reaching 1.5 million 300mm wpm in the final year of the reporting period. While non-Chinese companies will account for a substantial portion of that growth, Chinese-owned organizations are accelerating their capacity investments. These companies will represent about 43% of China's fab capacity in 2020, a proportion expected to reach 50% by 2022 and 60% by 2024.

Japan's share of 300mm installed capacity continues to trend downward, from 19% in 2015 to 12% in 2024. The Americas' share is also ticking lower, from 13% in 2015 to a projected 10% in 2024.

The biggest regional spenders will be Korea, with investments between US$15 billion and US$19 billion, followed by Taiwan, which will pour between US$14 billion and US$17 billion into 300mm fabs, and then China, with between US$11 billion and $13 billion in investments.

Regions spending less will see the steepest increases in investments between 2020 to 2024. Europe/Mideast will lead the pack with impressive 164% growth, followed by Southeast Asia at 59%, Americas at 35%, and Japan at 20%.

Spending Growth by Product Sector

Memory accounts for the bulk of the increase in 300mm fab spending. Actual and forecast investments show a steady rise in the upper single digits for each year from 2020 to 2023, with a stronger increase of 10% in store for 2024.

DRAM and 3D NAND contributions to 300mm fab spending will be uneven from 2020 to 2024. Investments for logic/MPU, however, will see steady improvement from 2021 to 2023. Power-related devices will be the standout sector in 300mm fab investments, with over 200% growth in 2021 and double-digit increases in 2022 and 2023.

Tracking 286 fabs and lines from 2013 to 2024, the *300mm Fab Outlook to 2024* reflects 247 updates to 104 fabs, nine new fab and line listings, and two cancellations since the publication of the March 2020 report.

Global Silicon Wafer Shipments on Track for 2020 Recovery and 2022 Record High (SEMI PR, 10/13/20)
Global silicon wafer shipments are set to increase 2.4% year-over-year in 2020, with growth continuing in 2021 and shipments reaching a record high in 2022, SEMI reported today in its annual silicon shipment forecast for the semiconductor industry.
"Silicon wafer shipments are recovering this year despite pressure from geopolitical tensions, the shifting global semiconductor supply chain and the COVID-19 pandemic," said Clark Tseng, director of Industry Research and Statistics at SEMI. "With the pandemic accelerating digitization to transform businesses and their delivery of services worldwide, we expect continued growth over the next two years."

2020 Silicon* Shipment Forecast (MSI = Millions of Square Inches)

	Actual		Forecast			
	2018	**2019**	**2020**	**2021**	**2022**	**2023**
MSI	12,541	11,677	11,957	12,554	13,220	13,761
Annual Growth	8.0%	-6.9%	2.4%	5.0%	5.3%	4.1%

*Total Electronic Grade Silicon Slices – Excludes Non-Polished Wafers

*Shipments are for semiconductor applications only and do not include solar applications

Source: SEMI (www.semi.org), September 2020

Silicon Wafer Shipments Slip in Third Quarter 2020 but Strong for Year (SEMI PR, 11/2/20)
Worldwide silicon wafer area shipments contracted 0.5% to 3,135 million square inches in the third quarter of 2020 compared to the second quarter of the year but registered a 6.9% increase from the 2,932 million square inches shipped one year ago during the same quarter, according to the SEMI Silicon Manufacturers Group (SMG) in its quarterly analysis of the silicon wafer industry.
"After a strong rebound in the first half of 2020, global silicon wafer shipments in the third quarter were flat to the previous quarter," said Neil Weaver, chairman of

SEMI SMG and vice president of Product Development and Applications Engineering at Shin Etsu Handotai America.

Silicon Area Shipment Trends - Semiconductor Applications Only

	Millions of Square Inches					
	2Q 2019	3Q 2019	4Q 2019	1Q 2020	2Q 2020	3Q 2020
Total	2,983	2,932	2,844	2,920	3,152	3,135

Source: SEMI (www.semi.org), November 2020

All data cited in this release includes polished silicon wafers such as virgin test wafers and epitaxial silicon wafers, as well as non-polished silicon wafers shipped to end users.

ARTICLES 8/10 Cornucopia

1) **Micron 176-Layer NAND Offers Density, Fast Performance State Storage For Cloud and Hybrid Workflows (Forbes, 11/7/20)**

Micron announced that it is shipping 176-layer TLC NAND flash in its Crucial SSD product for consumer applications. These flash memory die are being manufactured in the company's Singapore semiconductor fab. Prior NAND flash announcements this year have been for as high as 128-layer NAND flash, including Micron announcements. The company said that its 176-layer NAND is built from two 88-layer stacks. Some details about the announcement are shown below.

They also said that that with this product the company from floating gate to charge-trap technology for the storage cell and included CMOS chip logic under the flash array, as in recent Micron NAND flash products (the company's CuA technology). The move to charge-trap memory cells combined with Micron's replacement-gate architecture, which uses highly conductive metal wordlines instead of a silicon layer allowed achieving unparalleled 3D NAND performance. Micron said that this combination of technologies will also enable the company to drive aggressive, industry-leading cost reductions.

The company also said that it would have 65% fewer blocks in the NAND pages, which can be used to reduce writing and thus wear on the NAND flash cells. The 176-layer Micron NAND layers are thinner than prior products. The height of the 176-layer NAND stack was said to be the same as prior generation 64-layer Micron NAND. The 176-layer NAND results in a 30% smaller die size for a 512 Gb die.

Micron also says it has improved write latency and read latency by 35%. The company also reports a 33% increase in data transfer rate with industry-leading

1,600 mega-transitions per second on an ONFI bus. They also reported 35% improved read latency and 25% improved write latency, due to metal word lines, smaller page density and less overhead. Mobile storage is said to be 15% faster with a mixed workload.

In other updates Micron said that its X-100 SSD with 3D XPoint technology was released last Fall and that the company has customers, although it wouldn't disclose them. There will be presentations on the company's X-100 drives during the 2020 Flash Memory Summit this week.

Micron announced in late October that its uMCP5, universal flash storage (UFS) multichip package with low-power DDR5 (LPDDR5) DRAM was now available for mass production. The company said that its "uMCP5 combines high-performance, high-density and low-power memory and storage in one compact package, equipping smartphones to handle data-intensive 5G workloads with dramatically increased speed and power efficiency. The multichip package uses Micron's LPDDR5 memory, high-reliability NAND and leading-edge UFS 3.1 controller to power advanced mobile features previously only seen in costly flagship devices using discrete products, such as stand-alone memory and storage."

176-layer TLC NAND flash from Micron will enable higher density, higher performance NAND flash for SSDs and other applications. Initially available in the company's consumer Crucial SSD products, Micron intends to use the new high density flash in cloud and edge computing applications as well.

2) Solid State Storage for Cloud and Hybrid Workflows (Forbes, 11/5/20)
At NetApp's recent Insights virtual event it announced new all flash solutions for performance and capacity and ONTAP 9.8 support for hybrid cloud. At the 2020 virtual IBC ATTO recently announced an all DRAM SiliconDisk accelerator and Cloudian announced that its HyperStore object storage software is now flash optimized for mixed SSD and HDD storage systems.

NetApp's Cloud Manager provides policy driven management of application storage and data across multiple public cloud providers and on-premises locations. The Spot by NetApp Product Suite providing cloud infrastructure analytics, cost optimization, capacity optimization and workload optimization for Kubernetes containers. The company's ONTAP 9.8 provides increased cloud integration and data availability for enterprise applications. ONTAP 9.8 provides a hybrid cloud cache architecture, continuous availability and unified data management over SAN, NAS and object storage. The company also announced its Virtual Desktop 6.0 and virtual desktop managed service.

NetApp has long supported Dreamworks animation, which requires a balance of storage capacity and performance. The new FAS500f (shown below) is an all flash capacity oriented 2U high availability storage array (up to 734TB raw capacity with an expansion shelf) using QLC flash SSDs to provide higher capacity. It can scale

to 24 nodes and supports 2-4 ms latencies. This product has end to end NVMe support, has NVME over fibre channel with 32Gb FC and 25GbE ports and is managed by NetApp's ONTAP software. The product is targeted at high volume unstructured data applications, such as media and entertainment, animation, EDA, CAD/CAE and medical imaging.

NetApp also introduced an entry level all flash array (AFF), its 2U AFF A250 can hold 24 embedded NVMe SSDs with NVMe over fibre channel. It is available in a all SAN array (ASA) and is targeting enterprise applications, virtualization and consolidation. This product sis scheduled to start shipping in early December.

NetApp says it is providing a flexible path to cloud-enabled data centers with Updates to its NetApp Keystone Flex Subscription, providing a fast, flexible path to a cloud-enabled data center with "pay-as-you-grow" subscriptions for a cloudlike experience on premises. The Keystone Flex Subscription also offers public cloud integration available through the NetApp partner ecosystem. The new NetApp SolidFire Enterprise SDS solution, provides a simple and automated foundation for private cloud with NetApp Element® software as standalone software-defined storage that can be deployed on any hardware.

At the 2020 IBC ATTO was showing their SiliconDisk RAM-based, high performance storage appliance, with advertised capacities of 128GB and 512GB. Using RAM, rather than flash memory, this product provides much higher performance, for a price.

This product provides latencies less than 600 ns and up to 6.4M 4K IOPS and data transfer bandwidth up to 25 GB/s. It comes with 4-100 Gb Ethernet ports for a total of 400Gb of bandwidth. According to the company, "Data is instantly stored and retrieved with incredible speed letting you edit more streams of video, capture more data instances for AI/ML, manipulate more data sets quicker, and provides incredible performance to index look-ups."

The SiliconDisk includes a real time optimizer that provides performance analytics on your storage network connections, storage utilization and overall SiliconDisk data performance. It also has an xCORE I/O acceleration, handling reads and writes with almost zero additional processing overhead. Also, using DRAM, rather than flash memory, the system doesn't need to manage media wear.

At the start of the 2020 IBC, Cloudian announced that its HyperStore object storage software is now flash-optimized, enabling enterprises to meet the needs of performance-intensive workloads while deploying flash and HDD-based nodes with an adaptive hybrid architecture allows customers to reduce total cost by 40% by tiering less frequently used data to the HDD storage. HyperStore is available either as a software-only solution or in a pre-configured appliance, the HyperStore Flash 1000 series. The HyperStore Flash 1000 offers 77TB and 154TB capacities in a 1U form facto and is shown below.

HyperStore Flash 1000
- High-performance 1U platform
- 12x hot swappable 2.5" NVMe drives
  (including 2x drives for metadata)
- 76.8TB or 153.6TB raw storage capacity
- 10/25GbE and 40/100GbE networking
  options

According to the company, "Cloudian's new flash-optimized software delivers the needed performance while providing all the advantages of Cloudian's enterprise-grade object storage platform, including fully native S3 compatibility, industry-leading security and advanced management features such as multi-tenancy and quality-of-service. The flash-optimized HyperStore leverages the reduced-latency I/O profile of flash media on industry-standard hardware, delivering partial-object reads and low latency data accesses at scale. Cloudian's platform is certified with leading NVMe suppliers such as Intel and Kioxia and is Intel Optane-ready for even greater performance."

NetApp, ATTO and Cloudian leverage solid state storage to accelerate local workloads and enable hybrid cloud storage solutions.

3) Intel Sells its NAND Flash Business to SK Hynix (Forbes, 10/19/20)

Intel has reached a deal to sell its flash-memory business to SK Hynix from South Korea for about $9B. According to the Wall Street Journal, SK Hynix will buy most of Intel's memory business, including the related memory manufacturing operations in Dalian, China. It appears that Intel's SSD business is part of the deal. Intel plans to keep its Optane memory products, particularly its DIMM memory modules, which is closely tied to Intel's next generation of enterprise server CPUs. The image below shows an Intel NAND flash and Optane SSD.

The announcement said that the Intel NAND flash operations generated about $2.8B in sales in the first six months of 2020. Intel's overall memory sales during this period was about $3B. Intel' NAND flash revenue market share in C2Q 2020 was about 11%. Combined with SK Hynix's 12% market share, this will give SK Hynix over 20% NAND flash market share.

This acquisition makes SK Hynix the second largest NAND flash manufacturer after Samsung with 31% in C2Q 2020. Kioxia, Western Digital and Micron had 17%, 16% and 13.7% market share in the same period. Yangtze Memory in China

is a much smaller NAND flash manufacturer. The total number of NAND flash manufacturers will shrink from about 7 to 6 players.

SK Hynix has been looking at ways to expand its NAND flash business so it can have a larger market share. SK Hynix is the number two manufacturer of DRAM, second to Samsung. Before the Kioxia IPO was pulled, there were reports that SK Hynix had hoped to increase its ownership of Kioxia during the IPO.

In March 2020, Intel's CFO George Davis said that the company was unable to sell enough SSDs to make a profit from the 3D NAND chips it made in its Dalian, China factory. Davis said that Intel was exploring options such as closing its factory and buying chips from others or selling chips to third parties, or buying SSDs from a third party.

Chris Mellor of Blocks&Files said that a Chinese media report posted in July 2019 said that Hynix plans to acquire Intel's Fab 68 factory in Dalian, China. Hynix wanted to acquire the entire Dalian factory and 3D NAND business. Mellor said that Aaron Rakers from Wells Fargo told his subscribers that Intel NAND operating income was -$340M for the 12-months ending C2Q 2020 (source said to be from DRAMeXchange).

In a recent Forbes.com blog looking at WDC's NAND flash and HDD business we pointed out that NAND flash is currently in an oversupply situation with contract NAND flash prices at a considerable low compared to prior years, although it may be near or at the end of the oversupply as shown below. This chart, showing WDC flash memory gross margins, shows that flash profitability generally follows the flash boom/bust cycle of oversupply and undersupply.
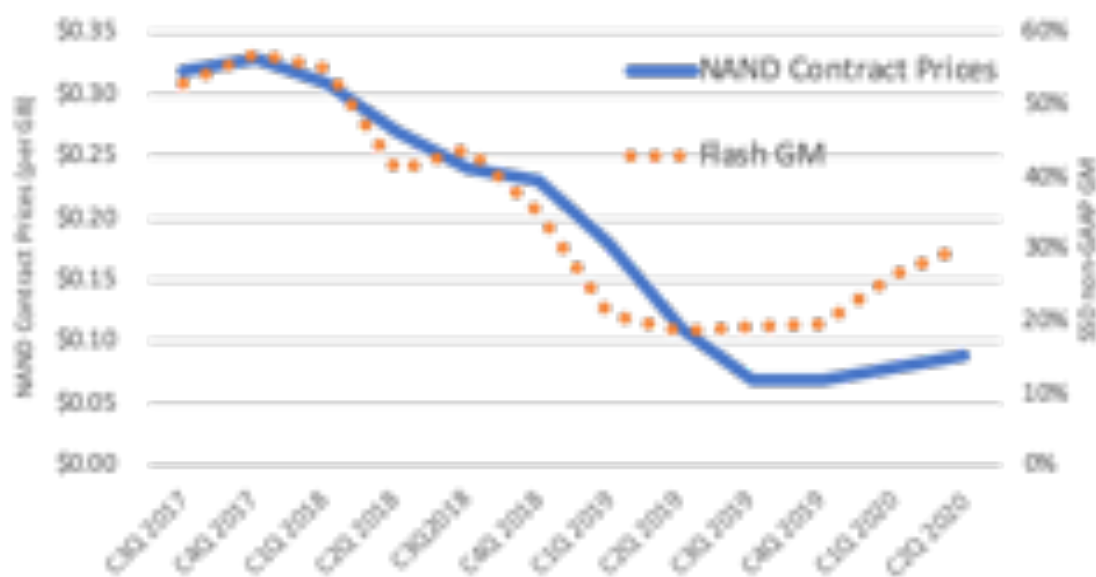
In its C2Q 2020 report Intel seemed to indicate that its Optane memory products were no longer losing money. If so, that may indicate that the production volume of these phase change memory devices has finally reached a level that the company can sell these products for more than the cost of manufacture.

Intel is selling these products at about half the price of DRAM in order to make them attractive to replace or expand DRAM in computer systems and servers. Intel has tied the beneficial use of Optane to its latest generation of server chips. This combination of better profitability Optane and having it be part of its server microprocessor strategy is probably one of the reasons that the company is keeping this part of its memory business.

When this sale is completed SK Hynix will have achieved second place in both DRAM and NAND flash production capacity. With a possible easing of the current NAND oversupply in the next few months, as well as fewer companies competing for the same customers, the company could be looking a at a good return on its investment and Intel will have $9B for investing in new technology.

4) Could WDC BE Broken Up? (Forbes 10/15/20)
In late September WDC said that it had created two separate business units. One focused on HDDs and the other on flash memory. The company also announced that it hired a former Symantec and Cisco executive, Robert Soderbury as GM of the flash unit and that it was looking for someone to lead its HDD business. The company did not indicate that it planned to divest or spin off either of these businesses at that time, but there are analysts who think WDC's CEO David Goecheler (CEO since March 2020) may be preparing for significant changes in the company.

Let's take a look at the flash memory and hard disk drive (HDD) business at WDC and in the overall market and see if we can get some sense of what each of these businesses have been like over the last few years and putting long term trends into perspective, see if we can get some insights into what these two businesses could be like if they were independent.

Both flash memory and HDDs are digital storage devices. Flash memory is used in many consumer and industrial applications. The biggest consumer of flash memory is in personal mobile devices such as smart phones. As the price of flash memory has been declining, solid state drives (SSDs) made with flash memory have made serious inroads on what had been HDD applications, such as storage in personal computers (both desktop and notebook).

SSDs have higher higher read/write speeds than HDDs. They are also more rugged and shock resistant. HDDs are less expensive for a given storage capacity. Client HDD (such as in PCs) are around 5 times less expensive than SSDs for a given storage capacity. Very high capacity HDDs (often used in enterprise nearline

storage in data centers) are about 10 times less expensive than SSDs for a given storage capacity.

The lower price difference for storage in client applications combined with slowing demand for additional capacity internal to these devices and the advantages of SSDs, have caused legacy client HDDs sales to fall, and SSD market share to increase. At the same time, the growing demand for data center storage, particularly in hyperscale data centers, has led to significant growth in high capacity nearline drives. As a consequence, although total HDD shipments at WDC have declined, the average sales price (ASPs) for HDDs has increased as shown below.
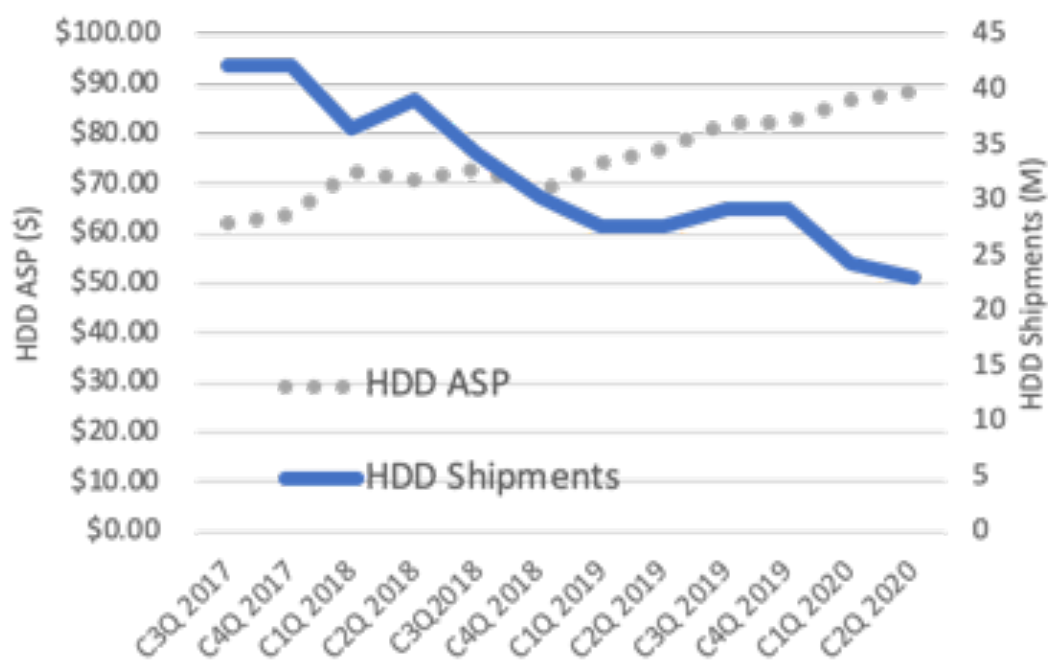
In fact, WDC HDD ASPs have increased by about 43% from C3Q 2017 through C2Q 2020, while WDC HDD shipments have declined by about 50% over the same period. As a consequence, WDC HDD revenue only declined about 21% over this period. This has resulted in fairly flat gross margins for HDDs at about 30% over this period. On the other hand, as shown below, gross margins for WDC SSDs have changed significantly over the same period. How come?

Unlike in the HDD industry, which only has three competing companies (Seagate, WDC and Toshiba), the NAND flash industry has six major players (Samsung, Kioxia, WDC, Micron, Intel and SK hynix) and a few smaller manufacturers. In addition, the NAND flash fabs, particularly with the move to 3D NAND cost billions of dollars to build, compared to a few hundred million to build an HDD production plant.

In the NAND flash industry, when prices are high due to a shortage of production compared to demand, all the manufacturers build new production capacity, which generally takes 18 months to 2 years to come on line. Then all this new production capacity comes on-line at about the same time and the supply of NAND flash greatly exceeds demand and prices drop. With less revenue and profit, the NAND manufacturers don't invest in new production facilities until demand increases and begins to exceed supply and prices and profits rise again.

With relatively steady increase in NAND flash demand and big swings in NAND production capacity we end up with a boom/bust cycle in the NAND flash industry. This has been going on in the industry for over two decades with the cycle time generally over a 4-5 year period. At present we are in an oversupply of NAND flash and prices are low, but possibly getting ready to recover. Note that the general cost of NAND flash per capacity declines over time and flash density increases, so the resulting swings in the price of NAND flash are swings about a declining trend line.

When there is an undersupply, like there was in 2017, NAND flash and SSD prices increase and gross margins and thus profitability, are high. A lot of 3D NAND

capacity came on line in 2018 through 2019 and that drove NAND contract prices down from 2017, as shown below. This chart also shows WDC SSD gross margins over the same time period. In general, undersupply in NAND drives higher prices for SSDs and thus better SSD gross margins.
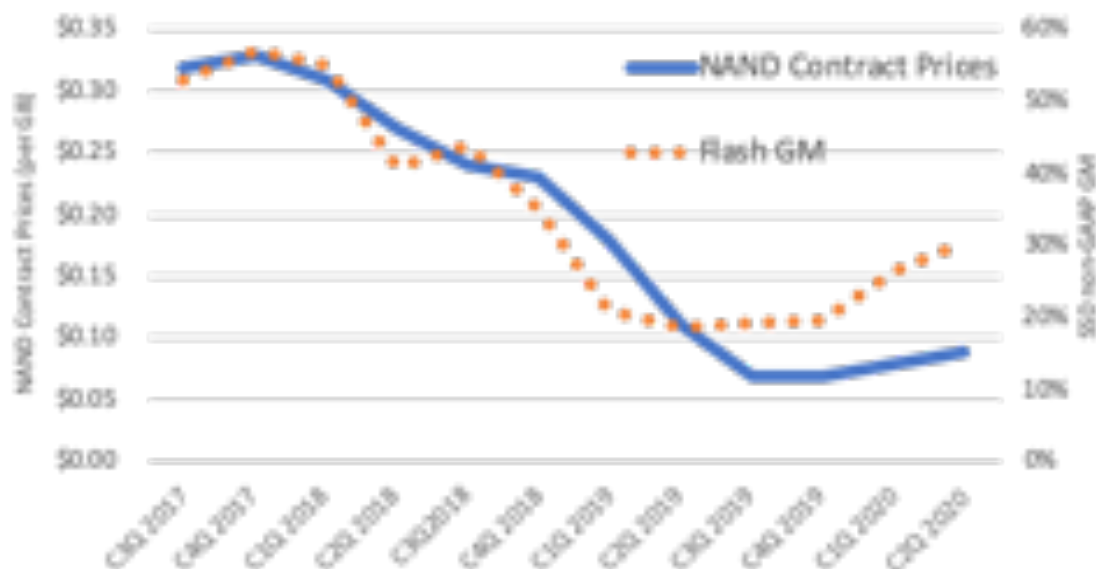
There were signs that contract prices were increasing slightly in early 2020, but COVID has dampened demand and could extend the period of oversupply into 2021. If YMT from China begins to provide some meaningful production in 2021 that oversupply situation could be extended further.

So, what does this tell us about the viability of WDC's flash memory and HDD as separate businesses. The figure below plots SSD, HDD and net (SSD + HDD) revenue from 2017 through C2Q 2020. Overall WDC has rebounded somewhat from a low point in 2019. During the latter part of 2019 HDD revenues were driving this rebound. In 2020 HDD revenues have decreased and flash revenues increased. The 2020 flash memory rebound is likely due to a combination of reduction of flash excess production capacity combined with some increase in demand.
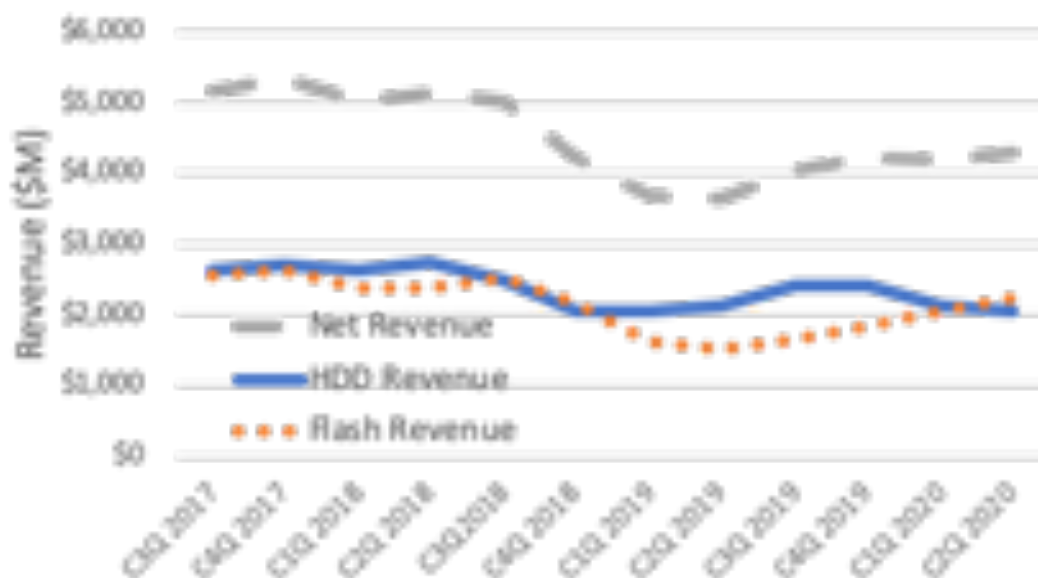
In general, the WDC HDD and SSD business are pretty comparable in revenue (most times), so breaking up the company would create two smaller companies with relatively equivalent revenues (at least for a while). However, as more legacy HDD applications migrate to SSDs HDDs revenue will decline and SSD revenues will tend to increase.

At some point in the future, assuming that nearline HDDs continue to advance HDD capacities so they maintain about a 10X difference in price compared to enterprise SSDs, the majority of WDC's HDD business will be in nearline (and other high capacity) HDDs. We project that this will occur between 2023-2024. At this point, the general annual decline in HDD shipping volumes will be much less because demand for higher priced high capacity HDDs will remain strong and revenues will generally follow enterprise and data center refresh cycles. HDDs will become mostly used in large storage installations and thus if WDC created a separate HDD company, its primary focus would increasingly be on these storage markets.

On the other hand, flash memory use in consumer devices will expand, creating greater demand. The need for high performance storage to support data centers, edge computing and enterprise applications will drive flash memory demand from that side as well. Thus, a broken out WDC flash memory business will experience continuing increase in demand from multiple user markets. On the other hand, if the number of flash memory competitors remains as it is today, the flash company will continue to experience the boom/bust cycle that has characterized the NAND flash industry, leading to large swings in profitability.

A flash memory focused company would do well look for opportunities to consolidate and increase its market share where that made financial sense. Fewer competitors would probably reduce the production oversupply during the bust

periods and provide more revenue to help the company weather these periods better, while giving them funds to develop the next generations of products.

Breaking up WDC into a separate HDD and flash memory business could create two viable storage company, that over time will provide value to very different, but potentially symbiotic, uses. The HDD business will become enterprise and especially data center focused, while an NAND flash business will seek to gain market share as a way to moderate and better survive the NAND flash boom/bust cycles.

5) NVIDIA Introduces High Performance Networking and Storage BlueField DPUs for Data Centers (Forbes 10/8/20)
During the NVIDIA Global Technology Conference the company announced its Bluefield-2 Data Processor Units (DPUs) based upon its Mellanox acquisition's Bluefield networking and NVMe storage technology, see below. The company's new DPU represents a new domain specific computing technology that the company hopes will be as much or more successful than its GPU business.
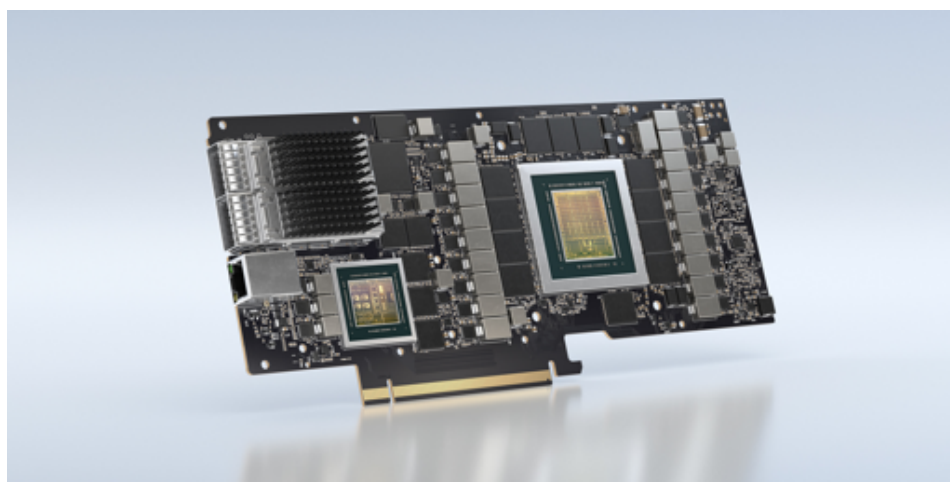
The NVDIA BlueField-2 DPU is enabled by the company's Data-Center-Infrastructure-on-a-Chip Software (DOCA SDK). The company also announced a partnership with VMware to power vmware's [Project Monterey](#). VMware's Project Monterey was announced in late September at its VMworld 2020 conference as a re-architecture of VMware Cloud Foundation (VCF). It is a continuation of an effort started in 2019 to integrate Kubernetes containers into the fabric of vSphere that resulted in a single platform for running VMs and containers, with a common operating model.

Because of the slowing in microprocessor scaling, specialized domain specific processors (often called accelerators) have proliferated to relieve workloads on generalized CPUs. Project Monterey leverages a new hardware technology called SmartNIC, designed to deliver maximum performance, zero-trust security and simplified operations to VCF deployments. Implementing Project Monterey

moves functionality that used to run on the core CPU to run on the SmartNIC. These SmartNICs (NIC stands for network interface card) enable bare metal operations systems and applications. The image below shows a block diagram of a Project Monterey SmartNIC. The NVDIA BlueField-2 DPU modules are one of the Project Monterey SmartNIC partnerships.
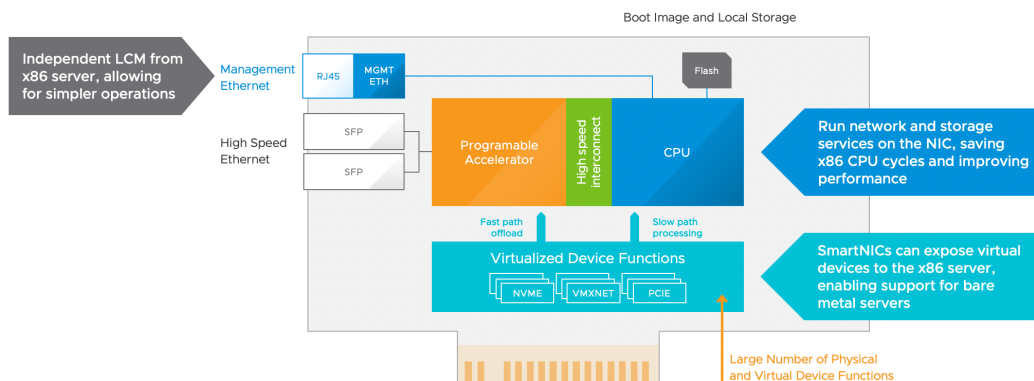
NVIDIA's CEO and founder, Jensen Huang, during his introductory keynote, spoke about the company's DPU and its supporting Data Center on a Chip Software (DOCA SDK) that enables developers to create DPU-based applications. The company said that "DOCA provides developers a comprehensive, open platform for building software-defined, hardware-accelerated networking, storage, security and management applications running on the BlueField family of DPUs."

Jensen revealed the company's three-year DPU roadmap (out to 2023, as shown below). Off-loading processing to a DPU can result in overall cost savings and improved performance for data centers. Jensen said that "A single BlueField-2 DPU can deliver the same data center services that could consume up to 125 CPU cores. This frees up valuable CPU cores to run a wide range of other enterprise applications."
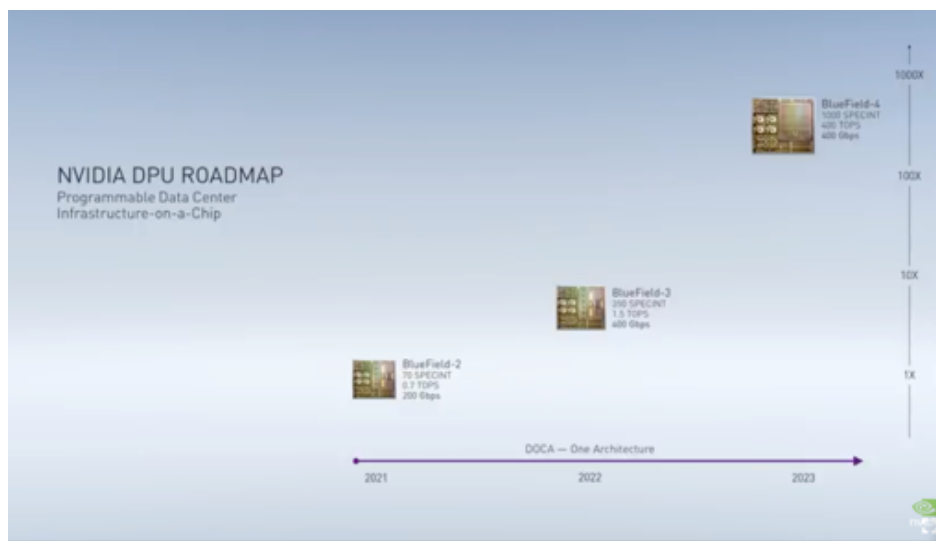
In addition to VMware NVIDIA said that it also has DPU partnerships with Red Hat, Canonical and Check Point Software Technologies. NVIDIA's current DPU lineup includes two PCIe products, that the company described below.

- The **NVIDIA BlueField-2 DPU**, which features all of the capabilities of the NVIDIA Mellanox® ConnectX®-6 Dx SmartNIC combined with powerful Arm cores. Fully programmable, it delivers data transfer rates of 200 gigabits per second and accelerates key data center security, networking and storage tasks, including isolation, root trust, key management, RDMA/RoCE, GPUDirect, elastic block storage, data compression and more.
- The **NVIDIA BlueField-2X DPU**, which includes all the key features of a BlueField-2 DPU enhanced with an NVIDIA Ampere GPU's AI capabilities that can be applied to data center security, networking and storage tasks. Drawing from NVIDIA's third-generation Tensor Cores, it is able to use AI for real-time security analytics, including identifying abnormal traffic, which could indicate theft of confidential data, encrypted traffic analytics at line rate, host introspection to identify malicious activity, and dynamic security orchestration and automated response.

BlueField-2 DPUs are sampling now and expected to be featured in new systems from leading server manufacturers in 2021. The higher performance BlueField-2X DPUs are under development and are also expected to become available in 2021. DOCA is now available on GitHub for early access.

Domain specific processors (accelerators) are playing greater roles in off-loading CPUs and improving performance of computing systems.   In data centers, NVIDIA's DPU with its DOCA software, could be an important element in recreating tomorrow's data centers running at higher performance and with greater efficiency.

6) Seagate Introduces HAMR HDDs, CORTX and Lyve Drive Rack (Forbes Blog, 10/7/20)
Seagate's latest DataSphere event allowed the company to talk about their shipping 18 TB HAMR HDDs and soon to come 20 TB drives as well as their CORTX open source intelligent object storage software. CORTX software is used on the Lyve Drive Rack for 1.7 PB of object storage.

According to recent data from Wells Fargo analyst Aaron Rakers using data from Trendforce and TrendFocus, enterprise solid state drives (SSDs) generally cost $185/TB and nearline hard disk drives (HDDs) cost about $19/TB, so enterprise SSSDs have a 9.7X price premium in $/TB, that has been relatively constant, as shown below. This disparity in prices for storage capacity is the primary reason that mass storage in data centers uses high capacity HDDs.

Enterprise SSD vs. Nearline / High-Cap HDDs - $ per TB
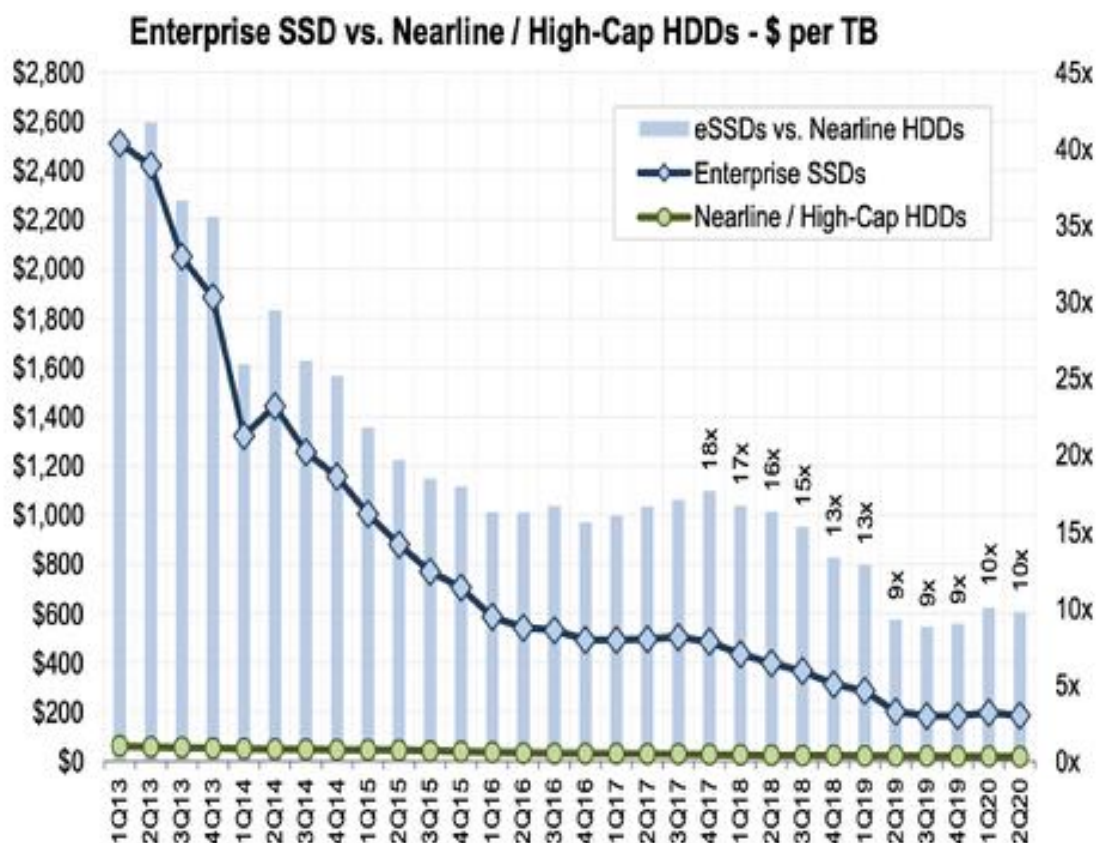
Source: TrendFocus; Wells Fargo Securities, LLC

Seagate Technology's primary business is building and selling HDDs, although it has some business with enterprise SSDs in partnership with Intel. The companies HDD business generated $2.3 B in revenue in CQ2 2020, while enterprise data solutions and SSDs generated $195 M. The company sold mostly to OEM's (74% of their business). Seagate sold more HDDs than any of the other HDD vendors through CQ2 2020 (44% of total shipments compared to 37% for WDC and 19% for Toshiba).

Seagate sold even higher percentage of nearline (high capacity enterprise) HDDs at about 52% of the total CQ2 2020 nearline HDD shipments. Large capacity HDDs, including nearline HDDs show the greatest growth in HDD shipments compared to legacy applications such as personal computers and consumer electronics where SSDs or network storage are gradually displaying HDDs. The average sales price (ASP) for HDDs has been increasing with the increasing percentage of shipping higher ASP, higher margin, nearline HDDs, as shown below.
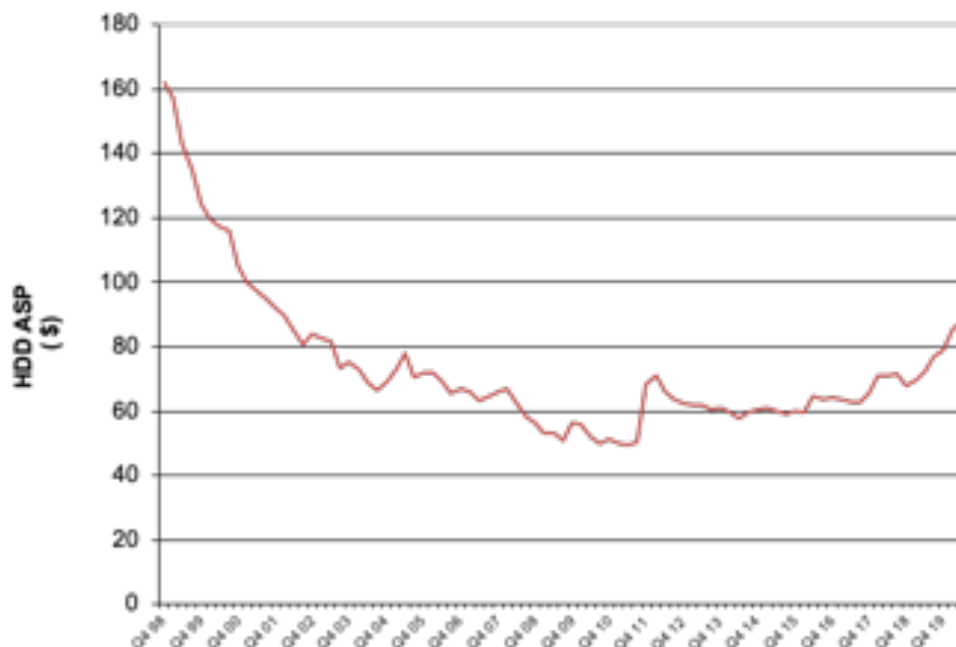
HDD ASP chart from Coughlin Associates, CQ4 1998 through CQ2 2020

At a recent Seagate DataSphere event Seagate said that higher capacity HDDs are providing greater cost per capacity advantages for hyperscale data centers (the cloud) than for enterprise data centers. This should help reduce the costs of cloud versus on-premises storage and thus increase cloud storage use for more applications. Note the 50 TB HDDs were shown in this chart sometime in the near future. Most of the storage capacity in the cloud (private and public) is object storage, because of its greater scalability.

Western Digital (WDC) announced that it was shipping 18 TBs and some 20 TB HDDs in July 2020. Seagate said that they introduced their 18 TB HDDs in August and that it would introduce 20 TB HDDs using heat assisted magnetic recording (HAMR) later in 2020.

Seagate also introduced their CORTX open source intelligent object storage software, now available on open source web site, GitHub. According to the company, CORTX "…enables efficient capture and consolidation of massive unstructured data sets for the lowest cost per petabyte…CORTX brings exabyte scalability to your private cloud." The company said that CORTX allows direct communication with HDDs, multi-level erasure codes (important for data reliability), intelligent metadata and automated monitoring.

Seagate introduced their Lyve Drive Rack that can bundle up to 1.7PB with CORTX object storage. The company points out that providing open source management software lowers the total cost of object storage, where software licensing fees and often exceed the acquisition costs of actual storage capacity. The Lyve drive Rack will use HDDs with Seagate's MACH2 (dual actuator) and HAMR high capacity HDDs. As shown below Intel, Supermicro and Dell/EMC are partnering with Seagate for this object storage introduction.

Seagate said that their Lyve Drive Rack, powered by CORTX will be available starting in December 2020. The company talked about use the CORTX Lyve Drive Rack in enterprise and public/private cloud applications, to support 5G edge storage applications, including AI applications running at the network edge.

Continued development of HDDs, particularly increasing storage capacity on HDD disks is the key to retaining a competitive advantage for HDDs over SSDs for mass storage in data centers.

Seagate's CORTX open source object storage software, combined with their scalable Lyve Drive Racks and advanced HDDs could provide upside for Seagate selling into the high margin enterprise and data center markets.

7) Data Gravity Grows Regional Data Center Needs (Forbes Blog, 10/2/20)
[Dave McCrory coined the term data gravity in 2010](#). Data gravity is the ability of bodies of data to attract applications, services and other data. The force of gravity, in this metaphor, is manifested in the way software, services and business logic are drawn physically closer to data, relative to its mass (the amount of

data). The larger the amount of data, the more applications, services and other data will be attracted to that data. Data gravity is often used to describe how more and more data moves to the cloud (large hyperscale data centers).

Digital Realty, which provides global data center, co-location and interconnection solutions, recently published results from its Data Gravity Index. Digital Realty conducted research between August 2019 and August 2020 and drew upon more than a dozen third-party data sources, ranging from the World Economic Forum and the United Nations to global consulting and market research firms, to construct this index. This index helped the company represent the intensity of data creation, data augmentation, available bandwidth and latency to provide a data intensity metric for several geographic locations for G2000 enterprises as shown below.

The Data Gravity Intensity, as measured in gigabytes per second, is expected to grow by a compound annual growth rate (CAGR) of 139% globally through 2024 as data stewardship drives global enterprises to increase their digital infrastructure capacity to aggregate, store and manage the majority of the world's data. This growth in intensity is shown in the figure below.
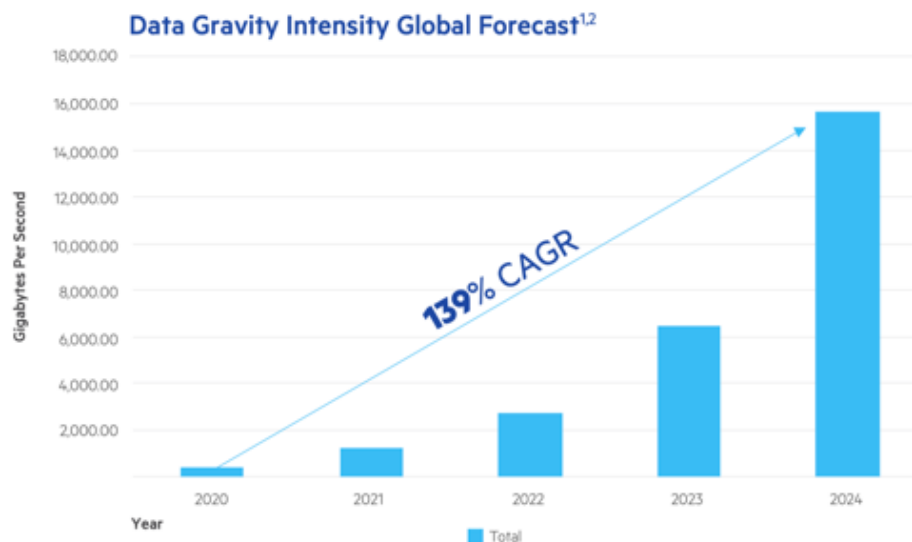
By 2024, Digital Realty estimated G2000 Enterprises will create data at a rate of 1.1 EB/s (exabytes per second) and will require 15.6 ZB (zettabytes) of additional data storage annually. The figures below show a 28% CAGR in data creation per second and a 53% CAGR in data storage from 2020 through 2024.

Calculating Enterprise Data Creation (Gigabytes Per Second) [1,2]

Calculating Enterprise Data Storage Growth (Exabytes) [1,2]
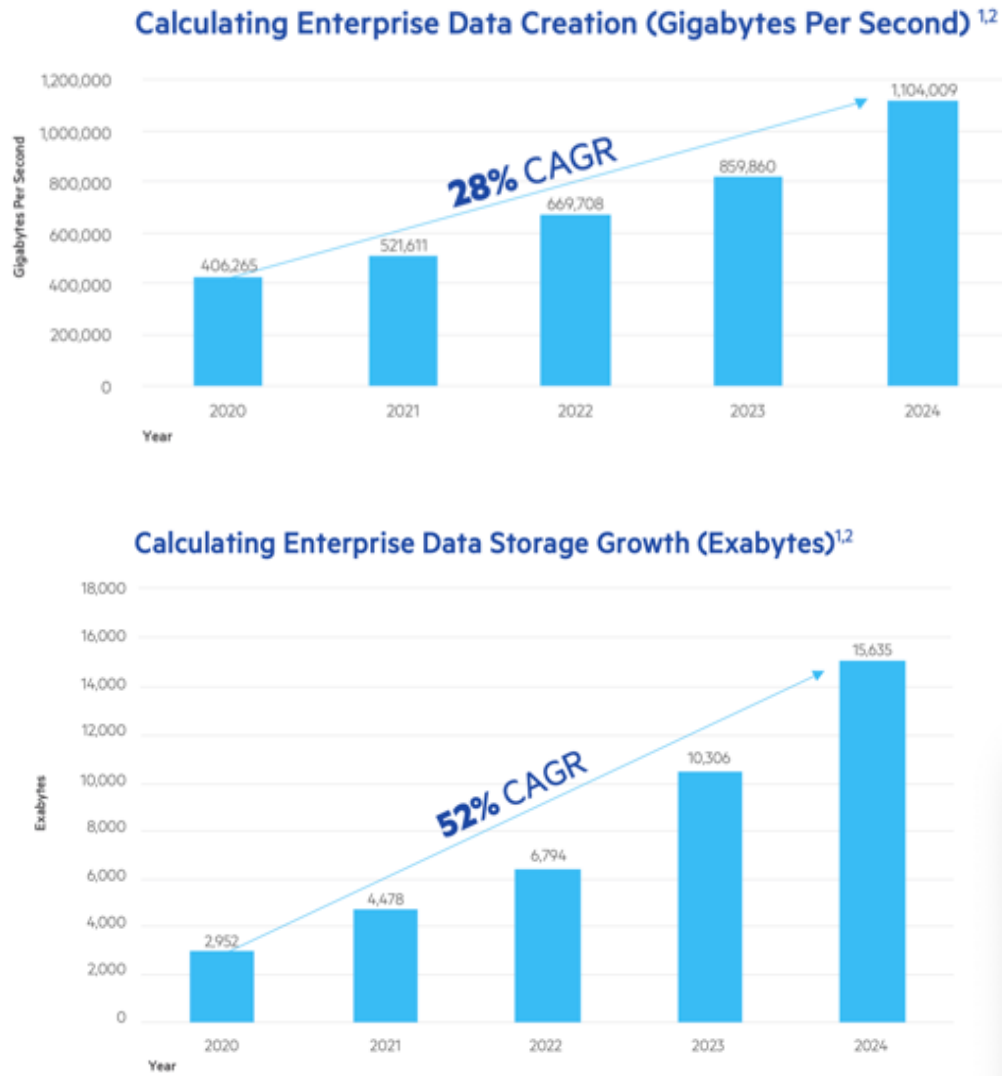
Data Gravity Intensity is expected to more than double annually across the Europe, Middle East and Africa (EMEA), Asia and Pacific (APAC) and North American regions through 2024. By 2024, EMEA is expected to remain the home to the greatest intensity of Data Gravity across the 21 metros analyzed in this study. Across the 21 metros, EMEA and APAC Data Gravity Intensity are increasing at faster rates than North America. EMEA region Data Gravity Intensity will exit 2024 at almost double the rate of North America.

The figure below shows 2020 compared to projected 2024 Data Gravity Intensity for the 21 metro areas. The six fastest growing metros in terms of Data Gravity Intensity through 2024 are projected to be Singapore, Hong Kong, Dallas, Sydney,

Seattle and Tokyo. Metro to metro data flows will play a big role in increasing Data Gravity Intensity, with London to Amsterdam having the greatest data flows in 2020 and projected for 2024, followed by Paris to London.
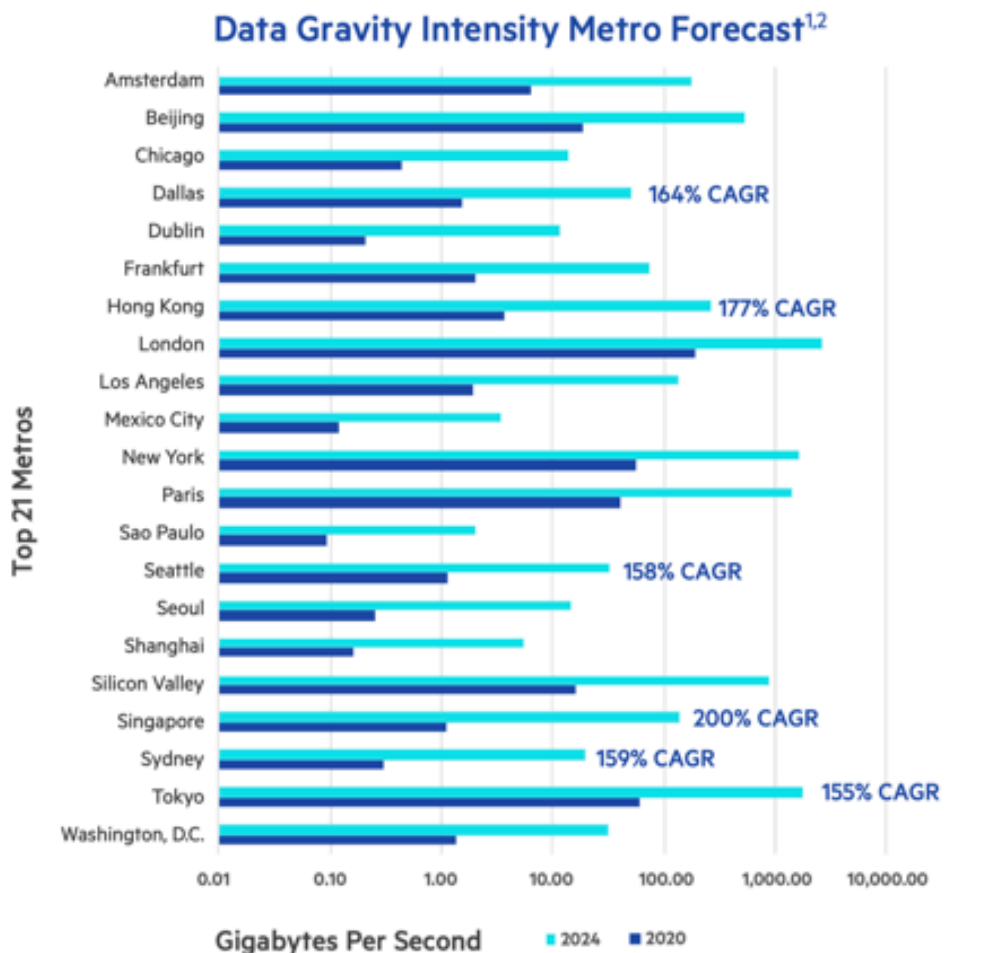
Digital Realty's Data Gravity Index for G2000 companies shows the growing impact of "data gravity" on regions and metropolitan areas and its impact on data creation and storage capacity from 2020 through 2024.

8) Cloud a the Edge, CUP Storage and LTO Gen 9 (Forbes, 9/2220)
This piece looks at developments and digital storage partners for public cloud company edge services, in particular AWS Outposts. We also look at a VAST Data GPU oriented AI storage offering and look at the introduction of LTO 9 magnetic tape technology in late 2020.

Public cloud companies have created services to bring their services to the edge of the network as well as in their hyperscale data centers. One example is AWS Outposts. Outposts was first announced in 2018, with general availability announced in December 2019.

Recently a number of storage companies made announcements related to AWS Outposts partnerships. AWS Outposts extends AWS infrastructure, services, APIs, and tools to customer datacenters, co-location spaces, or on-premises facilities. AWS Outposts is meant to provide low latency access to on-premises applications or systems, local data processing for local storage needs in a hybrid cloud storage environment.

These AWS Outpost connections included Zadara, who announced a partnership with data management provider Storage IT offering storage as a service solution in the AWS Marketplace. Qumolo also launched on AWS Outposts to enable file storage and data management. Qumolo on AWS Outposts allow customers to connect their file data to AWS and run AWS services.

VAST Data introduced its Universal Storage Platform that used Intel's Optane SSDs in the front end of a storage system as a cache for data stored on quad level cell (QLC) SSDs in 2019.
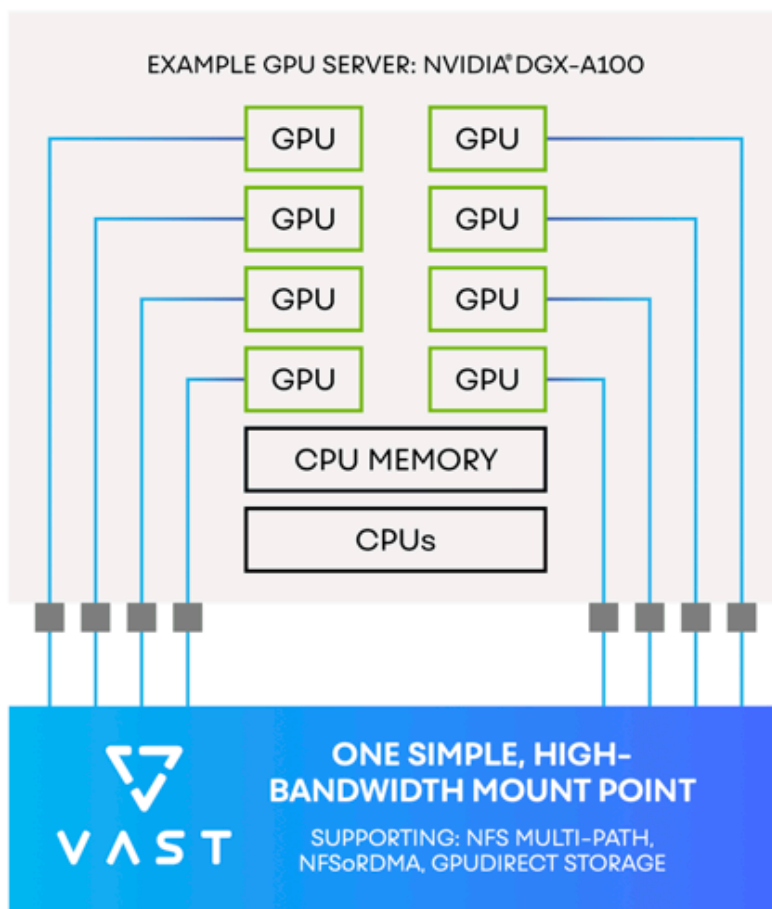
The company said that by using NVMe based Optane SSDs and QLC flash that they could bring the cost of a flash memory storage system to close to that of a HDD storage system. The company recently announced the availability of its next generation storage architecture that it calls LightSpeed. LightSpeed combines

VAST's NAS appliance with NVIDIA GPU-based and AI processor-based computing for AI applications.

VAST's announcement says that GPUDirect enables customers running NVIDIA GPUs to accelerate access to data and avoid extra data copies between storage and the GPU by avoiding the CPU and CPU memory altogether as shown in the image below. In initial testing, VAST demonstrated over 90GB/s of peak read throughput via a single NVIDIA DGX-2 client, nearly 3X the performance of VAST's NFS-over-RDMA and nearly 50X the performance of standard TCP-based NFS.

The company says that LightSpeed uses a disaggregated, shared everything (DASE) architecture (using elements from its Universal Storage platform) to lower the costs of SSD storage and thus eliminate the need for storage tiering. LightSpeed doubles the performance of prior VAST storage solutions. It also provides NFS support for NVIDIA GPUDirect Storage.

The LTO program technology provider companies (HPE, IBM and Quantum), which manages the most popular digital magnetic recording tape format officially announced the LTO 9 specification. LTO 9 tape cartridges support 18 TB of native storage capacity (less than the 24 TB native capacity for LTO 9 that was on prior LTO roadmaps). Whereas the most recent generations generally doubled storage capacity about every 2.3 years, this is a 50% increase from 12 TB native storage capacity for LTO 8. The LTO program says that they redid the LTO roadmap to reflect the changed capacity for LTO 9 and that following generations will double with each generation as shown below.

LTO ULTRIUM ROADMAP
ADDRESSING YOUR STORAGE NEEDS

	NATIVE	COMPRESSED
GEN12	UP TO 144TB	UP TO 360TB
GEN11	UP TO 72TB	UP TO 180TB
GEN10	UP TO 36TB	UP TO 90TB
GEN9	18TB	45TB
GEN8	12TB	30TB
GEN7	6TB	15TB
GEN6	2.5TB	6.25TB
GEN5	1.5TB	3TB

WORM | ENCRYPTION | PARTITIONING ENABLING LTFS
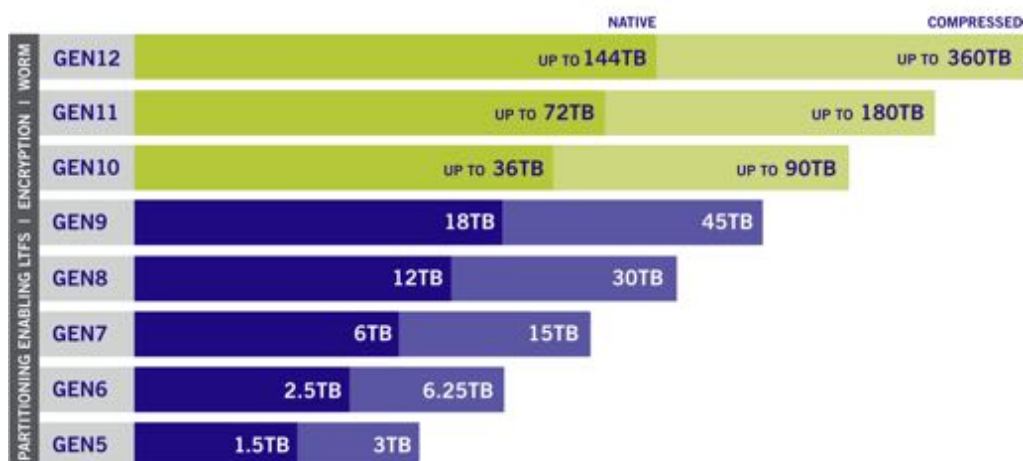
NOTE: Compressed capacity for generation 5 assumes 2:1 compression. Compressed capacities for generations 6-12 assume 2.5:1 compression (achieved with larger compression history buffer).
SOURCE: The LTO Program. The LTO Ultrium roadmap is subject to change without notice and represents goals and objectives only. Linear Tape-Open, LTO, the LTO logo, Ultrium, and the Ultrium logo are registered trademarks of Hewlett Packard Enterprise, International Business Machines Corporation and Quantum Corporation in the US and other countries.

The LTO generation 9 specifications include previously introduced features, such as multi-layer security support via hardware-based encryption, WORM (Write-Once, Read-Many) functionality and support for Linear Tape File System (LTFS). The new LTO generation 9 specifications include full backward read and write compatibility with LTO generation 8 cartridges. Quantum said that they will make LTO 9 tape drives available for their Scalar Tape Libraries and StorNext AEL archive systems beginning in December 2020. Other tape storage system vendors will be announcing LTO 9 support for products in late 2020.

AWS Outpost storage partners Zadara and Qumulo enable on-premises storage partnered with public cloud service. VAST Data introduces GPU AI high performance storage. The LTO program introduces LTO 9 tape technology with vendors providing products by late 2020.

9) Emerging Memories for IoT and Compute from TSMC, Intel and IBM (Forbes Blog, 9/11/20)
In earlier blogs I spoke about how new non-volatile memory technologies will be playing an increasing role for embedded and computing applications. In one of my August blogs I mentioned that it appeared that Intel's Optane memory may finally have reached enough production volume to make it cost effective at the price it must sell at to be competitive with DRAM. The figure below from the Coughlin Associates and Objective Analysis report on Emerging Memories Find Their Direction, shows our projections on the growth of shipped capacity for magnetic random access memory (MRAM) and 3D XPoint (Intel's Optane memory) as well as more conventional NAND flash and DRAM.
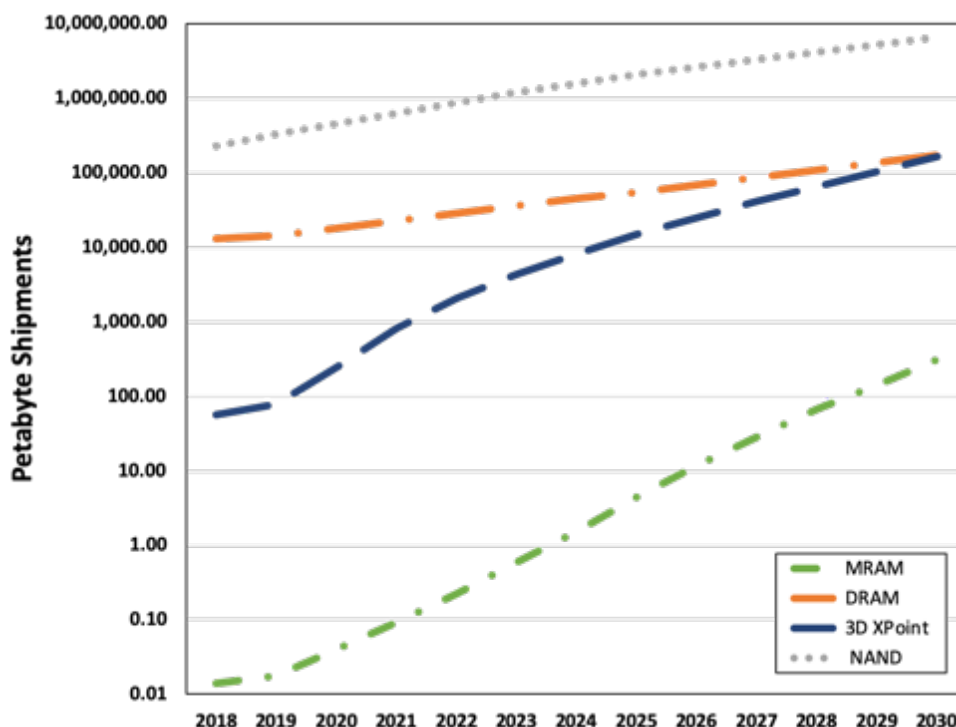
There was evidence of the growing use of MRAM, resistive ram (RRAM) and 3D XPoint memory during presentations at a recent TSMC online technology symposium as well as during the 2020 IEEE Hot Chips Conference. In addition, AI chip company Ambiq announced MRAM in its latest generation Apollo System on Chip (SoC) family. Let's look at some of these developments.

TSMC had an online technology symposium that I attended where the company where Kevin Zhang talked about their latest developments, including semiconductor technologies at 7, 5 and even 3nm. In addition, the company's annual report gives some insights on how the company will use emerging non-volatile memory technologies in embedded products.
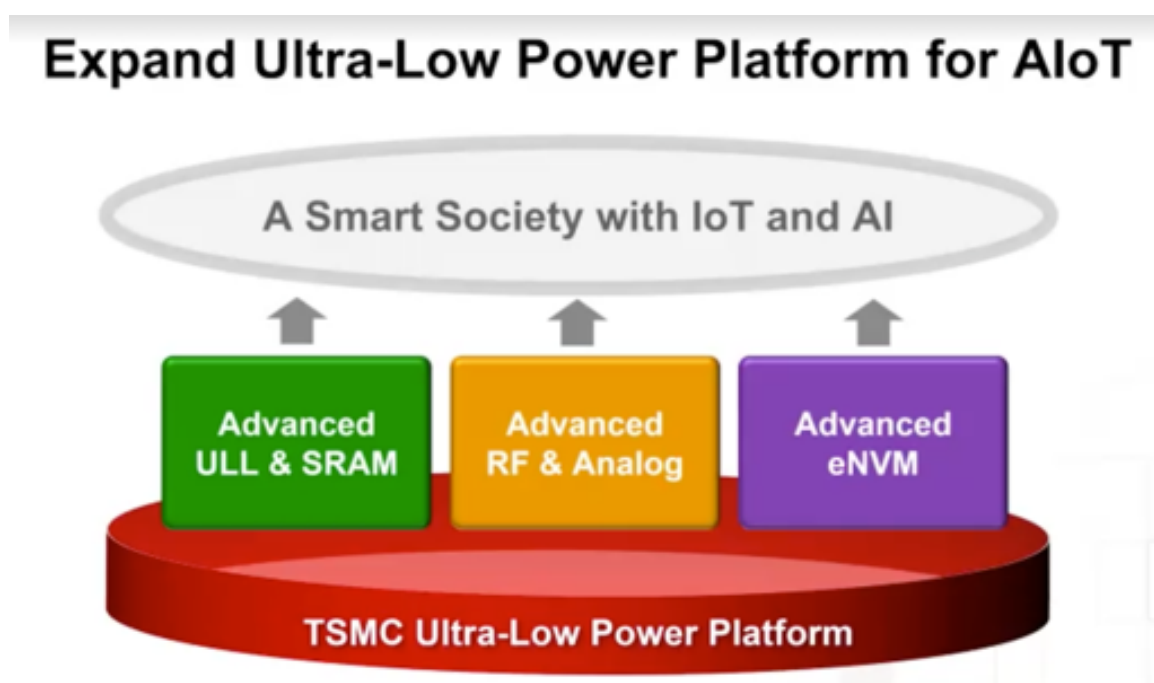
The company's annual report says that TSMC's 22nm resistive RAM (RRAM) started risk production in 2019 and is expected to complete IP reliability qualification in 2020. 40nm RRAM achieved technical qualification as consumer product qualifications continued. TSMC said that there will be multiple customer tape-outs in the second half of 2020. The company's RRAM is intended for use in low cost internet of things microcontroller MCUs and AI memory devices.

22nm embedded magnetic random access memory (MRAM) technology IPs are expected to complete reliability qualification in 2020. In addition, the company's 16nm MRAM is under development and is progressing well. Risk production for eFlash-like MRAM is expected in Q421 and SRAM-like MRAM is expected in Q422. The company sees MRAM replacing eFlash in high reliability MCUs, including for AI, IoT and automotive AEC-Q100 Grade-1 applications.

One of TSMC's customers, Ambiq, is developing chips that will enable the next generation of battery-powered always on voice recognition IoT endpoint devices. The company's 4th generation Apollo SoC family sets new standards for ultra-low power intelligent endpoint IoT devices. The Apollo 4 is implemented with TSMC's 22nm ULL process and the 32-bit Arm Cortex-M4 core with floating point unit (FPU) and Arm Artisan physical IP.

The SoC chip achieves power use as low as 3 microA/MHz using MRAM memory with low deep sleep current modes and operates up to 192 MHz clock frequency with TurboSPOT (sub-threshold power-optimized technology), SPOT) and with a 2D/2.5D graphics accelerator and MIPI DSI 1.2 with up to two lanes at 500 Mbps per lane.

The figure below shows the block diagram showing various features, including 2 MB of MRAM along with up to 1.8 MB of SRAM. The BLE Radio blocks are in the Bluetooth version of the chip.
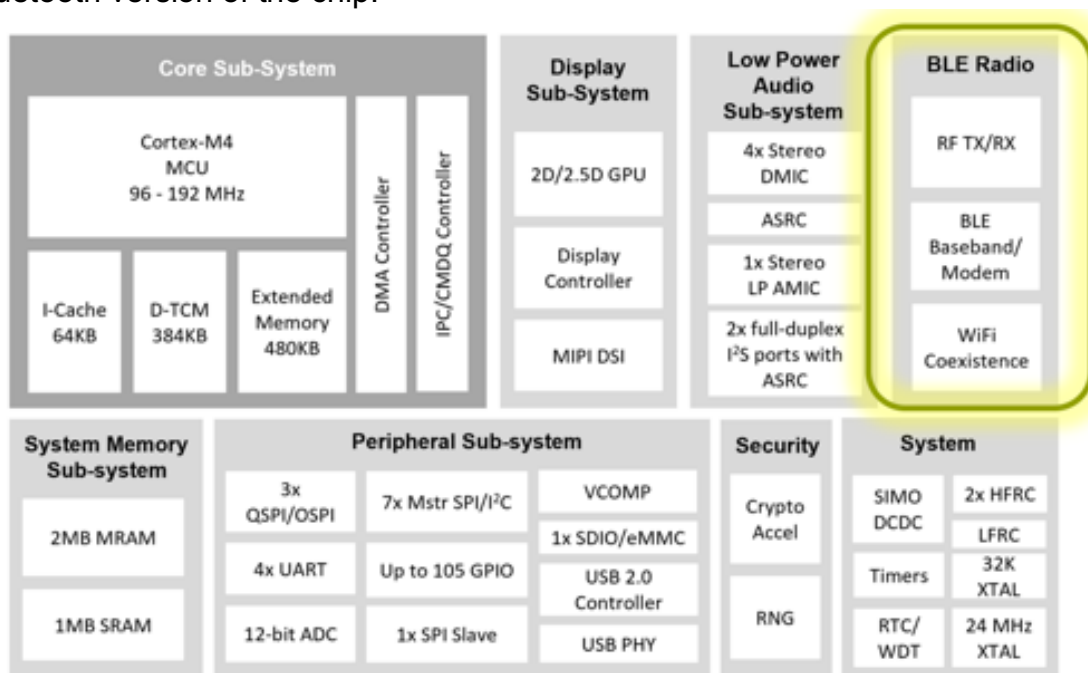
Ambiq says that the Apollo4 has enough compute and storage resources to handle complex algorithms and neural networks while displaying vibrant, crystal-clear, and smooth graphics. If additional memory is required, external memory is supported through Ambiq's multi-bit SPI and e.MMC interfaces.

According to Ambiq, the Apollo4 is purpose-built to serve as both an application processor and a coprocessor for battery-powered endpoint devices, including smartwatches, children's watches, fitness bands, animal trackers, far-field voice remotes, predictive health and maintenance devices, smart security devices, and smart home devices.

The product is targeted for use in intelligent endpoint IoT devices with always-on voice processing.

At the 2020 IEEE Hot Chips Conference there were a few interesting announcements related to emerging memories. Intel gave a talk about their Ice Lake server product where they said that their total memory encryption (TME) encrypts data in DRAM using AES-XTS-128 bit encryption. They also mentioned the use of Intel Optane Persistent 200 series (Barlow Pass) memory.

Intel also described latency and coherence optimizations that help the product and make more effective use of memory, including Optane. In particular Intel said they can minimize the impact of persistent memory latencies on performance. Intel also included non-volatile memory as a processor differentiator during a Tiger Lake presentation. There was also mention of the need for new high capacity, low power and low latency memory that is tightly coupled to compute as shown below.
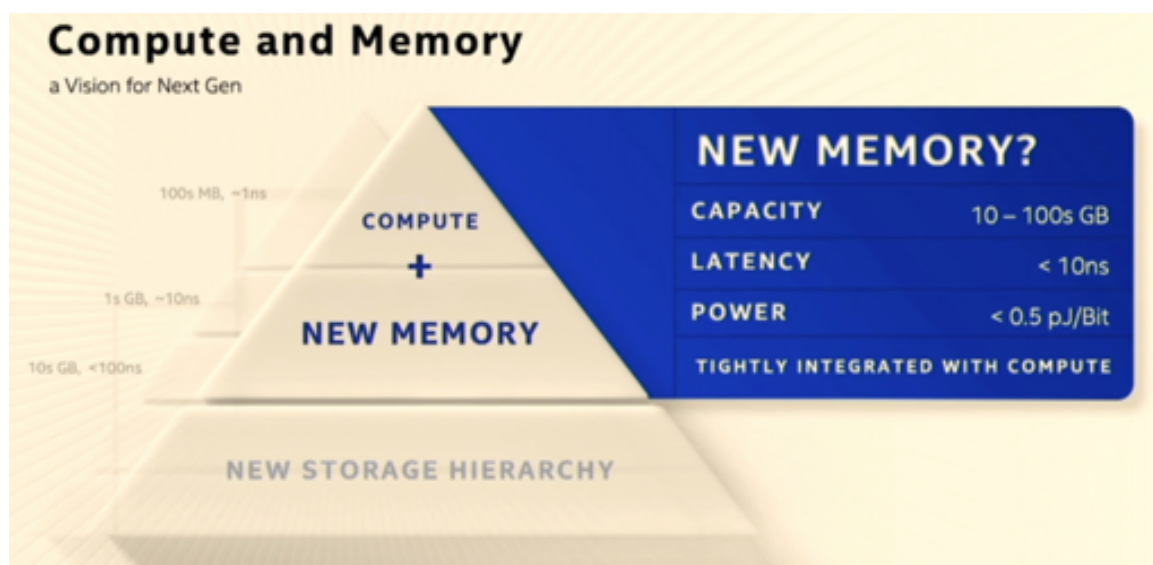
IBM spoke about their latest POWER10 processor for super computer applications (built with Samsung's 7nm foundry), which included support for non-volatile Storage Class Memory (SCM), similar to Intel's persistent memory (PM). As shown in the figure below Open Memory interface (OMI) provides high-capacity, encrypted persistent memory in a DIMM slot (likely Optane DIMMs). IBM says that POWER10 can support 2 PB of addressable load/store memory.
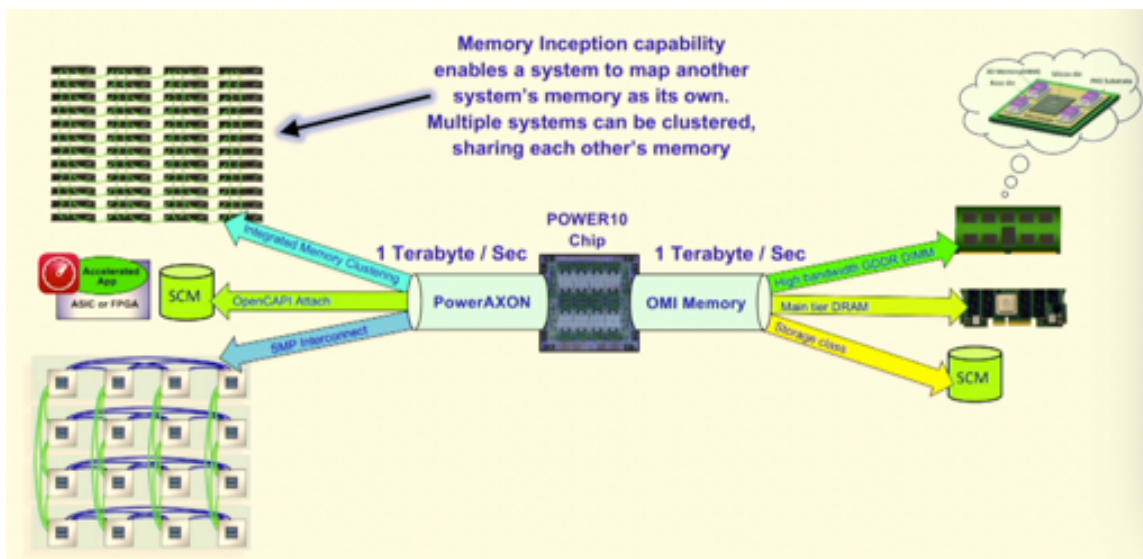
IBM also sees high capacity, encrypted persistent SCM attached to FPGAs or ASIC-based accelerators for a POWER10 host with high bandwidth and low latency using open coherent accelerator processor interface (OpenCAPI). POWER10 can also enable a system to map another system's memory as its own. Multiple systems can be clustered, sharing each other's memory at Petabyte scale.

Emerging memory for compute, IoT and AI/ML applications was on display at a recent TSMC technical conference, during the Apollo4 SoC announcement by Ambiq and in talks by IBM and Intel at the 2020 IEEE Hot Chips Conference.

10) NTT Storage is Off to the Races (Forbes Blog, 9/9/20)
Like many other sports, professional racing has come to rely on modern technology to provide safer environment for participants and a better experience for spectators. With many sporting events going on during the Covid-19 pandemic, technology plays an even greater role in providing a quality remote experience for fans. Let's look at the 2020 Indianapolis 500 races held in late August and the role that digital storage and memory played with the help of NTT.

Typically there are 8 cars with on-board or broadcast cameras (up to 14 cars with cameras for the Indy 500), which are used by TV and the INDYCAR App (see car with on-board cameras below).

Photo thanks to: NTT INDYCAR SERIES

There are up to four different placements for these cameras, they are not all in the cockpit. Every car has a special camera which records right above the driver's head towards the front of the car. This camera is not streamed to the public, rather it is used by Race Control and Competition, as well as the racing teams.

Much of the timing data, used in the Data Experience content and the INDYCAR App, is calculated using a system that captures data using timing lines around the track and measured to four decimal places (INDYCAR is the only series that tracks the timing data to this precision.) Sensors placed in consistent places on each race car, are measured as they cross the timing lines. Telemetry and timing data collected (140+ data points per car) include speed, RPM, gear, throttle, steering, tire iDs/Pressures/temperatures, G-forces in all 3 directions, overtake (push to pass), GPS information and many other data points.

The communication paths during the races are shown in the figure below. A relay node handles the live connection to the Indianapolis Motor Speedway live feed. An EMU node handles race playback to feed the large Accelerate Smart Platform node. The ENGINE node is very large with lots of parallelism and pipelining to handle the different types of data coming in.
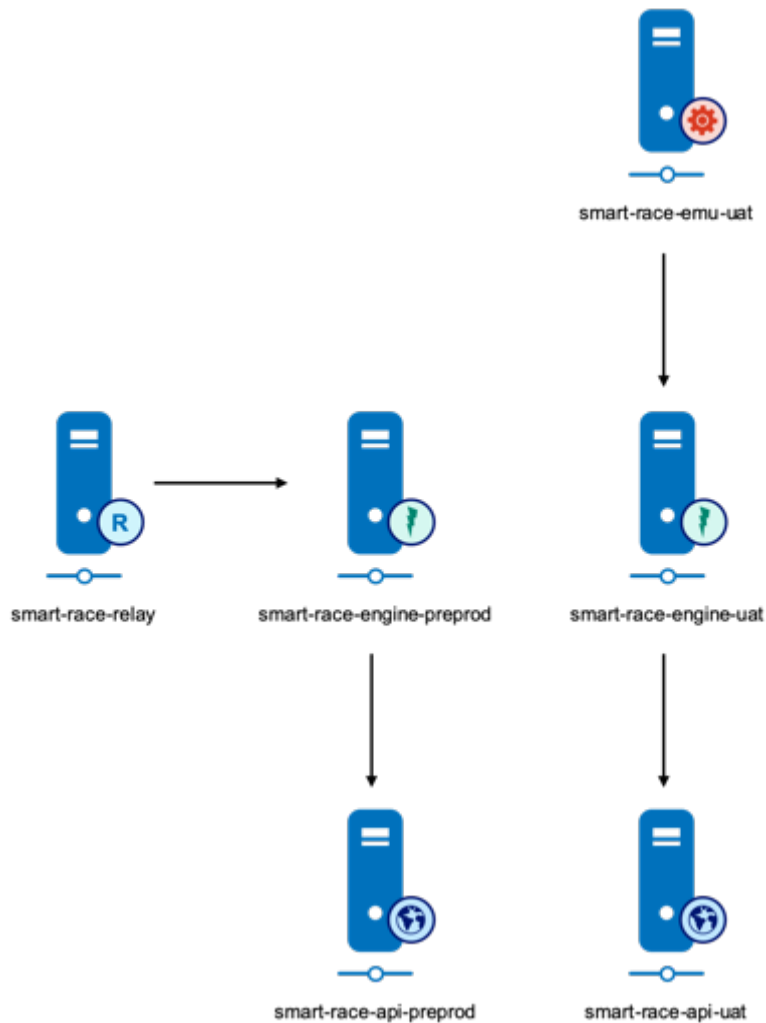
Image from: NTT INDYCAR SERIES

The ENGINE node consists of several modules. The Ingestor parses incoming data and directs it down the proper path(s). Telemetry processors handle per-car positioning, g-force calculations, quality adjustments and pit "stop" moments. The timing and scoring processor handles race conditions, rules and official stats. Logging data is written to a high speed SSD database, but processing of positions, leaderboards and events are done in-memory. The API prep node prepares data for API output handling REST API streaming of data to the presentation layer. The Predictive engine is described below.

The relay node handles the live connections to the Indianapolis Motor Speedway live feed. During a race, about 4 GB of data is ingested from the competing cars while they hurtle around the track at over 200 MPH. 95% of the data comes from the cars and 5% from the timing and scoring system. Each car has hundreds of changing monitored conditions per second. Sometimes there are gaps in the telemetry data and predictive algorithms determine the car's position information. The race involved complex situational rules that must be understood and enforced and there are dozens of differently formatted message types used.

The NTT Accelerate Smart Platform utilizes AI and Advanced Analytics to uncover interesting Action Events as they unfold during the race.

In some other storage related news Zadara is providing storage solutions for Japan's Rakuten Mobile's virtualized mobile network. According to the Zadara release, the mobile carrier leverages Zadara's storage-as-a-service platform, which provides a fully managed data management solution designed for any data types, any protocol and for any cloud environment.

Intelligent video content management company IPV and Systems integration company IMT made a joint announcement about the integration of [IPV's Curator media asset management](#) and [IMT's SoDA application](#). SoDA enterprise storage predicts the costs and strearmlines data transfers to and from the public cloud. The announcement says that the Dry Run feature in SoDA can help content owners, increasingly using cloud services to support remote work, set up real-world policy-based file transfers with known costs to support constrained budgets.

Digital storage technology, networking and AI technologies technologies enables new sporting experiences such those using NTT's INDYCAR support. Zadara enables Rakutan Mobile and IPV and IMT use SoDA to control cloud costs.

11) Western Digital's AmorLock, Security without Passwords (Forbes Blog, 9/3/20)

With so many people working at home, data vulnerability has increased significantly. The security measures set up in established corporate office environments are often missing in a home office. People need new tools to improve the security of their data in their home office and when sharing data with others. Security of data is particularly important when that data has immediate value, such as with the work of media and entertainment professionals.

Western Digital introduced its ArmorLock Security Platform. This platform provides a storage device or system with what WDC says is next-gen security. This platform is targeted to meet the security needs of data and content-oriented use cases such as finance, government, healthcare, IT enterprise, legal and media and entertainment. Western Digital says that it will apply this security platform across a range of storage solutions.

The first product using this platform is the new G-Technology ArmorLock encrypted NVMe SSD. This product is targeted at users in the media and entertainment industry. This industry has to deal with financial losses associated with hijacked media files and leaked films and is eager for new and better ways to protect critical content. With much collaborative M&E activity using the cloud, that has been a focus of security solutions, but data on portable storage devices, often used to move content from one person to another, is often vulnerable to unauthorized access and subsequent loss.
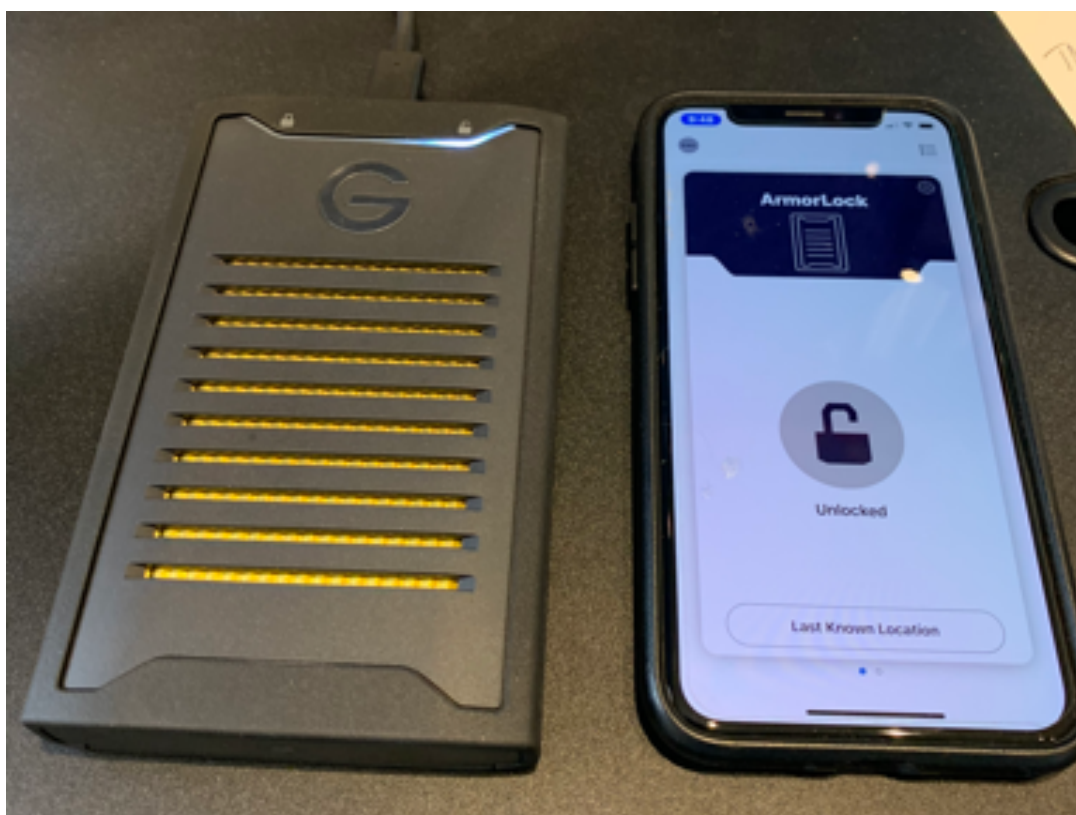
The G-Tech ArmorLock encrypted NVMe SSD uses a high performance NVMe SSD with up to 2 TiB capacity (with 1 GB/s read and write speeds) in a rugged and heat dispersing aluminum enclosure with a USB-C (USB 3.2, Gen 2) connector and works with Mac and Windows OSs. The drive provides IP67 dust and water resistance, 1,000 pounds crush resistance and can survive a 3 M drop). The external drive automatically encrypts all its data. This data is not accessed using an easy to forget or lose password, but rather is accessed via a secure Bluetooth or wired connection to a user's smart phone that uses zero-knowledge pubic key management. Since phones use password and/or biometric access, the phone and the app provide access to the encryption key on the drive that unlocks the contents and provides access.

In addition to secure access through a smart phone app, the ArmorLock Security Platform in the G-Tech ArmorLock encrypted SSD has numerous security features built in from manufacturing to end of use. This security platform leverages WDC's work with [RISC-V](#) and [OpenTitan](#). WDC also announced that it was releasing its Sweet B high-performance core cryptography library that underlies the ArmorLock Security Platform into GitHub Open Source. Sweet B using open source elliptic curve cryptography. The release includes documentation, a comprehensive test suite and an independent third-party audit by the security research firm Trail of Bits.

The ArmorLock apps can provide the ability of administrators to configure and manage multiple drives and multiple users to control who has access to what. This enables safe physical shipping of content between physical locations. Remote user authentication is possible using popular messaging and email services. The drive also allows fact secure crypto-erase and reformatting in one step and tracking the last known location of the drive on a map. It also support continued security support, improvements and new features.

Media and entertainment organizations need secure local digital storage products. WDC's RISC V-based G-Technology ArmorLock encrypted NVMe external SSD can provide password free encrypted collaborative digital storage for remote work, in the studio and in the field.

12) Media and Entertainment Storage TAM to Exceed $16B by 2025 (Forbes Blog, 8/31/20)
Media and entertainment storage drivers and demand are discussed in the latest report from Coughlin Associates on [Digital Storage in Media and Entertainment](#). The 251 page report offers in depth analysis of the role of digital storage in all aspects of professional media and entertainment.

Projections are given out to 2025 for digital storage demand in content capture, post-production, content distribution and content archiving are provided in 62 tables and 129 figures.

The sixteenth annual report includes results from a 2020 survey of Coughlin Associates, Digital Production Buzz, HPA and SMPTE members on their digital storage needs in these target segments (comparing the results to similar 2009, 2010 and 2012-2019 surveys). These surveys were used to refine the current report analysis from previous editions and track industry trends. The pie chart below, from the report, shows the breakdown of media for long term archives for the survey participants.
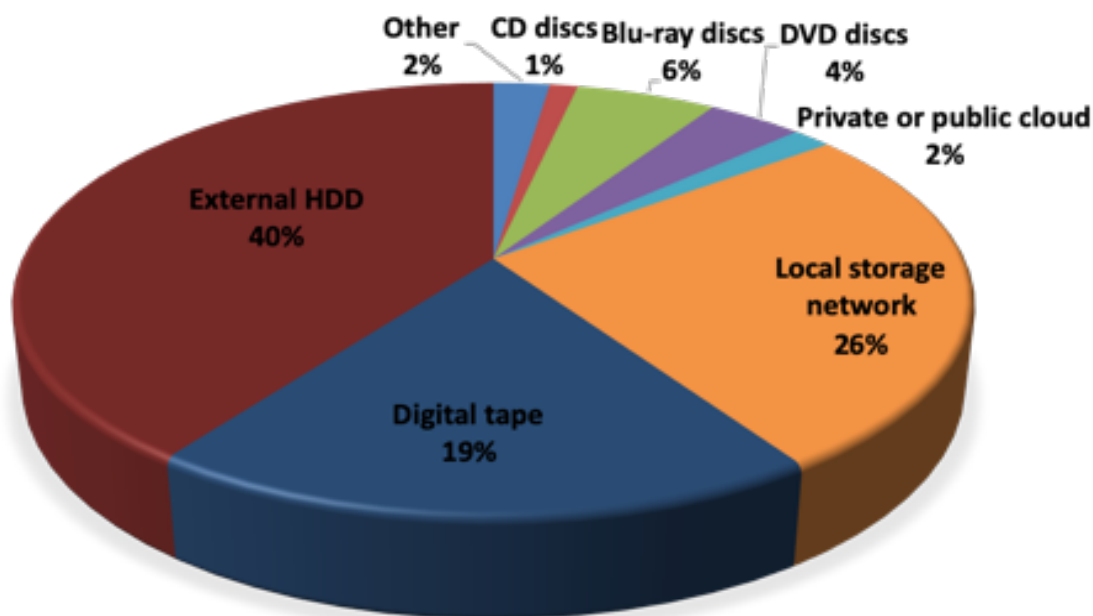
As a result of changes in the economics of storage devices higher performance solid-state storage will play a bigger role in the future. The cloud and hybrid storage including the cloud have assumed a new importance for many workflows during the Covid-19 pandemic. When the pandemic passes, use of cloud storage will continue to grow in the media and entertainment storage market going forward.

Some highlights from the report:

- The Covid-19 pandemic in 2020 will have a big impact on content creation in 2020 and likely into 2021, except for broadcast acquisition. The figure below shows the impact on storage for M&E content acquisition in 2020 and 2021.

- Spending for digital cinema in 2020 and 2021 will also be impacted by the pandemic
- Creation, Distribution & Conversion of video content creates a huge demand driver for storage device and systems manufacturers

- As image resolution increases and as stereoscopic VR video becomes more common, storage requirements explode
- The development of 4K TV and other high-resolution venues in the home and in mobile devices will drive the demand for digital content (especially enabled by high HEVC (H.265) and VVC (H.266) compression and even greater standards for compression to enable 8K and higher resolution and frame rate workflows.
- HDD areal density increases are slower but flash memory growth has increased and the price declined. This, plus the growth in higher resolution and higher frame rate content, is causing more applications to use flash memory
- Activity to create capture and display devices for 8K X 4K content is occurring with planned implementation in common media systems in this decade
- Active archiving will drive increased use of HDD storage for "archiving" applications, supplementing tape for long term archives
- Optical storage developments for higher capacity write-once Blu-ray optical cartridges will create higher capacity discs and this may help slow the reduction in optical disc archiving
- Flash memory dominates cameras and is finding wider use in post-production and content distribution systems
- From 2019 to 2025 entertainment and media digital storage TAM (without archiving and preservation) will increase by about 1.8 X from $7.3B to $13.3 B
- The growth in storage capacities will result in a total media and entertainment storage revenue growth of about 1.6 X between 2019 and 2025 (from $10.3 B to $16.5B)
- Overall annual storage capacity demand for non-archival applications is expected to increase over the period from 2019 to 2025 by 5.0X from 24.3 EB to 122.4 EB
- Between 2019 and 2025 we expect about a 3.0 X increase in the required digital storage capacity used in the entertainment industry and about a 3.4 X increase in storage capacity shipped per year (from 70.8EB to 241EB
- In 2019 content distribution is estimate at 31% of total storage revenue followed by archiving and preservation at 29%, post-production at 22% and content acquisition at 18%.
- In 2025 the projected revenue distribution is 33% content distribution, 25% post production, 23% content acquisition and 19% archiving and preservation.
- By 2025 we expect about 56% of archived content to be in near-line and object storage, up from 48% in 2019
- In 2019 we estimate that 74.7% of the total storage media capacity shipped for all the digital entertainment content segments was in HDDs with digital tape at 19.0%, 2.7% optical discs and flash at 3.5%

- By 2025 tape capacity shipment share has been reduced to 13.0%, HDDs shipped capacity is 76.4%, optical disc capacity is down to about 0.5% and flash capacity percentage is at 10.1%
- Media revenue is expected to increase about 1.2X from 2019 to 2025 ($1.8B to $2.2B).
- The single biggest application (by storage capacity) for digital storage in the next several years as well as one of the most challenging is the digital conversion of film, video tape and other analog formats and its long-term digital preservation
- Over 116 Exabytes of new digital storage will be used for digital archiving and content conversion and preservation by 2025
- Storage in remote "clouds" is playing an important role in enabling collaborative workflows, content distribution and in archiving
- Overall cloud storage capacity for media and entertainment is expected to grow over 13X between 2019 and 2025 (2.2 EB to 29.0 EB)
- Overall object storage capacity for media and entertainment is expected to grow about 3.7 X between 2019 and 2025 (14.3 EB to 52.7 EB)
- Cloud storage revenue will be about $3.7 B by 2025
- By our estimates, professional media and entertainment storage capacity represents about 5.8% of total shipped storage capacity in 2019.
- Professional media and entertainment consume about 28% of all tape capacity shipments, 4.9% of all hard disk drive shipments and 2.3% of all flash memory shipments in 2019. We estimate that media and entertainment spending was about 9% of total storage revenue in 2019.

As a result of the Covid-19 epidemic, M&E content acquisition storage will suffer loses in 2020 and 2021, except for broadcast. This will also impact post production storage. Cloud storage will assume a new importance for remote work. The latest M&E storage report projects out to 2025.

13) FC NVMe Storage, Edge Stroage and Backup Options (Forbes Blog, 8/26/20)
This blog catches up with recent announcements about fibre channel NVMe over fabric, IX Systems TrueNAS storage, including storage at the network edge, as well as Acronis and BackupAssist data protection products. We also provide a link to a Weka DataOps white paper.

The Fibre Channel industry Association (FCIA) announced that the International Committee on Information Technology Standards (INCITS) published the FC-NVMe-2 standard. This standard includes enhancements that significantly increase the speed of bit error detection and recovery during data transmission. These bit errors are detected and recovered at the transport layer below the protocol layer, causing less delay in transmitting error free data.

Fibre channel is a popular technology for creating block level access to networked storage devices in a Storage Area Network because of its lossless data transmission. Fibre channel is also popular as a transport for SCSI commands through a network and is being used by many storage system companies to deliver NVMe over fabric NVMe-oF) network storage solutions.

iX Systems announced its M60 unified storage system powered by its TrueNAS 12.0 operating system based upon OpenZFS. TrueNAS 12.0 merges the FreeNAS and TrueNAS brands and unifies the software and documentation. FreeNAS becomes TruNAS CORE, still Open Source and freely available as an edition of the TrueNAS Open Storage software.

The other versions of the software are TrueNAS Enterprise and TruNAS SCALE (high availability) editions. The company says that TrueNAS 12.0 is 30% faster than the previous version due to the use of persistent cache and fusion pools where flash provides metadata and small I/O data. The companies M-Series storage systems can provide up to 24 HDDs or 28 SSDs in 4U and have 8-100GbE ports to provide over 20 GB/s and 1 M IOPS performance and up to 20PB of top loading storage capacity with high density expansion shelves.

IX Systems also announced storage products for the network edge. The TrueNAS Mini-X storage appliance utilizes the TrueNAS CORE 12.0 software. The company announcement says that "TrueNAS Mini-X supports applications with high capacity and remote data requirements. The two new storage systems (Mini-X+ and Mini-X) provide up to 85TB of storage in a compact (13.5L) chassis with seven hot swap drive bays (5 x 3.5" and 2 x 2.5"). The Mini-X storage platform is designed to address a broad range of office/edge requirements for block, file, video, and unstructured data storage. Hard Disk Drives (HDDs) and Solid State Drives (SSDs) can be mixed into fusion pools which provide the performance of flash and the economics of disk drives. " The image below shows the two new edge storage appliances.

Storage at the network edge is growing with increasing growth of data generation at the edge from the growth of IoT, surveillance and other big data applications.

A recent Acronis survey found that nearly half (47%) of remote workers never received clear guidance on securing their home machines while working at home. Acronis says that its latest True Image release provides enterprise protection for people working from home.

Acronis announced the release of Acronis True Image 2021 that integrates cybersecurity capability with personal backup for home users, prosumers and small businesses around the world. The company says that "Incorporating cybersecurity capabilities such as real-time antimalware protection, on-demand antivirus scans, web filtering, and videoconference protection into Acronis True Image ensures users have complete cyber protection." The advanced antimalware capabilities are included with Advanced and Premium licenses and offered as a three-month trial with Standard and Essential licenses.

Another company, BackupAsssist, gave me a briefing about their cyber resilience backup and recovery solutions for small and media size enterprises running Microsoft Windows. They have a new product, BackupAssist ER that focuses on express data recovery and expert response for Windows Servers, providing Disaster Recovery as a Service (DRaaS) at a lower cost than other solutions.

The software provides disk to disk to cloud backups. The product also monitors the data being backed up to look for suspicious files and activity that signal a ransomware attack. There are disaster recovery methods, first VM instant boot, second bare metal recovery and download cloud backup to anywhere and it allows recovery of granular files, exchange and applications to a point in time..

A few weeks ago I wrote a blog that included information about WekaIO. For those interested in finding more about DataOps and how Weka's exascale filesystem can enable accelerated DataOps you might be interested in this White Paper.

NVMe over Fibre Channel improvements increase NVMe network capability. iX Systems TrueNAS provides data center and edge storage products and Acronis and BackupAssist offer new capabilities for personal and SME data protection.

14) Spin Memory Selector Improves DRAM, ReRAM and MRAM Density, New Microchip SSD Controller (Forbes Blog, 8/19/20)
Spin Memory, a magnetic random-access memory (MRAM) startup announced a new semiconductor technology that could allow a dramatic improvement in DRAM as well as emerging memory technologies, such as MRAM. Spin Memory calls this technology the Universal Selector. It announced the technology on August 12 but gave more details at its talk at the IEEE TMRC Conference on August 20.

Selectors are the technology that is used to isolate a memory cell from other memory cells in a memory array. Many memories, including MRAM, use transistors as their selectors, but conventional transistors consume more space than the memory cell and thus limits the memory density that can be achieved. DRAM can suffer from a problem called row hammer disturbs as well as its own limits on achievable cell density. Much of the work on this selector technology was done as a joint project between Spin Memory and imec.

Spin Memory's Universal Selector is a selective, vertical epitaxial cell transistor whose channel has a low enough doping concentration that it operates in full depletion. The fully depleted cell transistor along with other unique process and device features leads to a crucial architectural change, allowing the channel to be completely electrically isolated from the silicon substrate. This completely eliminates the possibility of any trapped or migrating electrons causing row hammer, making this design row hammer-immune.

The company says that this new way of building transistors utilizes materials and processes that already exist in standard silicon manufacturing processes. This should allow faster utilization of this technology in creating new non-volatile memories since it doesn't require an investment in specialized hardware or resources.

The Universal Selector improves DRAM array density by 20% –35% through its $4F^2$ (4F2) DRAM bitcell configuration. The figure below shows the DRAM advantage of this selector technology.

The Path to ~$4F^2$ DRAM with Spin's Selector

Allows true $4F^2$ DRAM with buried bitline directly underneath channel

Contact to Storage Node
Wordline
N+ monoSi
Buried Bitline
N+ monoSi
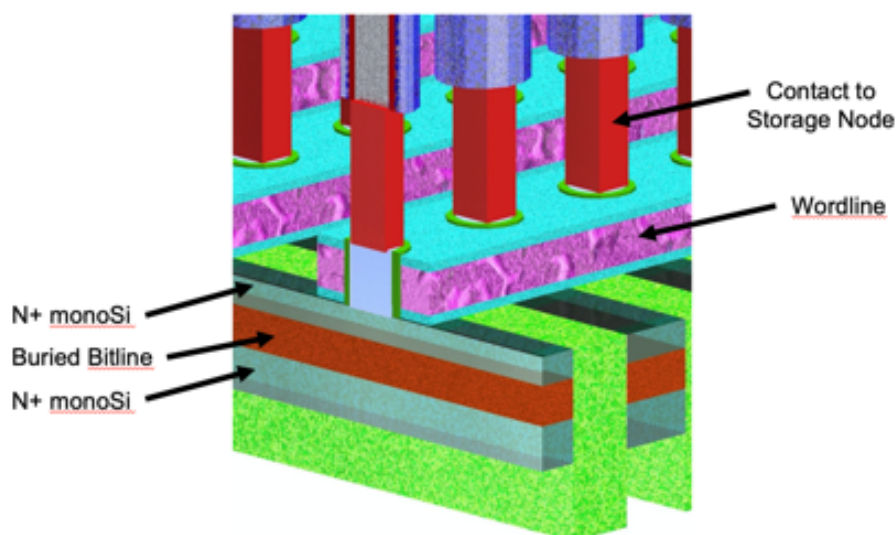
For emerging memories such as MRAM, ReRAM and PCRAM, the Universal Selector enables manufacturers to create 1T1R memory bitcells of $6F^2$ to $10F^2$ (6F2 – 10F2, where F is), enabling manufacturers to embed up to five times more memory in the same area footprint with minimal additional wafer processing costs. This drastically improved memory density will fulfill the demands of cutting-edge applications — allowing artificial intelligence, virtual reality, edge computing and more to reach new technological heights.

The company says that its Universal Selector will bring conventional STT MRAM to a higher SRAM-like performance. A very dense high-performance MRAM could accelerate replacement of SRAM by MRAM in on-chip memory.

Microchip announced its Flashtec NVMe 3108 controller. This is a PCIe Gen 4 NVMe controller that supports 8 flash channels running at speeds up to 1,200 mega-transitions per second (MT/s). This product is a derivative of the Flashtech NVMe 3016 16 channel controller, introduced at the 2019 Flash Memory Summit and is aimed at low power and form factor optimized SSDS.   The product joins Microchips Data Center solutions.

The Flashtec NVMe 3108 is geared towards smaller form factor and lower power SSDs, such as M.2 and E1.S form factors. It also includes security features such as secure boot and AES 256 data encryption. These controllers also support single and dual port applications.   The companies says the NVMe 3xxx family supports next generation SSD applications such as shown in the future below.
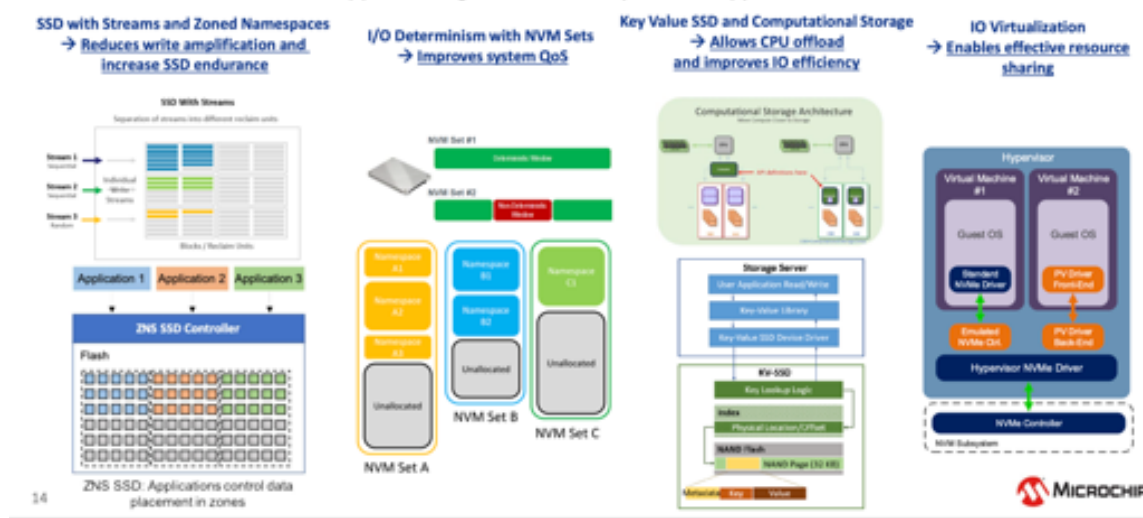
Spin Memories new selector technology could revolutionize memory density for DRAM as well as emerging non-volatile memories. Microchips 3xxx SSD controllers can enable NVMe SSDs with advanced features.

15) Is Intel Ready to Make Money on Optane (Forbes Blog, 8/15/20)
During Intel's last earnings announcement the company provided information to indicate that 3D XPoint (which Intel sells as Optane memory) may have finally reached break-even. This is big news for the emerging memory world, since it is believed that the company has been subsidizing Optane manufacturing so its prices are about half those of DRAM memory, which it is intended to displace.

The following information is from a blog by Jim Handy, a colleague and analyst covering memory technologies and shows why Intel may finally have achieved enough production volume to reach manufacturing break-even on its Optane memory. The following material is from Jim's Blog.

"The chart below shows profits for NAND flash makers from 2016 through the most recent quarter. It's a rough way of comparing major NAND flash manufacturers' business. As of August 14, all major NAND makers have reported their earnings for the second quarter of 2020."
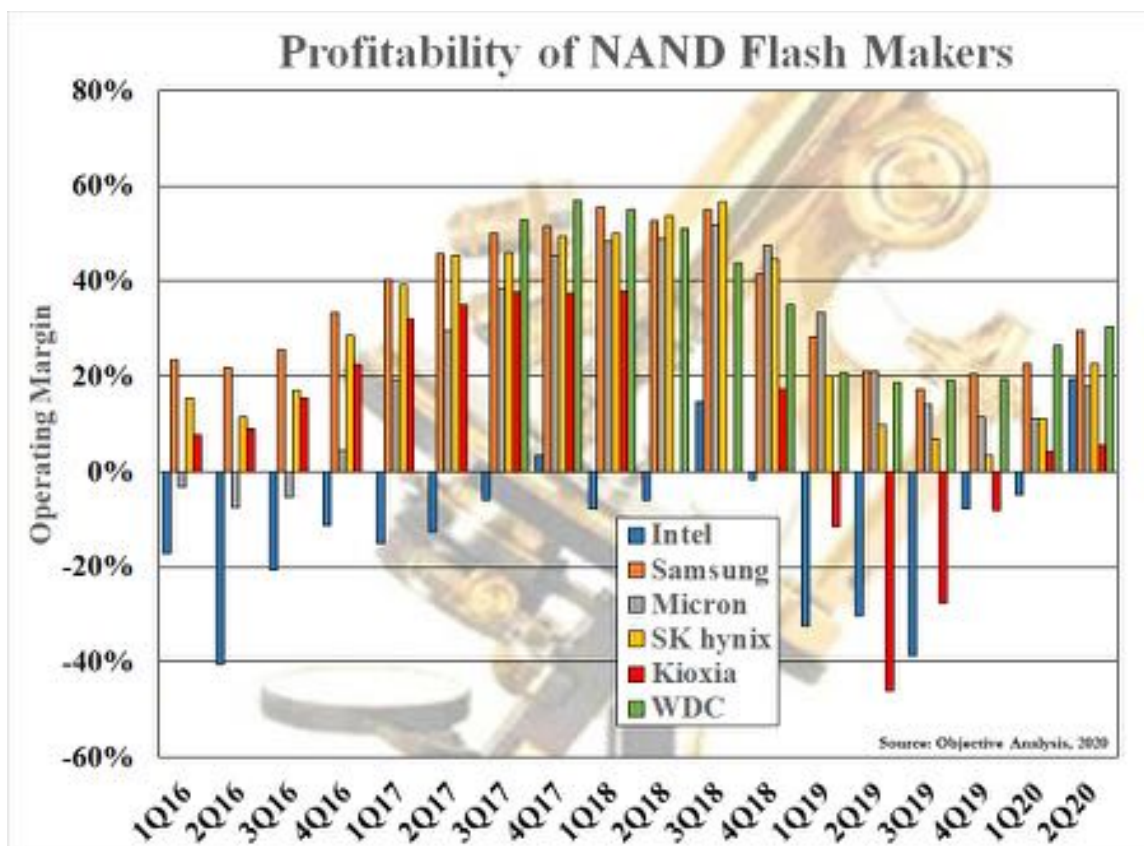
Jim goes on to provide the following observations about this chart. The margins shown for Samsung, SK hynix and Micron are for DRAM and NAND flash combined. Operating margins are shown for most companies, but WDC only reports the gross margin for its flash business. Intel's margin is for its Non-volatile

Solutions Group (NSG) and includes NAND flash and products based on 3D XPoint memory.

"The important take-away from this chart is that Intel's NSG margins have been negative every quarter except for 4Q17, 3Q18, and last quarter, 2Q20. During 2017 & 2018 the other NAND flash makers had impressive profits. Why didn't Intel?

The Memory Guy guesses that Intel was profiting from its NAND flash business as much as its peers, but the 3D XPoint Optane effort was sucking all of those profits out of the business, and more, to cause losses.

In fact, if you estimate that Intel's NSG group's NAND profit was equal to the average of its competitors, then you can calculate XPoint losses of about $2 billion for 2017, another $2 billion for 2018, and $1.5 billion for 2019!"

Jim's chart shows that Intel's operating margin for the NSG group in CQ2 2020 was about 19%, close to the operating margin of the other flash memory companies. Thus it is reasonable to assume that the group's NAND profits are no longer being offset by its Optane losses.

If Optane is passing manufacturing break even then it could start to generate a profit on this business for Intel and may help to attract other companies (perhaps Micron) to make 3D XPoint memory as well.

In Jim's and my Emerging Memories Find their Direction Report we project the growth of emerging memories such as 3D XPoint and MRAM as well as DRAM and NAND flash. The figure below is from that report.
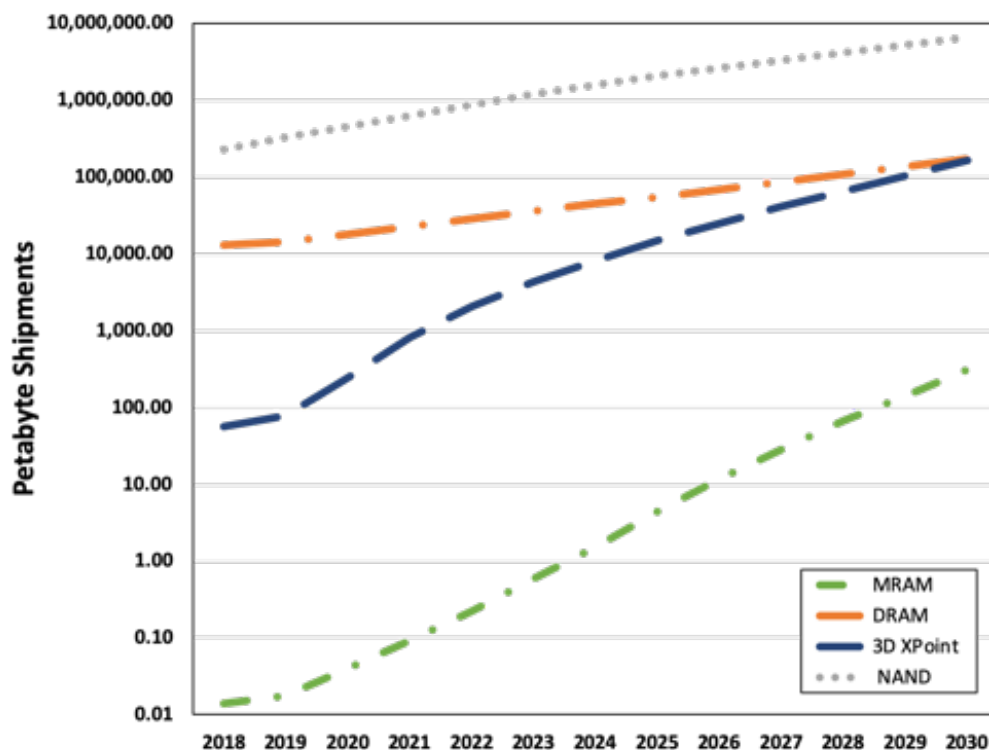
New applications as well as displacement of existing memories will drive the use of non-volatile memory technology. Emerging high performance non-volatile memories like Intel's Optane and MRAM will enable significant changes to computers, servers and embedded products, making them more efficient and powerful.

Intel reaching break even on its Optane memory would be a real accomplishment and an indication of things to come for emerging non-volatile memories. Fast non-volatile memories will transform computer and embedded device architectures and enable the connected, IoT world of tomorrow.

16) HDD Quarterly Results and Projections (Forbes Blog, 8/11/20)
Let's look at CQ2 2020 HDD results and revised projections for HDDs through 2025. These are results from the Q2 2020 Coughlin Associates newsletter.

Total HDD shipments in CQ2 2020 were down 12.4% from CQ1 (59.4 M units in CQ4 2019 compared to 67.8 M units in CQ4 2019) compared with down 12.9% in CQ1 2020 from CQ4 2019, down 5.5% in CQ4 2019 from CQ3 2019, up 5.8% in CQ3 from CQ2 2019, and up 1.0% in CQ2 2019 from CQ1 2019.

Estimated notebook HDD shipments were down 11.2% from the prior quarter while desktop HDD shipments declined by 9.5%% Q2Q. CE HDD shipments were down 22.7% while branded shipments were down 18.6% Q2Q. High performance

enterprise HDDs were down 30.3% while near line enterprise HDDs were down 11.4% Q2Q.

3.5-inch HDDs declined by 10.0% Q/Q. 2.5-inch HDDs decreased by 16.4% Q2Q.

In **Table 1** we see an 8.9% ASP increase from CQ4 2019 to CQ1 2020 compared to an 2.4% ASP increase from CQ3 2019 to CQ4 2019, 4.5% ASP increase from CQ2 2019 to CQ3 2019, a 4.2% increase from CQ1 2019 to CQ2 2019 and a 1.6% increase from CQ4 2018 to CQ1 2019.

TABLE 1. AVERAGE DISK DRIVE SALES PRICES (ASP) AND UNIT VOLUMES (MILLIONS/$ PER UNIT)

	Q2 19 Units/$	Q3 19 Units/$	Q4 19 Units/$	Q1 20 Units/$	Q2 20 Units/$
Seagate	31.4/$70.2	33.8/$73.1	32.4/$76.6	29.3/$86.2	26.4/$87.9
WD	27.7/$75.0	29.3/$81.0	29.0/$81.0	24.4/$85.0	23.1/$87.0

The multiyear trends in ASPs as shown in **Figure 1**.

Table 2 gives CQ1 2020 drive numbers by company and application.

Table 3 shows CQ1 2020 drive numbers by company and form factor.

Table 4 shows CQ2 2020 Estimated Exabytes Shipped by company and general application. Note that per Seagate's reports, Legacy includes PC, CE, Branded and enterprise applications.

Figure 2 shows the unit shipment market share of the three HDD producers for CQ1 2020. Note that Toshiba lost 2% unit market share Q/Q, while Seagate and Western Digital gained 1% unit market share Q/Q each.

FIGURE 1. AVERAGE DRIVE PRICE TREND FOR SEAGATE, WESTERN DIGITAL AND HGST (Q4 '98 TO Q2 '20)
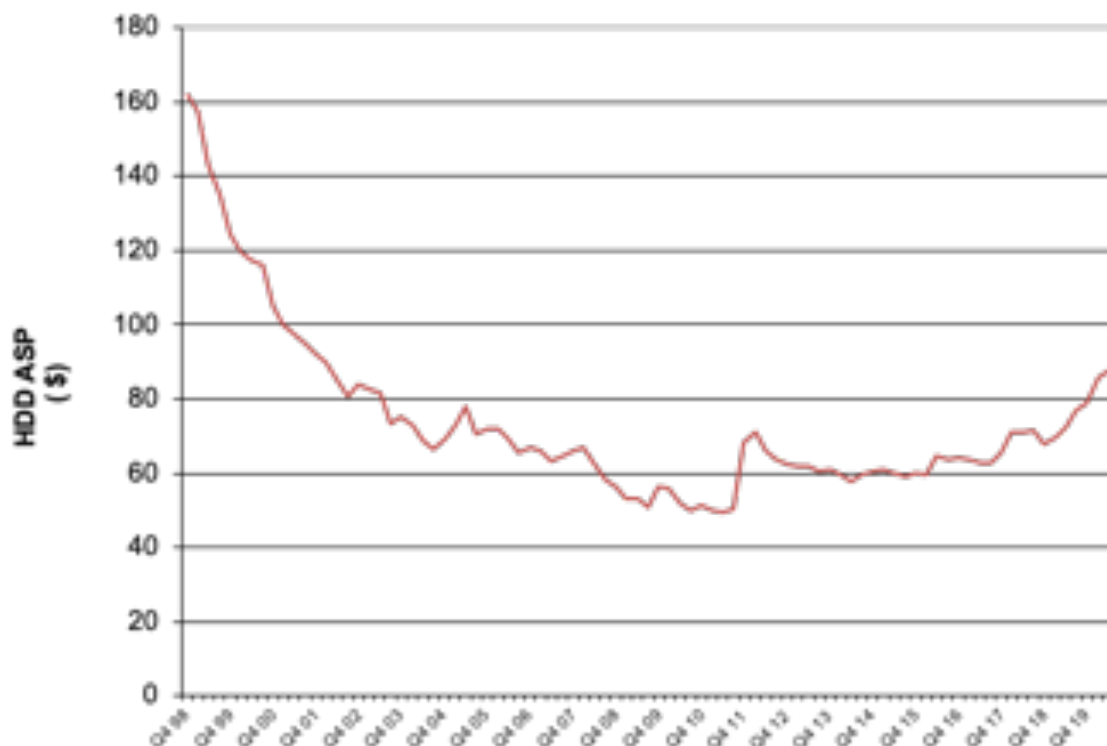
TABLE 2. CALENDAR Q2 2020 ESTIMATED DISK DRIVE SHIPMENTS BY APPLICATION (UNITS IN MILLIONS)

Company	Mobile	CE	Branded	Desktop	Near Line	Enterprise	Total Q1
Seagate	4.0	5.8	2.5	3.7	8.6	1.8	**26.4**
WD	6.0	4.2	2.7	3.4	6.7	0.1	**23.1**
Toshiba	2.6	2.7	1.13	1.4	0.9	0.7	**9.6**
Total	**12.6**	**12.7**	**6.3**	**8.5**	**16.2**	**2.6**	**59.4**

TABLE 3.   CALENDAR Q2 2020 ESTIMATED DISK DRIVE FORM FACTOR SHIPMENTS (UNITS IN MILLIONS, ESTIMATED)

Company	2.5 inch	3.5 inch	Total Q4
Seagate	9.2	17.2	**26.4**
WD	9.5	13.6	**23.1**
Toshiba	6.2	3.4	**9.6**
Total	**9.2**	**17.2**	**26.4**

TABLE 4.   CALENDAR Q2 2020 ESTIMATED DISK DRIVE EXABYTES OF CAPACITY SHIPMENTS

Company	Nearline	Other Mass	Legacy	Total Q4
Seagate	79.50	12.00	26.40	**117.90**
WD	78.21	13.70	31.20	**123.11**
Toshiba	25.14	0.74	23.24	**49.12**
Total	**182.85**	**26.44**	**80.84**	**290.1**

FIGURE 2. 2020 MARKET SHARE THROUGH CQ2
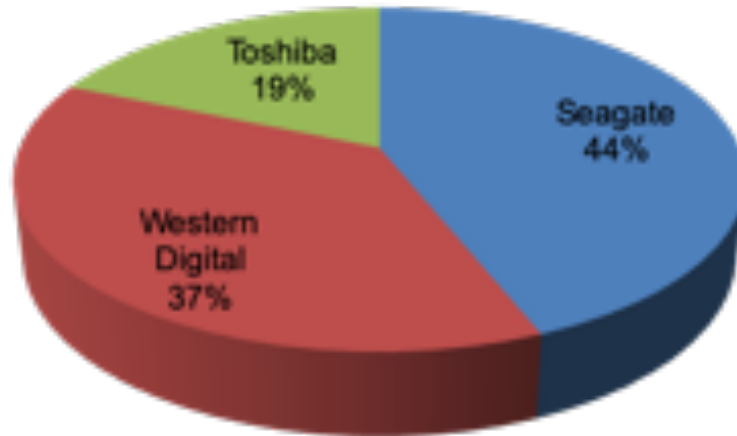
Figure 3 shows high, median and low estimate of total drive unit volume estimates out to 2025.   We have reduced our estimat es for 2020 and future years based upon continuing softening in Q2 2020.

FIGURE 3. BANDED HARD DRIVE VOLUME PROJECTIONS
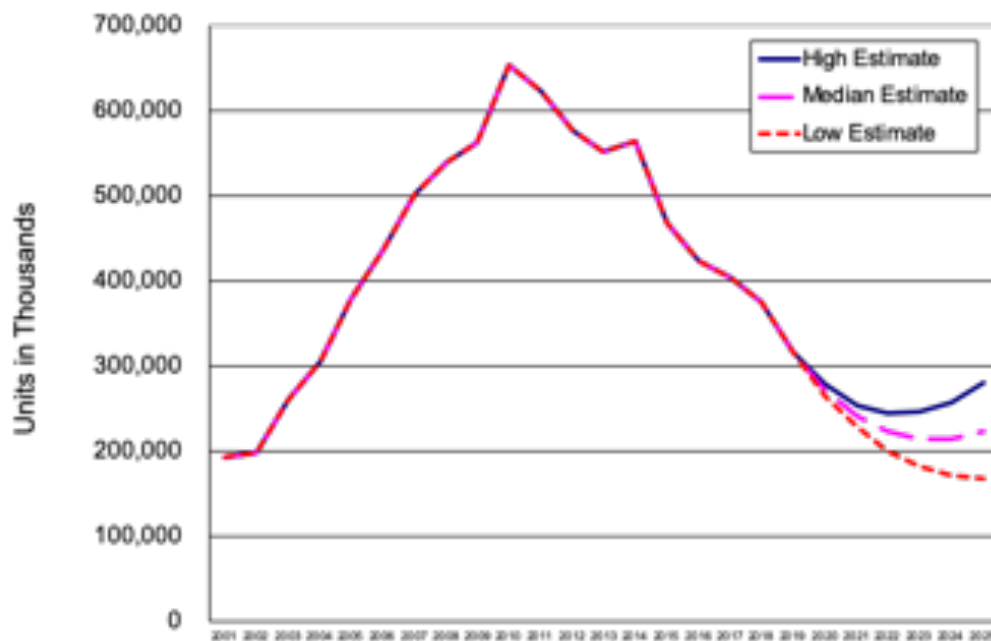
Figure 4 shows laboratory demonstrations and product announcement maximum areal densities history.

Figure 5 gives our projections for drives by market niche out to 2025. **Figure 6** does the same for drive form factor.

Figure 7 shows the average $/GB for HDDs. **Figure 8** shows total projected shipments for Tape (LTO), SSDs and HDDs.

FIGURE 4. AREAL DENSITY ANNOUNCEMENT DEVELOPMENTS
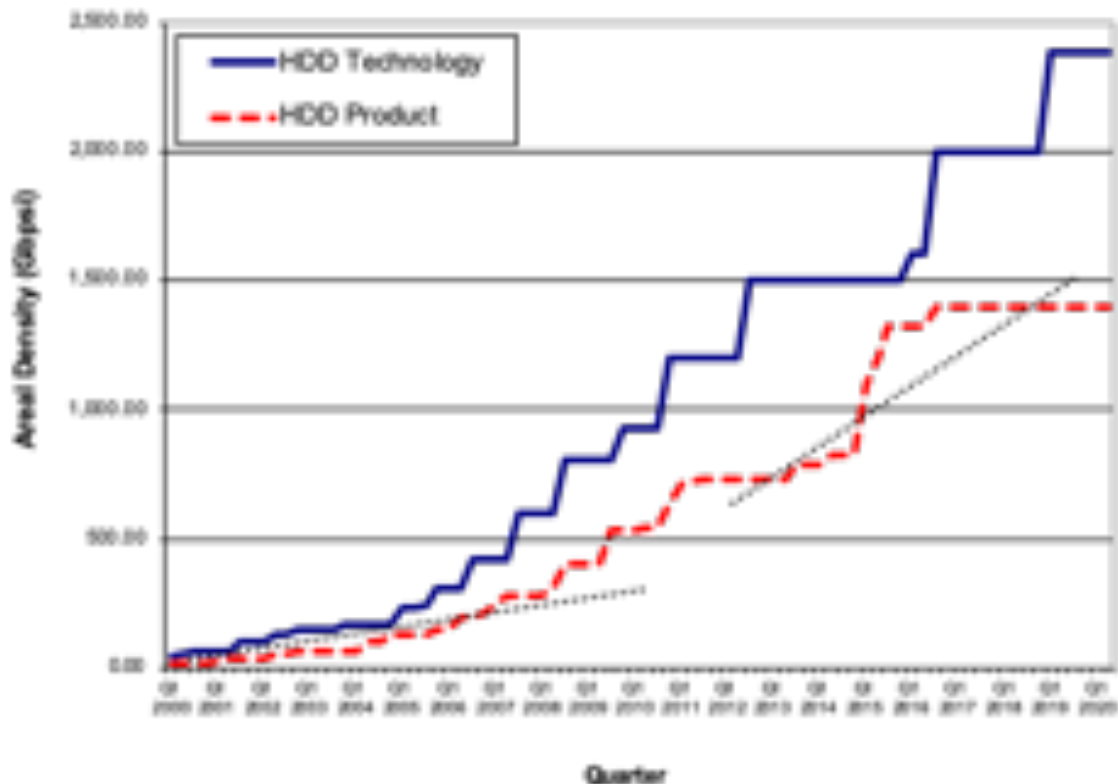
FIGURE 5. PROJECTION OF DRIVES BY MARKET NICHES (1,000'S UNITS)
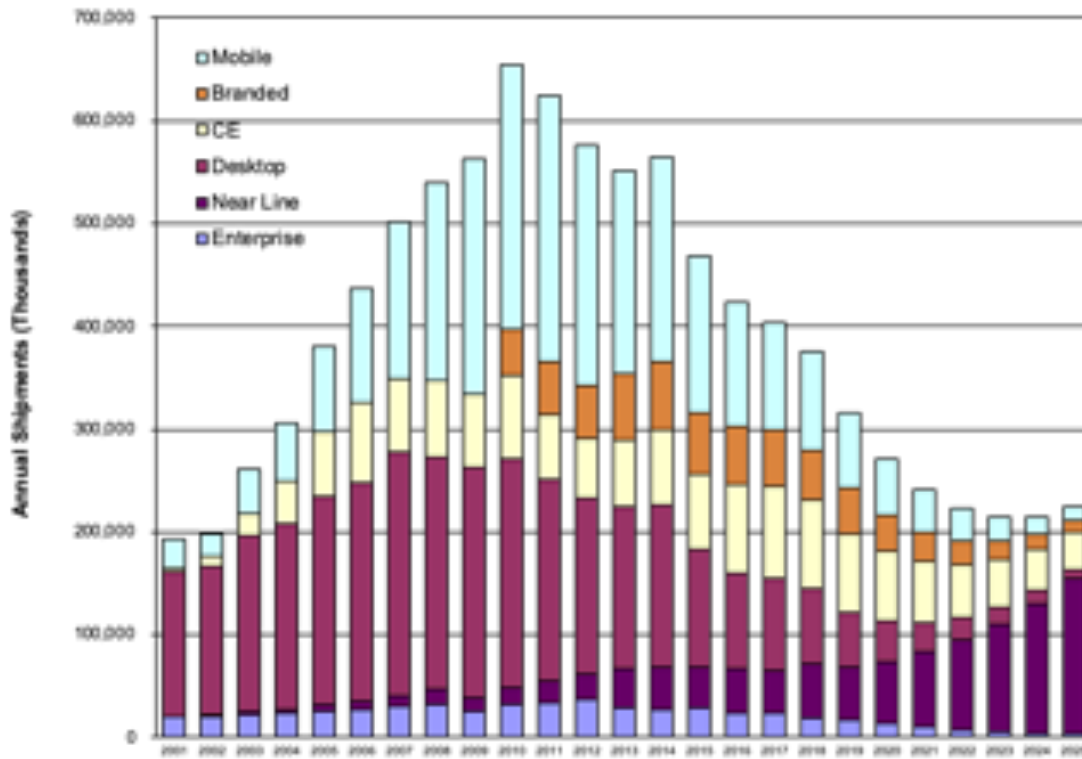
FIGURE 6. PROJECTION OF DISK DRIVES BY FORM FACTOR (1,000'S UNITS)
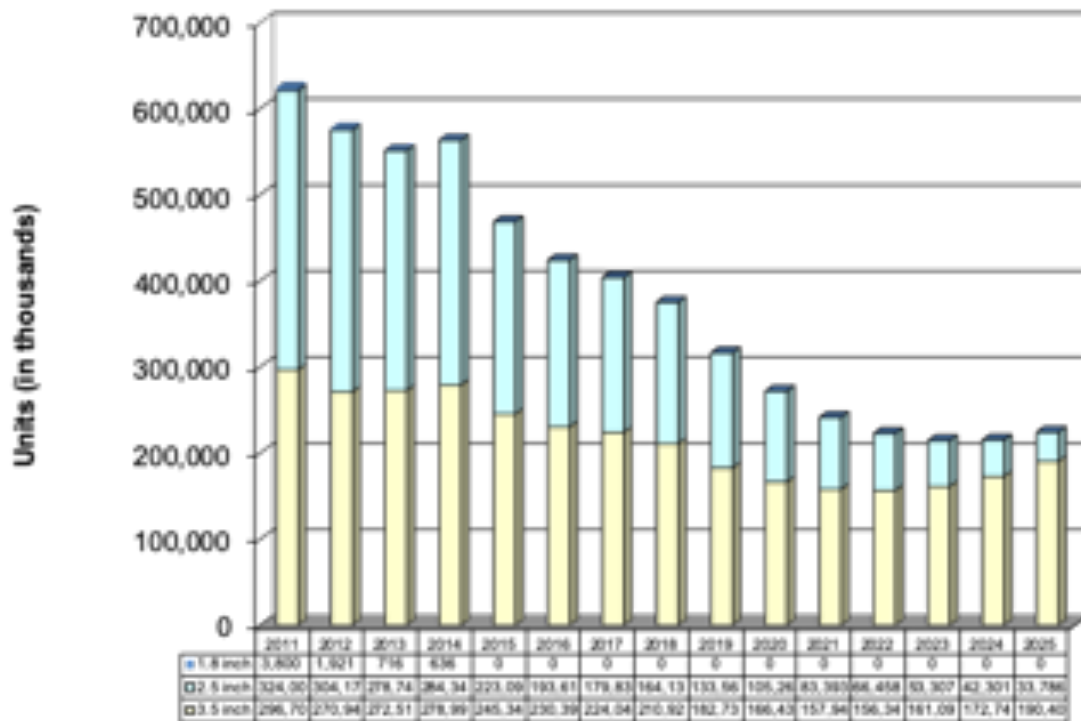
FIGURE 7. AVERAGE $/GB FOR HDDS
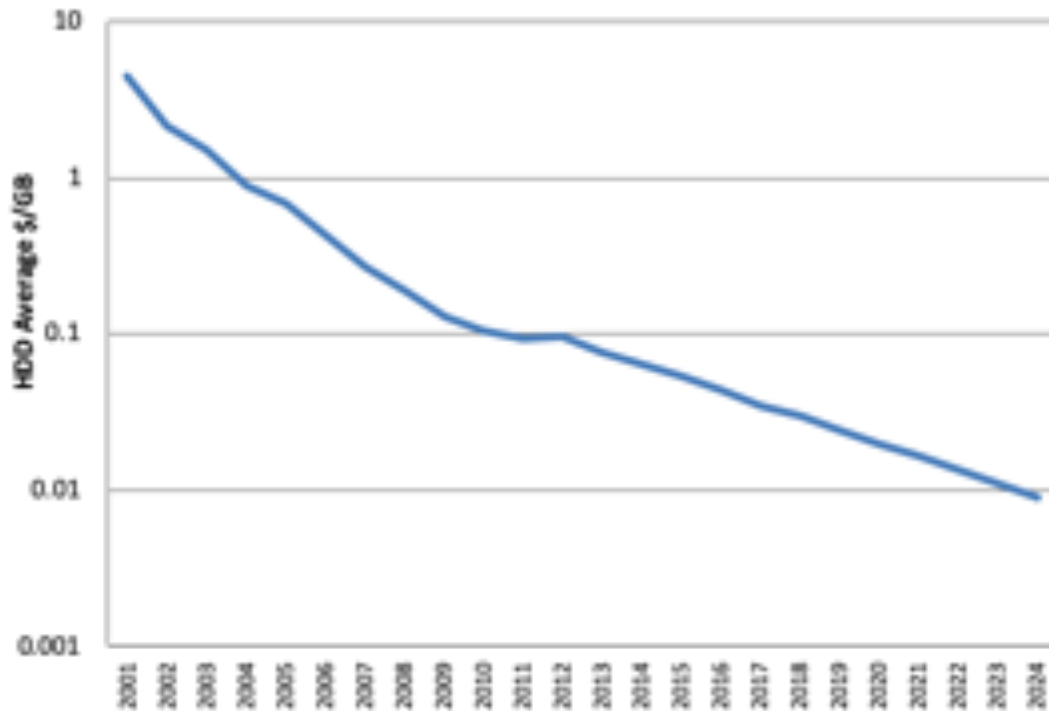
FIGURE 8. CAPACITY SHIPMENTS FOR LTO TAPE, SSDS AND HDDS
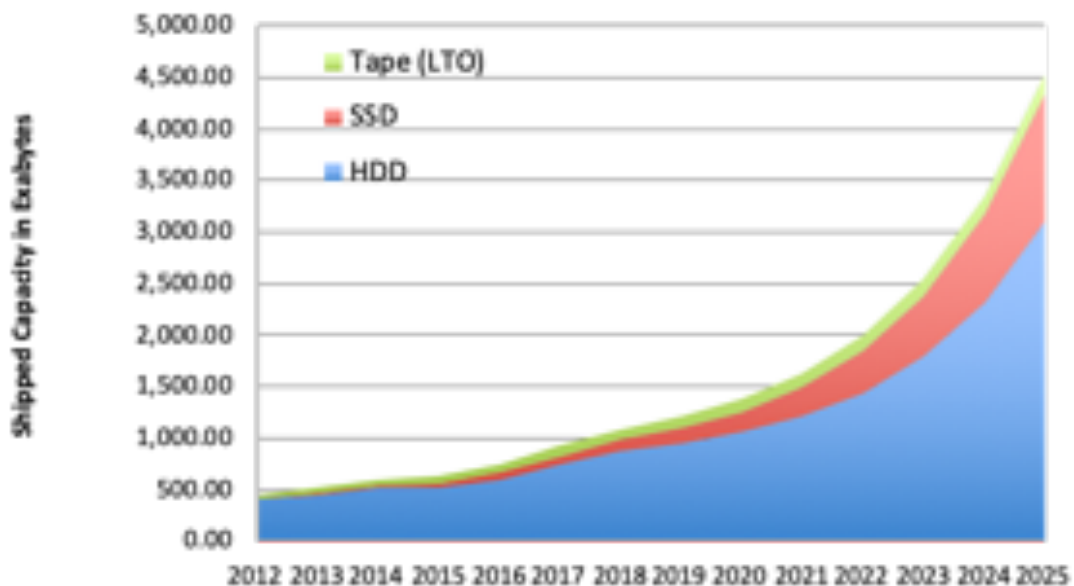
HDD shipments in the first half of 2020 were down 18.8% compared to the first quarter of 2019. Over the same period Nearline HDD shipments experienced 56% growth, driven by data center purchases, while other HDDs shipments declined.

GUEST ARTICLES

1) **How Has the COVID-19 Shock Changed Your Total Available Market?, November Update, Steve Daniel, Daniel Research Group**

1)

A Forecast of the United States Economic Business Demographic Structure
November 2020 Update
(important changes highlighted in yellow)

Wealth Trump Health

Context

May you live in interesting times – alleged Chinese curse.
Be careful what you wish for, lest it come true! Aesop's Fables.
Well we live in interesting times. Now What?

DRG's BEDD was designed and developed to forecast the Total Available Market (TAM) for technology or technology enabled products and services measured in terms of number of buyer/users – Employees, Businesses, Business sites, and Payroll.

GDP and other traditional econometric metrics forecasted by established and credible sources are inputs to the model and influence the output. The value add

of the model is the forecast of the structural changes to the economy in terms of the distribution of the metrics across the Sector. Sub-Sector, Industry, and Business Size Class (by Employees) taxonomy. Basically, it answers only one question, "**How big is your market?**"

Up until late March of this year, the model's central algorithm extrapolated long-term slow moving trends in the distribution of the metrics within the taxonomies over time, constrained by industry level and total US growth forecasts published by various US Government Sources.   The first rule of this approach is to ask the question, ***"Is the process that created the past, the same that will determine the future?"***   By March 31ˢᵗ, the answer was clearly **no**!

Forecasting Challenges

Initial Chaos – Initial Covid 19 and economic forecasts and guidance from government and other credible sources differed widely sowing confusion. Since the value of economic forecasts is primarily derived from its use by individuals and enterprises in decision making, **DRG** chose to delay modifying, updating and developing new forecast models until sufficient data became available in order to understand the current state, relationships and trends in the economy. By mid-September sufficient data had become available.

Data Reliability and Variance – Complicating the process was the disruptions in the data collection, process and reporting systems, as well as the politicization of reporting.   Most of the inputs into our models are derived from the analysis of an aggregation of varied and conflicting data and options. Given the increase of variance in the research data and information, the weight has shifted somewhat from reliance on quantitative input to qualitative. One of the functions of a good model is to facilitate the process by which an analysts can express their qualitative assessments in quantitative terms.

Update Frequency - The sudden onset of the Covid 19 virus and the magnitude of the economic immediately shifted the observational focus from Annual and Quarters to Months and Weeks.   While **BEDD** remains an annual forecast model, the new **C19UER** and **WFH** models are monthly forecast models, In addition, some of the input data is tracked and updated weekly.

Causal Variable Selection – The shock that Covid 19 gave to the economy is somewhat unique in that it is initially a Labor Shock, not a Capital, Demand or Supply shock.   The rate and magnitude of unemployment is determined more by occupation than by any other economic demographic. Therefore, **Occupation,** not industry is the best taxonomy within which to understand the impact of Covid 19 on employment and spending. Fortunately, two existing government database were available to provide the necessary data, information, and knowledge, the Department of Labor O-Net database and the Bureau of Labor Statistics Industry-Occupation Matrix.   Used together, these two were utilized to forecast the number of employees that would become unemployed, and for how long, by occupation

and industry. Additional employment data by occupation from the Department of Labor Unemployment database and the Bureau of Labor Statistics Covid 19 Survey Database was incorporated into the models

Unemployment - C19UER is a new model that forecasts Labor Force, Employment, Unemployment and the Unemployment Rate by month, first by forecasting each Occupation and then aggregating to each Industry, and then total US. This model is update frequently to reflect actual Industry and Occupation data when published, as well as new studies and analysis from credible sources providing guidance regarding employment and unemployment trends.

Employment Redistribution - Two of the more imported changes in the Business Economic Demographic structure of the US economy is loss of hundreds of thousands of small businesses and the eventual reemployment of most these workers by the remaining medium and large business. Redistribution will also be manifested across occupations and industry, but the redistribution across employers by size class will have the most significant impact on the demand for products and services necessary to support those employees.

Work From Home The second impact of Covid 19 on the distribution of Labor is the immediate increase in the number of employees Working From Home (WFH). **WFH** is a second new models that forecasts the number of employees Working From Home by Occupation, by Industry, by Month.   The model is updated frequently as actual data is published, as well as new studies and analysis provide guidance regarding Work From Home levels and trends.

Many employees were already working from home prior to Covid 19 and the trend was increasing, Covid 19 accelerated the process. In addition to forecasting the immediate significant increase in the remote work force, the model predicts what the new post Covid higher level and trend will be. However, absent the Covid 19 constraint WFH will decrease back to some new level a bit higher than the pre-Covid level because for most it is not the optimal way to maximize economic output, or maintain domestic tranquility.

Partisan Political Paralysis
There are three destabilizing forces acting in our society today.
1. The Covid 19 virus that is a threat to our health
2. The Recession that the Covid 19 and our responses to it, has created
3. Tribal Civil Unrest

Add the new Cancel Culture movement and there is not a person in the country that does not belong to an identity group that is being attacked. Everyone feels threatened. When people feel threatened by forces that they have little or no control over they seek to find reasons for their distress, as well as agency that authority can address. Sadly, authority, up until recently was the source of the

third destabilizing force, and had abdicated desperately needed leadership responsibility.

<mark>Within the last 48 hour of the writing of this report, it has been announced that a 90% effective vaccine may be soon available for distributed that will significantly reduce or even remove the Covid 19 virus health threat.</mark>   Eventually the economy will recover and the jobs, but not all of the businesses, will come back because the underlying demand for the products and services produced is still there.   While it may take many generation for the causes of the civil unrest in our society to be eradicated, its injection into partisan politics needs to end now.

When Will the New Normal Get Here?
Specifically, when will people decide to return to most pre Covid 19 personal and business routines. To answer that question, it may be useful to apply a model that DRG has used to predict product and service buying decisions.

Consumer decide to buy, or not, based on inputs from four sources.

- **External Advocacy** – marketing content from sellers about the capabilities, attributes, and benefits of the product or service.

- **External Observation** – Claims by sellers about the number of consumers who have purchased and/or are using the product or service.

- **Internal Advocacy** – Asked for, or offered, opinion or advice from personally known trusted and credible individuals

- **Internal Observation** – What did trusted and credible individuals that you know actually purchase and use.

DRG research has identified **Internal Observation** as the most important, and in some case the only, source influencing the individuals buying decision.

Individuals will decide to return to most pre Covid 19 personal and business routines when a critical number of personally known trusted and credible individuals have already done so. Each person will determine what that number is for themselves. However, as this time, it is not possible to estimate what the population average is since the magnitude and trend of the most important influencing factors are still unknown.

Model Methodology and Sources
Business Economic Demographic Database (BEDD)
The **BEDD** model is essentially a pie slicing model where the size of the pie is simply the forecast of the total number of employees in the US economy. Historically that forecast is derived by applying the forecast of the annual employment growth rate published by the Congressional Budget Office (CBO) to

the historic and current employment data as published by the Bureau of Labor Statistics. ==Given the rapidly changing economic conditions, and the decision by the CBO not to publish updates to its economic forecasts, **DRG** has developed an alternative model to forecast the overall Employment Growth rate based on current data and trends to date.==
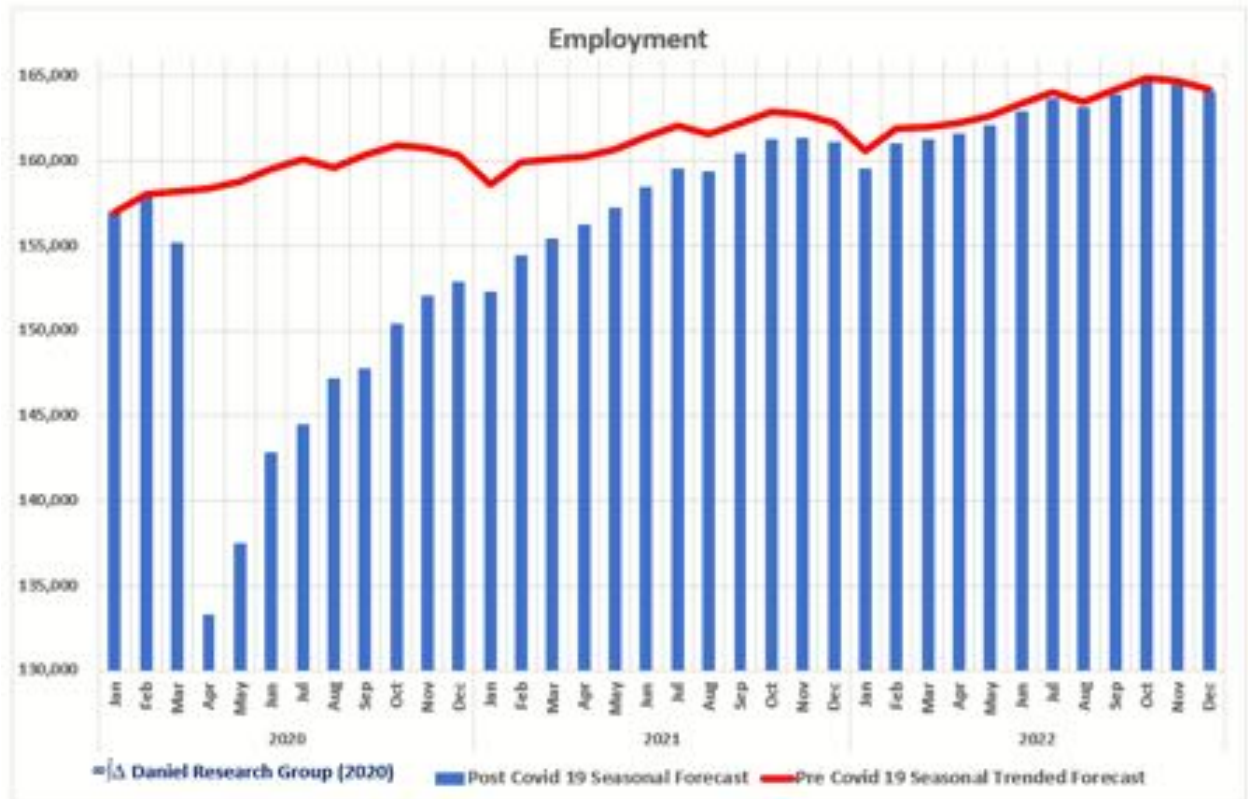
Allocation of employment to Sectors, Sub-Sectors, Industries and Company Size Class is based on long-term relative industry growth rates published by the Bureau of Labor Statistics (updated October 2020), as well as extrapolation of long term Sectors, Sub-Sectors, Industries and Company Size Class distribution and ratio trends derived from the Census Bureau's Statistics of United States Business database.

Additional historic data from the Census Bureau, the U.S. Office of Personnel Management, and the Department of Defense, is also incorporated into the model. ==In the absence of new CBO forecasts, DRG also development its own GDP forecast model based on current economic data and trends.==
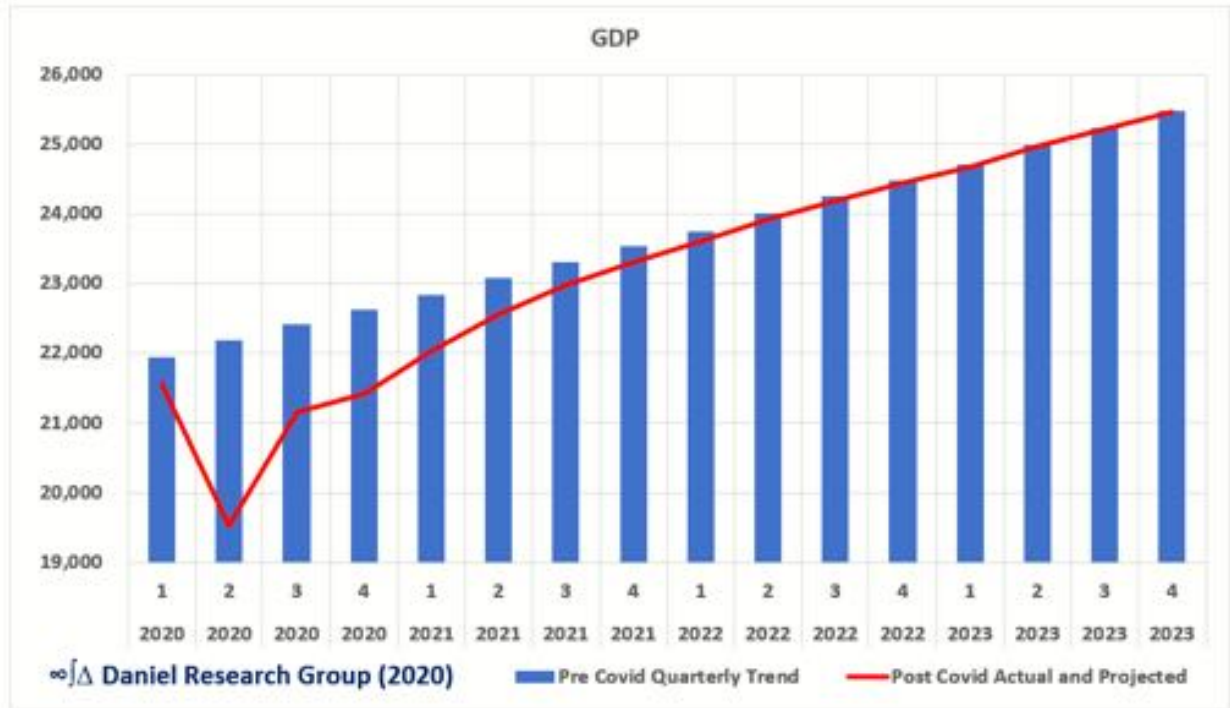
Both the Employment and GDP models agree that the US economy will recover to Pre Covid 19 projected levels by the middle of 2022. **This is a more optimistic forecast then most sources are predicting.**

Covid 19 Unemployment Rate (C19UER)

The **C19UER** model primarily uses monthly data from the Census Bureau, the Bureau of Labor Statistics and the Department of Labor Unemployment Insurance databases and reports. The **C19UER** 2020 through 2024 industry level forecasts are inputs to both the **BEDD** and **WFH** models and reflect Industry level seasonal patterns, as well as our assumption regarding Covid 19 waves.

The direct negative economic impact of Covid 19 is the loss of jobs through both mandatory and voluntary business shut downs, as well as significant decrease in demand for specific products and services. However, job loss is correlated more with occupation than with industry. We design and developed **C19UER** to forecast Occupation Unemployment by considering three sets of factors for each occupation.

1. Degree of social interaction with other employees and customers
2. Importance of the job to the mission and success of the business
3. Ability to perform the job at home

Data for this analysis was obtained from the Department of Labor O-Net Database

Based on these factors **DRG** developed an unemployment rate forecast for each Standard Occupation Classification occupation at the 3-digit level. Unemployment for each industry was then computed as the sum of the unemployment for each occupation within that industry. Other factors that influenced the final output included the industry level seasonal unemployment pattern, the pre Covid 19 level of unemployment for that industry, and Covid 19 assumptions. While most industries are expected to return to the pre Covid 19 unemployment level at some point in the future, some will not.

The industry level unemployment forecasts produced by **C19UER** were used to compute industry level and total US employment forecasts that were inputted into the **BEDD** model to produce the more detailed forecasts presented in this article. Both **C19UER** and **BEDD** models will be updated every month.

Work From Home (WFH)

The **WFH** model forecasts the percent and number of employees (from the **C19UER** Model) that will be working at home by occupation by months. Input parameter by occupation are derived from actual data starting in may 2020. Other input data included pre Covid 19 Work From Home rates by occupation and industry, as well as assumptions about the post Covid 19 Work From Home rate by occupation. The **WFH** model uses data from the Department of Labor O-Net database, data from the Census Bureau's American Time Use Study database, as well as published reports from other sources. Industry level forecasts are constructed by aggregating the occupation forecasts within each industry.

Assumptions

There are four major factors that will influence the US Economy

1. Covid 19 Case and Death Levels and Trends

Based on current data and projections published by The Centers for Disease Control and Prevention (CDC) our **C19UER** model assumption includes a continuation of the current Covid 19 surge through 20Q4 that is more likely to slow down the rate of rehiring than precipitate an increase in job loss. However, if predetermined thresholds are reached, a resumption of government mandated shut-downs will cause the rate of unemployment to increase.

Ultimately the timing and rate of economic activity convergence on a post Covid new stable state will be dependent on the widespread availability of an effective vaccine and/or therapeutics. Credible experts predict that the earliest this may be possible is 21Q1. Our assumption is 21Q2.   We are also assuming that there will be a mild Covid Surge in 21Q3.

2. Government Guidance, Fiscal and Monetary Policy and Actions

At the onset of the Covid 19 Labor shock the US Government used both Fiscal and Monetary Policy to attempt to protect the economy from a demand shock, a catastrophic reduction in consumer spending, as well as forestalling a supply shock in terms of permanent closure of business, as well as damage to supply chains. As well as could be expected ,given the need for immediate action not allowing for a more nuanced program, the objective has been met. For a time. Most benefits will expire in 21Q1 and as of this writing, no additional stimulus package has been negotiated between Congress and either the incumbent or presumptive new administration.

The programs and policies that essentially just injected cash into the system will end in 21Q1. As will many of the other policies protecting consumers from other negative consequences such as evictions. Our assumption is that the Congress and the Administration will provide another round of stimulus programs that will forestall a complete collapse of consumer spending for the rest of 2020. The exact nature of how these new programs will be designed, focused, and implemented is unknown at this time. There is considerable partisan debate as to both objectives and implementation details at this time.

Partisan difference has also contributed to the lack of a cohesive and effective policy regarding resolving the conflict between health and economic objective. Does health trump wealth, or does wealth trump health?   Recognizing the interdependence between the risks and rewards associated with different policy choices, finding a Nash Equilibrium type solution should have been accomplished. The failure to do so can be directly attributed to the extreme partisan political paralysis our society is experiencing.

3. Consumer Behavior

Consciously or subconsciously, individuals make many risk taking decisions by considering the utility value of the reward, the utility value of the risk and the risk itself. If I go to work, I will get a paycheck. However, I may get sick and die. There is only a very small chance that I will get sick and die, so I will go to work.

In mathematical terms,
    if G = the good thing that can happen
    B = the bad thing that can happened
    and P = the probability that the bad thing will happen, then
    The expected utility value of the risk taking is V = [G *(1 – P)] – (P * B)
    If V is greater than one, than take the risk. If not, then don't

The problem for most people is the inability to accurately estimate G, B and P. We overestimate G, underestimate B, and more significantly underestimate P. Even though in this case there is more than sufficient information about the true level of P. Further complicating the consumer risk taking decision process is that while P and B may be known G is a complex basket of many rewards and benefits spanning economic, phycological, group identity, altruistic, and other life management objectives.

Based on a comprehensive review and analysis of many consumer surveys conducted over the past few months, our conclusion is that regardless of government policy or advocacy, half of the population will not take on existential health risks to themselves or their families, and half will. This is an astonishing conclusion and correlated highly with major identity group world views. One would think that the more a person is responsible for others the more they will avoid risk. However, for many, memes trump genes and allegiance to group norms out weighs scientific facts. This conclusion had informed our assumptions about the near term unemployment rates at the occupation level. While the economy will recover faster than our prior forecast predicted, it will come at a cost of more lives lost.

4. Demand Has Not Changed

Assuming that the overall government strategy of subsidizing consumer spending until Covid 19 is contained or eliminated sometime in mid-2021, the road back to pre Covid 19 employment will happen. Although according to the CBO that will not happen until 2026. Our models predict that tis will happen in 2022. While hundreds of thousands of business will disappear from the economy, the jobs won't. They will be added to the remaining mid and larger sized firms that will fill those existing and new jobs. The reason is that the underlying demand for the goods and services has not fundamentally changed. What has changed is the distribution of that supply by industry, occupation, and company size class. These changes were occurring before the Covid-19 shock. Covid-19 just accelerated the process.

US Economy Structural Changes, 2019-2024

US Economy Structural Changes			
Sector	**Public & Private**		
Sub-Sector	**Total**		
Size Code	**Total**		
Size Class	**(All)**		
Metric	**Employees**		
Industry		**2019 to 2024**	**CAGR**
Forestry, Fishing, Hunting, Agriculture		198,914	8.2%
Mining		75,965	10.3%
Utilities		88,976	10.4%
Construction		1,357,329	16.9%
Manufacturing		1,013,053	7.9%
Wholesale		561,642	9.5%
Retail		447,644	2.9%
Transportation, Warehousing		472,683	7.8%
Information		251,248	8.0%
Finance, Insurance		649,046	9.0%
Real Estate, Rental, Leasing		249,372	10.7%
Professional, Scientific, Technical Services		1,477,134	14.0%
Management of Companies, Enterprises		223,552	9.2%
Administrative Support, Waste Management, Remediation Services		1,118,836	11.1%
Education		1,567,325	10.9%
Health Care, Social Assistance		3,610,883	15.6%
Arts, Entertainment, Recreation		-494,503	-16.9%
Accommodation, Food Services		-3,686,239	-26.1%
Other Services		-70,366	-1.2%
National Defense		-34,837	-1.2%
Public Administration		331,084	8.0%
Total		**9,408,741**	**6.0%**
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US Economy Structural Changes			
Sector	**Public & Private**		
Sub-Sector	**Total**		
Industry	**(All)**		
NAICS	**Total**		
Metric	**Employees**		
Size Class		**2019 to 2024**	**CAGR**
Less than 5		-153,686	-2.5%
5 to 9		-331,456	-4.8%
10 to 19		25,388	0.3%
20 to 99		177,341	0.7%
100 to 499		1,762,175	8.0%
500 to 999		618,693	7.0%
1000 to 2499		732,714	6.0%
2500 to 4999		-81,876	-0.9%
5000 to 9999		747,622	7.8%
10000 or more		5,911,826	12.6%
Total		**9,408,741**	**6.0%**
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Less then 100		-282,413	-0.1%
100 or More		9,691,154	0.9%

US Economy Structural Changes		
Sector	Public & Private	
Sub-Sector	Total	
Size Code	Total	
Size Class	(All)	
Metric	Annual Payroll ($1,000)	
Industry	**2019 to 2024**	**CAGR**
Forestry, Fishing, Hunting, Agriculture	28,958,737	26.2%
Mining	10,638,707	15.9%
Utilities	20,994,211	25.0%
Construction	177,937,396	33.6%
Manufacturing	119,279,367	15.1%
Wholesale	73,760,622	16.7%
Retail	72,634,949	15.3%
Transportation, Warehousing	84,230,065	24.5%
Information	136,794,212	39.7%
Finance, Insurance	166,303,143	22.0%
Real Estate, Rental, Leasing	36,342,280	26.8%
Professional, Scientific, Technical Services	277,251,288	29.3%
Management of Companies, Enterprises	16,537,912	6.3%
Administrative Support, Waste Management, Remediation Services	122,617,061	26.5%
Education	167,344,183	25.3%
Health Care, Social Assistance	374,124,615	30.9%
Arts, Entertainment, Recreation	-7,285,897	-6.7%
Accommodation, Food Services	-44,777,826	-15.1%
Other Services	28,695,917	13.8%
National Defense	364,035	0.2%
Public Administration	60,824,901	23.4%
Total	**1,923,569,875**	**22.2%**
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US Economy Structural Changes		
Sector	Public & Private	
Sub-Sector	Total	
Industry	(All)	
NAICS	Total	
Metric	Annual Payroll ($1,000)	
Size Class	**2019 to 2024**	**CAGR**
Less than 5	43,719,410	13.8%
5 to 9	28,034,127	9.8%
10 to 19	46,621,437	12.2%
20 to 99	158,732,398	13.8%
100 to 499	294,960,756	25.0%
500 to 999	105,830,820	22.1%
1000 to 2499	157,777,029	22.6%
2500 to 4999	76,193,632	13.9%
5000 to 9999	139,536,417	22.2%
10000 or more	872,163,849	29.2%
Total	**1,923,569,875**	**22.2%**
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Less then 100	277,107,373	1.2%
100 or More	1,646,462,503	2.3%

US Economy Structural Changes			
Sector	Public & Private		
Sub-Sector	Total		
Size Code	Total		
Size Class	(All)		
Metric	Firms		
Industry		**2019 to 2024**	**CAGR**
Forestry, Fishing, Hunting, Agriculture		36,340	11.2%
Mining		7,546	29.6%
Utilities		531	9.4%
Construction		10,112	1.3%
Manufacturing		-2,171	-0.8%
Wholesale		-10,872	-4.0%
Retail		-10,243	-1.6%
Transportation, Warehousing		200	0.1%
Information		7,972	11.2%
Finance, Insurance		1,085	0.5%
Real Estate, Rental, Leasing		45,637	13.5%
Professional, Scientific, Technical Services		76,761	9.0%
Management of Companies, Enterprises		-103	-0.6%
Administrative Support, Waste Management, Remediation Services		-2,430	-0.9%
Education		24,600	15.6%
Health Care, Social Assistance		4,987	0.7%
Arts, Entertainment, Recreation		-38,794	-28.7%
Accommodation, Food Services		-165,766	-31.3%
Other Services		-26,182	-3.6%
National Defense		-71	-11.4%
Public Administration		369	5.9%
Total		**-40,492**	**-0.6%**
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US Economy Structural Changes			
Sector	Public & Private		
Sub-Sector	Total		
Industry	(All)		
NAICS	Total		
Metric	Firms		
Size Class		**2019 to 2024**	**CAGR**
Less than 5		25,187	0.6%
5 to 9		-62,773	-6.0%
10 to 19		-5,663	-0.8%
20 to 99		-6,650	-1.0%
100 to 499		6,252	4.7%
500 to 999		825	4.2%
1000 to 2499		1,938	14.1%
2500 to 4999		-382	-6.8%
5000 to 9999		67	1.8%
10000 or more		707	13.0%
Total		**-40,492**	**-0.6%**
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Less then 100		-49,899	-0.1%
100 or More		9,407	0.5%

Note that our prior forecast published in October forecasted that close to 350,000 business would be lost by 2024. The faster recovery forecast has significantly reduced that number.

US Economy Structural Changes			
Sector	Public & Private		
Sub-Sector	Total		
Size Code	Total		
Size Class	(All)		
Metric	Establishments		
Industry		**2019 to 2024**	**CAGR**
Forestry, Fishing, Hunting, Agriculture		37,445	11.1%
Mining		12,264	34.8%
Utilities		4,710	19.6%
Construction		13,253	1.7%
Manufacturing		7,146	2.3%
Wholesale		4,005	1.0%
Retail		-8,584	-0.8%
Transportation, Warehousing		8,861	3.2%
Information		32,074	23.1%
Finance, Insurance		-3,475	-0.7%
Real Estate, Rental, Leasing		89,732	19.8%
Professional, Scientific, Technical Services		119,208	12.0%
Management of Companies, Enterprises		3,981	10.2%
Administrative Support, Waste Management, Remediation Services		4,726	1.5%
Education		24,476	11.5%
Health Care, Social Assistance		105,341	11.1%
Arts, Entertainment, Recreation		-37,849	-24.9%
Accommodation, Food Services		-213,665	-29.7%
Other Services		-14,394	-1.8%
National Defense		-437	-11.4%
Public Administration		4,691	7.7%
Total		**193,509**	**2.3%**
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US Economy Structural Changes			
Sector	Public & Private		
Sub-Sector	Total		
Industry	(All)		
NAICS	Total		
Metric	Establishments		
Size Class		**2019 to 2024**	**CAGR**
Less than 5		29,387	0.7%
5 to 9		-61,351	-5.7%
10 to 19		-801	-0.1%
20 to 99		25,821	3.0%
100 to 499		25,368	5.8%
500 to 999		6,654	4.3%
1000 to 2499		12,015	6.5%
2500 to 4999		13,958	9.2%
5000 to 9999		15,102	9.8%
10000 or more		127,356	15.0%
Total		**193,509**	**2.3%**
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Less then 100		-6,944	0.0%
100 or More		200,453	1.0%

Quarterly Industry Un-Employment Rates, 20Q1 to 21Q4

| Quarterly Inndustry Unemployment Rates | Year | Quarter | | | | | | |
| | 2020 | | | | 2021 | | | |
Industry	1	2	3	4	1	2	3	4
Forestry, Fishing, Hunting, Agriculture	8.5%	2.7%	3.2%	5.6%	5.3%	5.1%	4.8%	5.4%
Mining	5.3%	12.7%	16.1%	16.7%	15.1%	12.7%	12.6%	14.2%
Utilities	4.8%	15.3%	15.0%	11.0%	9.9%	8.8%	8.5%	9.6%
Construction	8.0%	15.8%	10.0%	11.1%	10.0%	7.9%	7.7%	8.8%
Manufacturing	4.8%	12.5%	8.4%	7.5%	6.6%	5.9%	5.8%	6.6%
Wholesale	4.4%	12.2%	7.8%	7.3%	6.1%	5.5%	5.4%	6.1%
Retail	4.4%	10.9%	8.2%	7.2%	6.4%	5.6%	5.1%	5.4%
Transportation, Warehousing	6.8%	14.1%	12.5%	11.5%	10.2%	8.9%	8.0%	8.1%
Information	2.2%	8.5%	8.8%	7.7%	7.6%	6.6%	6.2%	7.2%
Finance, Insurance	2.7%	4.0%	4.7%	5.3%	4.5%	4.2%	4.0%	4.6%
Real Estate, Rental, Leasing	2.7%	3.9%	4.7%	5.3%	4.6%	4.1%	3.7%	4.2%
Professional, Scientific, Technical Services	4.5%	8.5%	7.9%	7.1%	6.2%	5.7%	5.6%	6.2%
Management of Companies, Enterprises	2.4%	3.1%	4.4%	5.1%	4.5%	4.2%	4.1%	4.7%
Administrative Support, Waste Management, Remediation Services	3.3%	7.5%	6.7%	6.3%	5.6%	4.8%	4.5%	5.1%
Education	2.9%	8.4%	6.4%	5.4%	4.7%	4.5%	4.4%	4.7%
Health Care, Social Assistance	2.9%	8.4%	6.4%	5.5%	5.1%	4.9%	4.5%	5.1%
Arts, Entertainment, Recreation	5.9%	42.8%	21.5%	16.1%	13.7%	9.9%	7.9%	9.0%
Accommodation, Food Services	5.9%	42.8%	21.5%	17.0%	15.8%	13.0%	11.1%	11.1%
Other Services	4.2%	22.5%	10.8%	9.9%	8.3%	7.1%	6.5%	7.0%
Federal Ex USPS & Military	2.1%	5.7%	5.8%	4.1%	3.6%	3.4%	3.3%	3.9%
Federal Postal Service	2.1%	5.7%	5.8%	4.0%	3.3%	3.4%	3.3%	3.9%
State Ex Education	2.1%	5.7%	5.8%	4.1%	3.5%	3.4%	3.3%	3.8%
Local Ex Education	2.1%	5.7%	5.8%	4.0%	3.3%	3.0%	2.9%	3.4%
Total	4.1%	12.9%	8.9%	7.8%	7.0%	6.1%	5.6%	6.2%

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Quarterly Inndustry Unemployment Rates
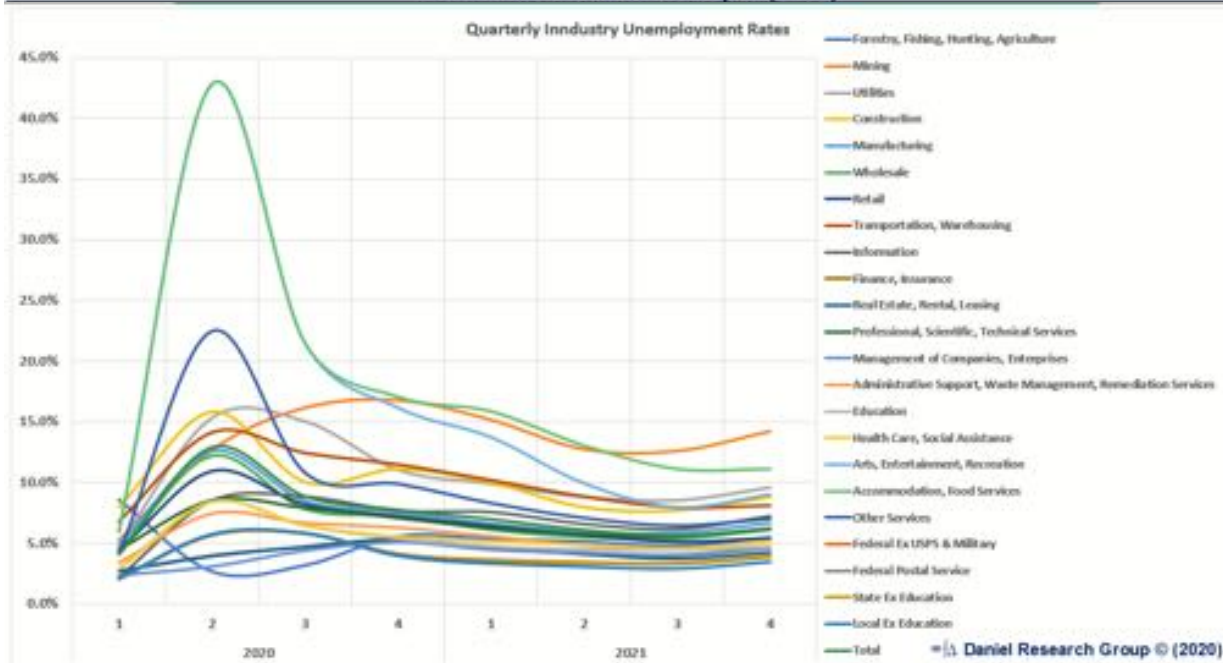
Quarterly Occupation Un-Employment Rates, 20Q1 to 21Q4

Quarterly Occupation Unemployment Rates	Year	Quarter 2020				2021			
Occupations		1	2	3	4	1	2	3	4
Management		5.1%	9.2%	6.6%	6.6%	6.3%	5.8%	5.5%	6.2%
Business and Financial Operations		2.2%	3.8%	5.3%	5.3%	4.8%	4.4%	4.4%	5.1%
Computer and Mathematical		1.8%	3.7%	4.0%	4.7%	4.9%	4.9%	4.8%	5.5%
Architecture and Engineering		2.9%	5.7%	5.2%	5.3%	5.5%	5.3%	5.3%	6.1%
Life, Physical, and Social Science		2.8%	4.9%	5.6%	5.0%	5.2%	4.8%	4.6%	5.2%
Community and Social Service		1.7%	4.2%	5.7%	4.8%	4.2%	4.3%	4.2%	4.9%
Legal		1.9%	5.1%	8.4%	6.6%	5.5%	4.5%	4.5%	5.2%
Educational Instruction and Library		1.2%	7.2%	6.6%	5.3%	4.6%	4.4%	4.4%	4.9%
Arts, Design, Entertainment, Sports, and Media		3.6%	17.9%	18.7%	13.8%	9.9%	7.2%	6.6%	7.4%
Healthcare Practitioners and Technical Occupation		1.4%	7.1%	5.0%	4.3%	4.4%	4.5%	4.4%	5.1%
Healthcare Support		2.5%	9.4%	7.6%	6.4%	6.1%	5.5%	4.8%	5.1%
Protective Service		1.3%	3.4%	4.8%	4.7%	3.8%	3.5%	3.4%	4.1%
Food Preparation and Serving Related		5.4%	43.4%	22.0%	17.2%	16.1%	13.3%	11.2%	11.0%
Building and Grounds Cleaning and Maintenance		6.0%	14.4%	12.4%	10.2%	8.3%	6.3%	5.3%	6.1%
Personal Care and Service		3.9%	43.0%	23.2%	17.0%	13.4%	10.0%	7.7%	7.6%
Sales and Related		4.9%	13.7%	9.8%	9.1%	8.1%	6.7%	5.8%	6.0%
Office and Administrative Support		2.8%	7.4%	5.6%	5.0%	4.6%	4.5%	4.4%	5.0%
Farming, Fishing, and Forestry		29.4%	4.8%	4.9%	6.5%	8.1%	8.2%	8.2%	9.5%
Construction and Extraction		10.9%	16.2%	11.5%	11.6%	10.3%	8.0%	7.9%	9.0%
Installation, Maintenance, and Repair		3.8%	10.5%	6.5%	6.6%	5.7%	4.7%	4.4%	5.1%
Production		7.8%	16.2%	8.1%	7.0%	6.1%	5.4%	5.4%	6.2%
Transportation and Material Moving		3.7%	9.6%	8.4%	7.0%	6.0%	5.8%	5.8%	6.5%
Total		4.1%	12.9%	8.9%	7.8%	7.0%	6.1%	5.6%	6.2%

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Quarterly Occupation Unemployment Rates

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Monthly Industry Un-Employment Rates 2020

Monthly Unemployment Rates Industries	Year 2020 Jan	Month Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Forestry, Fishing, Hunting, Agriculture	10.3%	8.9%	6.3%	3.3%	2.1%	2.6%	3.1%	3.4%	3.0%	4.1%	6.3%	6.3%
Mining	2.5%	6.1%	7.6%	8.3%	7.9%	22.2%	16.8%	14.6%	17.0%	14.1%	18.2%	18.0%
Utilities	3.7%	4.3%	6.4%	14.4%	16.3%	15.3%	18.1%	14.4%	12.6%	9.7%	11.7%	11.6%
Construction	7.3%	7.4%	9.2%	20.5%	14.7%	12.1%	11.0%	9.9%	9.2%	8.9%	12.3%	12.2%
Manufacturing	4.3%	4.9%	5.2%	14.0%	13.1%	10.4%	10.0%	7.9%	7.4%	6.3%	8.1%	8.1%
Wholesale	4.6%	4.0%	4.7%	13.8%	13.0%	9.6%	8.7%	7.5%	7.3%	6.3%	7.8%	7.7%
Retail	4.7%	4.3%	4.3%	10.6%	11.4%	10.8%	9.1%	7.6%	7.9%	6.2%	7.7%	7.7%
Transportation, Warehousing	5.9%	6.6%	8.0%	13.2%	15.9%	13.4%	14.5%	12.1%	10.9%	10.6%	12.2%	11.8%
Information	2.3%	2.5%	1.8%	7.0%	7.9%	10.8%	11.3%	7.8%	7.5%	5.1%	9.0%	9.0%
Finance, Insurance	3.1%	2.1%	2.8%	2.9%	4.2%	4.9%	4.6%	4.6%	4.9%	4.3%	5.7%	5.8%
Real Estate, Rental, Leasing	3.1%	2.1%	2.8%	2.7%	4.2%	4.9%	4.6%	4.6%	4.9%	4.3%	5.8%	5.9%
Professional, Scientific, Technical Services	4.2%	4.3%	5.0%	7.8%	8.4%	9.4%	8.8%	8.2%	6.8%	6.0%	7.6%	7.7%
Management of Companies, Enterprises	2.6%	2.6%	2.5%	2.6%	2.9%	3.8%	4.4%	4.4%	4.4%	4.1%	5.5%	5.7%
Administrative Support, Waste Management, Remediation Services	3.4%	3.2%	3.5%	6.6%	7.7%	8.1%	7.8%	6.1%	6.1%	5.4%	6.7%	6.8%
Education	2.6%	2.6%	3.3%	8.0%	8.9%	8.3%	7.8%	6.4%	5.2%	4.2%	5.9%	6.0%
Health Care, Social Assistance	2.6%	2.6%	3.3%	8.0%	8.9%	8.3%	7.8%	6.4%	5.2%	4.2%	6.1%	6.2%
Arts, Entertainment, Recreation	5.4%	5.1%	7.4%	55.5%	42.5%	29.7%	25.7%	20.5%	18.2%	15.6%	16.6%	16.1%
Accommodation, Food Services	5.4%	5.1%	7.4%	55.5%	42.5%	29.7%	25.7%	20.5%	18.2%	15.6%	17.7%	17.8%
Other Services	4.4%	3.3%	4.7%	28.3%	22.2%	16.7%	12.1%	10.2%	10.2%	9.2%	10.3%	10.1%
Federal Ex USPS & Military	2.2%	1.7%	2.3%	5.3%	5.1%	6.6%	8.1%	5.6%	3.8%	3.0%	4.5%	4.7%
Federal Postal Service	2.2%	1.7%	2.3%	5.3%	5.1%	6.6%	8.1%	5.6%	3.8%	3.0%	4.4%	4.4%
State Ex Education	2.2%	1.7%	2.3%	5.3%	5.1%	6.6%	8.1%	5.6%	3.8%	3.0%	4.6%	4.7%
Local Ex Education	2.2%	1.7%	2.3%	5.5%	5.2%	6.6%	8.1%	5.6%	3.8%	3.0%	4.4%	4.5%
Total	4.0%	3.8%	4.5%	14.4%	13.0%	11.2%	10.5%	8.5%	7.7%	6.6%	8.4%	8.4%

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Monthly Occupation Un-Employment Rates 2020

Monthly Unemployment Rates Occupations	Year 2020 Jan	Month Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Management	5.2%	4.7%	5.3%	12.6%	7.4%	7.4%	7.5%	6.2%	6.0%	5.6%	7.0%	7.2%
Business and Financial Operations	2.3%	2.0%	2.3%	1.9%	4.5%	4.9%	5.9%	5.1%	4.9%	4.6%	5.6%	5.8%
Computer and Mathematical	1.6%	1.3%	2.3%	4.4%	2.0%	4.8%	3.9%	4.3%	3.8%	3.2%	5.2%	5.6%
Architecture and Engineering	2.8%	2.8%	3.0%	4.7%	6.2%	6.2%	6.8%	5.4%	3.3%	3.7%	5.9%	6.3%
Life, Physical, and Social Science	2.9%	2.6%	2.8%	3.4%	5.7%	5.6%	6.2%	5.8%	4.9%	3.3%	5.8%	6.0%
Community and Social Service	1.7%	1.5%	1.8%	1.9%	4.6%	6.2%	6.4%	6.3%	4.4%	3.3%	5.6%	5.5%
Legal	1.9%	1.8%	2.0%	1.5%	7.0%	7.1%	10.1%	8.9%	6.4%	5.1%	7.4%	7.2%
Educational Instruction and Library	1.1%	1.0%	1.4%	3.8%	9.3%	8.8%	8.0%	6.5%	5.3%	4.0%	5.9%	5.9%
Arts, Design, Entertainment, Sports, and Media	3.6%	3.3%	4.0%	16.1%	18.4%	19.5%	21.5%	16.7%	18.2%	14.1%	14.1%	13.1%
Healthcare Practitioners and Technical Occupation	1.3%	1.2%	1.7%	5.8%	8.3%	7.4%	6.4%	4.8%	3.9%	2.8%	5.0%	5.1%
Healthcare Support	2.3%	2.2%	3.0%	8.5%	10.3%	9.5%	9.2%	7.5%	6.3%	5.1%	7.0%	7.3%
Protective Service	1.4%	1.1%	1.4%	0.9%	4.3%	5.1%	5.4%	5.4%	3.6%	4.1%	4.8%	5.0%
Food Preparation and Serving Related	4.7%	4.3%	7.2%	56.7%	42.6%	30.3%	26.4%	20.9%	19.0%	15.7%	17.9%	18.0%
Building and Grounds Cleaning and Maintenance	6.3%	5.9%	5.9%	10.0%	17.3%	16.0%	14.7%	11.4%	11.0%	9.9%	10.4%	10.3%
Personal Care and Service	3.3%	2.9%	5.5%	59.6%	38.0%	30.8%	27.8%	21.4%	20.3%	17.7%	17.1%	16.3%
Sales and Related	4.7%	4.6%	5.3%	15.9%	13.3%	11.9%	11.1%	9.8%	8.7%	8.0%	9.7%	9.6%
Office and Administrative Support	2.9%	2.6%	3.0%	6.6%	7.7%	7.7%	7.2%	5.1%	4.6%	3.7%	5.5%	5.6%
Farming, Fishing, and Forestry	33.1%	30.5%	24.7%	7.3%	4.7%	2.1%	5.3%	5.8%	3.8%	2.7%	8.2%	8.5%
Construction and Extraction	10.3%	10.4%	12.2%	19.9%	15.2%	13.5%	12.6%	11.9%	9.9%	8.9%	13.1%	12.8%
Installation, Maintenance, and Repair	3.9%	3.6%	3.8%	10.6%	10.8%	10.3%	7.9%	6.8%	4.9%	5.5%	7.2%	7.2%
Production	7.6%	7.6%	8.3%	23.7%	13.9%	10.6%	9.8%	7.4%	7.2%	5.7%	7.7%	7.7%
Transportation and Material Moving	3.8%	3.6%	3.7%	6.2%	12.7%	10.1%	9.6%	7.5%	8.1%	6.2%	7.5%	7.3%
Total	4.0%	3.8%	4.5%	14.4%	13.0%	11.2%	10.5%	8.5%	7.7%	6.6%	8.4%	8.4%

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Annual Industry Un-Employment Rates, 2019 to 2024

| Annual Unemployment Rates | Year | | | | |
Industry	2020	2021	2022	2023	2024
Forestry, Fishing, Hunting, Agriculture	5.0%	5.2%	4.1%	3.4%	3.0%
Mining	12.6%	13.7%	13.7%	13.8%	14.1%
Utilities	11.6%	9.2%	8.5%	8.1%	7.7%
Construction	11.2%	8.6%	7.7%	7.1%	6.6%
Manufacturing	8.3%	6.3%	5.5%	5.0%	4.5%
Wholesale	7.9%	5.8%	5.0%	4.4%	3.9%
Retail	7.7%	5.6%	4.4%	3.8%	3.4%
Transportation, Warehousing	11.2%	8.8%	7.1%	6.4%	5.8%
Information	6.8%	6.9%	6.2%	5.6%	5.1%
Finance, Insurance	4.1%	4.3%	3.4%	2.9%	2.4%
Real Estate, Rental, Leasing	4.1%	4.2%	3.0%	2.3%	1.8%
Professional, Scientific, Technical Services	7.0%	5.9%	5.0%	4.3%	3.7%
Management of Companies, Enterprises	3.7%	4.4%	3.5%	2.9%	2.3%
Administrative Support, Waste Management, Remediation Services	5.9%	5.0%	4.0%	3.5%	3.0%
Education	5.7%	4.6%	3.6%	3.0%	2.4%
Health Care, Social Assistance	5.7%	4.9%	3.8%	3.2%	2.6%
Arts, Entertainment, Recreation	21.4%	10.2%	7.1%	6.3%	5.6%
Accommodation, Food Services	21.6%	12.8%	8.6%	7.8%	7.2%
Other Services	11.8%	7.2%	5.6%	5.0%	4.5%
Federal Ex USPS & Military	4.4%	3.6%	2.7%	2.1%	1.5%
Federal Postal Service	4.4%	3.5%	2.8%	2.3%	1.9%
State Ex Education	4.4%	3.5%	2.6%	2.1%	1.6%
Local Ex Education	4.4%	3.2%	2.2%	1.6%	1.1%
Total	8.4%	6.2%	4.9%	4.3%	3.8%

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Annual Occupation Un-Employment Rates 2020 to 2024

Annual Unemployment Rates Occupations	Year				
	2020	2021	2022	2023	2024
Management	6.8%	6.0%	4.9%	4.2%	3.7%
Business and Financial Operations	4.1%	4.7%	4.0%	3.4%	2.9%
Computer and Mathematical	3.5%	5.0%	4.3%	3.7%	3.2%
Architecture and Engineering	4.7%	5.5%	5.0%	4.4%	3.9%
Life, Physical, and Social Science	4.6%	5.0%	4.2%	3.6%	3.1%
Community and Social Service	4.0%	4.4%	3.7%	3.1%	2.6%
Legal	5.5%	4.9%	4.1%	3.5%	2.9%
Educational Instruction and Library	5.0%	4.6%	3.8%	3.1%	2.6%
Arts, Design, Entertainment, Sports, and Media	13.4%	7.8%	6.2%	5.6%	5.1%
Healthcare Practitioners and Technical Occupation	4.4%	4.6%	3.9%	3.3%	2.8%
Healthcare Support	6.4%	5.4%	4.0%	3.3%	2.8%
Protective Service	3.5%	3.7%	2.9%	2.4%	1.9%
Food Preparation and Serving Related	21.8%	12.9%	8.3%	7.5%	6.9%
Building and Grounds Cleaning and Maintenance	10.7%	6.5%	4.9%	4.3%	3.8%
Personal Care and Service	21.6%	9.7%	5.6%	4.7%	4.1%
Sales and Related	9.4%	6.6%	4.9%	4.4%	3.9%
Office and Administrative Support	5.2%	4.6%	3.8%	3.2%	2.7%
Farming, Fishing, and Forestry	11.5%	8.5%	9.1%	9.4%	9.9%
Construction and Extraction	12.5%	8.8%	8.0%	7.5%	7.1%
Installation, Maintenance, and Repair	6.8%	5.0%	4.0%	3.4%	3.0%
Production	9.8%	5.8%	5.1%	4.5%	4.0%
Transportation and Material Moving	7.2%	6.0%	5.5%	4.9%	4.4%
Total	8.4%	6.2%	4.9%	4.3%	3.8%

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Quarterly Industry Percent Work From Home, 2020 – 2021

Percent Work From Home by Industry

NAICS	Industry	2020				2021			
		1	2	3	4	1	2	3	4
11	Forestry, Fishing, Hunting, Agriculture	26.0%	34.1%	25.9%	20.3%	18.4%	18.3%	18.3%	18.4%
21	Mining	15.3%	22.6%	16.7%	14.7%	14.0%	13.8%	13.7%	13.8%
22	Utilities	21.3%	31.9%	23.6%	19.7%	18.4%	18.3%	18.2%	18.2%
23	Construction	13.4%	17.0%	11.4%	10.5%	10.5%	10.4%	10.4%	10.4%
31	Manufacturing	15.4%	22.3%	16.3%	13.6%	13.0%	12.9%	12.9%	12.9%
42	Wholesale	19.5%	28.5%	20.4%	16.1%	14.7%	14.6%	14.6%	14.6%
44	Retail	17.7%	25.3%	16.5%	12.5%	11.2%	11.2%	11.2%	11.2%
48	Transportation, Warehousing	17.7%	25.4%	16.4%	12.4%	11.0%	11.0%	11.0%	11.0%
51	Information	32.3%	48.4%	38.1%	32.6%	30.9%	30.8%	30.8%	30.7%
52	Finance, Insurance	31.9%	49.1%	37.9%	30.3%	27.5%	27.5%	27.5%	27.5%
53	Real Estate, Rental, Leasing	20.9%	29.7%	20.9%	16.5%	15.1%	15.0%	15.0%	15.0%
54	Professional, Scientific, Technical Services	34.4%	55.3%	44.8%	37.1%	34.4%	34.4%	34.4%	34.4%
55	Management of Companies, Enterprises	32.7%	51.2%	40.5%	33.0%	30.3%	30.3%	30.3%	30.3%
56	Administrative Support, Waste Management, Remediation Services	15.0%	22.6%	15.9%	12.5%	11.3%	11.3%	11.2%	11.2%
61	Education	33.9%	62.4%	38.6%	25.5%	19.4%	19.4%	19.4%	19.4%
62	Health Care, Social Assistance	16.2%	26.9%	18.2%	13.8%	12.2%	12.2%	12.1%	12.1%
71	Arts, Entertainment, Recreation	16.0%	26.5%	17.2%	13.4%	12.2%	12.1%	12.0%	12.0%
72	Accommodation, Food Services	5.3%	9.4%	5.7%	4.0%	3.5%	3.4%	3.4%	3.4%
81	Other Services	18.7%	31.7%	21.3%	16.6%	14.8%	14.7%	14.7%	14.7%
91	Federal Ex USPS & Military	30.4%	47.8%	37.6%	30.6%	28.1%	28.1%	28.1%	28.1%
92	Federal Postal Service	26.2%	38.0%	26.5%	19.3%	16.7%	16.7%	16.7%	16.7%
93	State Ex Education	26.2%	42.9%	32.3%	25.5%	22.9%	22.9%	22.8%	22.9%
94	Local Ex Education	19.0%	30.1%	20.9%	16.1%	14.4%	14.3%	14.3%	14.3%
	Total	19.4%	30.8%	21.7%	17.1%	15.6%	15.5%	15.5%	15.5%

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Percent Work From Home by Industry

Legend:
- Forestry, Fishing, Hunting, Agriculture
- Mining
- Utilities
- Construction
- Manufacturing
- Wholesale
- Retail
- Transportation, Warehousing
- Information
- Finance, Insurance
- Real Estate, Rental, Leasing
- Professional, Scientific, Technical Services
- Management of Companies, Enterprises
- Administrative Support, Waste Management, Remediation Services
- Education
- Health Care, Social Assistance
- Arts, Entertainment, Recreation
- Accommodation, Food Services
- Other Services

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Quarterly Occupation Percent Work From Home, 2020 – 2021

		2020				2021			
SOC	Industry	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
11	Management Occupations	36.2%	48.5%	37.7%	29.6%	26.7%	26.7%	26.7%	26.7%
13	Business and Financial Operations Occupations	41.8%	66.6%	56.0%	47.1%	43.8%	43.8%	43.8%	43.8%
15	Computer and Mathematical Occupations	40.3%	75.5%	67.5%	60.2%	57.2%	57.2%	57.2%	57.2%
17	Architecture and Engineering Occupations	35.8%	58.4%	51.1%	42.4%	40.2%	40.2%	40.2%	40.2%
19	Life, Physical, and Social Science Occupations	39.4%	68.6%	56.6%	42.3%	38.5%	38.5%	38.5%	38.5%
21	Community and Social Service Occupations	29.9%	69.2%	51.5%	39.1%	33.6%	33.6%	33.6%	33.6%
23	Legal Occupations	45.2%	72.8%	58.5%	47.2%	42.0%	42.0%	42.0%	42.0%
25	Educational Instruction and Library Occupations	40.2%	79.0%	42.1%	27.5%	18.5%	18.5%	18.5%	18.5%
27	Arts, Design, Entertainment, Sports, and Media Oc	48.8%	55.3%	43.0%	40.9%	42.3%	42.3%	42.3%	42.3%
29	Healthcare Practitioners and Technical Occupation	16.7%	24.0%	15.1%	11.6%	10.8%	10.8%	10.8%	10.8%
31	Healthcare Support Occupations	3.8%	6.8%	4.8%	3.8%	3.4%	3.4%	3.4%	3.4%
33	Protective Service Occupations	10.1%	14.6%	7.9%	5.3%	4.4%	4.4%	4.4%	4.4%
35	Food Preparation and Serving Related Occupations	2.6%	4.6%	2.6%	1.6%	1.3%	1.3%	1.3%	1.3%
37	Building and Grounds Cleaning and Maintenance Occ	2.9%	4.2%	2.2%	1.5%	1.5%	1.5%	1.5%	1.5%
39	Personal Care and Service Occupations	7.5%	15.4%	8.7%	5.5%	4.6%	4.6%	4.6%	4.6%
41	Sales and Related Occupations	20.9%	30.0%	19.1%	14.2%	12.5%	12.5%	12.5%	12.5%
43	Office and Administrative Support Occupations	26.7%	39.3%	27.1%	19.4%	16.5%	16.5%	16.5%	16.5%
45	Farming, Fishing, and Forestry Occupations	3.1%	2.7%	1.6%	0.7%	1.0%	1.0%	1.0%	1.0%
47	Construction and Extraction Occupations	7.1%	6.5%	3.3%	4.6%	5.9%	5.9%	5.9%	5.9%
49	Installation, Maintenance, and Repair Occupations	9.1%	10.3%	4.3%	5.2%	5.9%	5.9%	5.9%	5.9%
51	Production Occupations	6.4%	7.3%	4.4%	4.3%	4.8%	4.8%	4.8%	4.8%
53	Transportation and Material Moving Occupations	3.3%	4.7%	2.7%	2.2%	1.8%	1.8%	1.8%	1.8%
	Total	19.4%	30.8%	21.7%	17.1%	15.6%	15.5%	15.5%	15.5%

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Percent Work From Home by Occupation

Management Occupations
Business and Financial Operations Occupations
Computer and Mathematical Occupations
Architecture and Engineering Occupations
Life, Physical, and Social Science Occupations
Community and Social Service Occupations
Legal Occupations
Educational Instruction and Library Occupations
Arts, Design, Entertainment, Sports, and Media Oc
Healthcare Practitioners and Technical Occupation
Healthcare Support Occupations
Protective Service Occupations
Food Preparation and Serving Related Occupations
Building and Grounds Cleaning and Maintenance Oc
Personal Care and Service Occupations
Sales and Related Occupations
Office and Administrative Support Occupations
Farming, Fishing, and Forestry Occupations
Construction and Extraction Occupations
Installation, Maintenance, and Repair Occupations
Production Occupations
Transportation and Material Moving Occupations
Total

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90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

Q1   Q2   Q3   Q4   Q1   Q2   Q3   Q4
         2020   2021

BEDD Output Tables and Charts
Top-Line Tables
Total US Economy

Business Economic Demographic Database								
Sector	Total							
Sub-Sector	Total							
Industry	Total							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	6,508.721	6,015.198	6,362.685	6,470.251	6,479.350	6,468.229	-40.492	
AGR	0.2%	-7.6%	5.8%	1.7%	0.1%	-0.2%	-0.1%	
Annual Change		-493.523	347.487	107.566	9.099	-11.121		
Primary Firms (K)	6,415.564	5,928.430	6,271.266	6,376.822	6,385.085	6,373.323	-42.241	
AGR	0.2%	-7.6%	5.8%	1.7%	0.1%	-0.2%	-0.1%	
Annual Change		-487.134	342.836	105.556	8.263	-11.762		
Employees (K)	155,611	146,343	156,099	160,644	162,989	165,020	9,408.741	
AGR	1.4%	-6.0%	6.7%	2.9%	1.5%	1.2%	1.2%	
Annual Change		-9267.950	9755.844	4544.808	2344.525	2031.514		
Establishments (K)	8,541.499	7,947.090	8,438.294	8,624.999	8,687.585	8,735.008	193.509	
AGR	0.6%	-7.0%	6.2%	2.2%	0.7%	0.5%	0.4%	
Annual Change		-594.409	491.204	186.704	62.587	47.423		
Annual Payroll ($M)	8,651	8,465	9,222	9,737	10,157	10,574	1,924	
AGR	3.7%	-2.1%	8.9%	5.6%	4.3%	4.1%	4.1%	
Annual Change		-186	757	515	421	417		
Employees per Primary Firm	24.3	24.7	24.9	25.2	25.5	25.9	1.6	
AGR	1.2%	1.8%	0.8%	1.2%	1.3%	1.4%	1.3%	
Annual Change		0.43	0.21	0.30	0.33	0.37		
Establishments per Primary Firm	1.33	1.34	1.35	1.35	1.36	1.37	0.04	
AGR	0.4%	0.7%	0.4%	0.5%	0.6%	0.7%	0.6%	
Annual Change		0.01	0.01	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	55.6	57.8	59.1	60.6	62.3	64.1	8.5	
AGR	2.3%	4.0%	2.1%	2.6%	2.8%	2.8%	2.9%	
Annual Change		2.25	1.23	1.53	1.71	1.76		

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Sector: Both, Sub-Sector: Selected, Industry: All, Size Class: All, Primary Firms (K) — CAGR: -0.1%

↔∫Δ Daniel Research Group © (2020) ■ Primary Firms (K) — Annual Growth Rate

By Sector

		Business Economic Demographic Database							
Sector		Private							
Sub-Sector		Total							
Industry		Total							
Size Class		Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		6,418.361	5,927.472	6,270.439	6,376.194	6,384.558	6,372.934	-45.427	
	AGR	0.2%	-7.6%	5.8%	1.7%	0.1%	-0.2%	-0.1%	
	Annual Change		-490.889	342.967	105.755	8.364	-11.624		
Primary Firms (K)		6,325.903	5,841.382	6,179.686	6,283.415	6,290.928	6,278.652	-47.251	
	AGR	0.2%	-7.7%	5.8%	1.7%	0.1%	-0.2%	-0.1%	
	Annual Change		-484.521	338.304	103.729	7.513	-12.276		
Employees (K)		130,771	122,108	130,619	134,505	136,458	138,114	7,342.779	
	AGR	1.5%	-6.6%	7.0%	3.0%	1.5%	1.2%	1.1%	
	Annual Change		-8662.838	8510.711	3886.327	1952.328	1656.251		
Establishments (K)		8,301.054	7,715.846	8,197.022	8,379.753	8,440.162	8,485.512	184.458	
	AGR	0.6%	-7.0%	6.2%	2.2%	0.7%	0.5%	0.4%	
	Annual Change		-585.208	481.176	182.731	60.409	45.350		
Annual Payroll ($M)		7,242	7,060	7,711	8,150	8,507	8,860	1,618	
	AGR	3.8%	-2.5%	9.2%	5.7%	4.4%	4.1%	4.1%	
	Annual Change		-182	651	439	358	352		
Employees per Primary Firm		20.7	20.9	21.1	21.4	21.7	22.0	1.3	
	AGR	1.3%	1.1%	1.1%	1.3%	1.3%	1.4%	1.3%	
	Annual Change		0.23	0.23	0.27	0.28	0.31		
Establishments per Primary Firm		1.31	1.32	1.33	1.33	1.34	1.35	0.04	
	AGR	0.4%	0.7%	0.4%	0.5%	0.6%	0.7%	0.6%	
	Annual Change		0.01	0.01	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee		55.4	57.8	59.0	60.6	62.3	64.1	8.8	
	AGR	2.3%	4.4%	2.1%	2.6%	2.9%	2.9%	3.0%	
	Annual Change		2.44	1.22	1.56	1.75	1.80		

ʃΔ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Selected, Industry: All, Size Class: All, Primary Firms (K)   CAGR: -0.1%

ʃΔ Daniel Research Group ® (2020)   Primary Firms (K)   Annual Growth Rate

Business Economic Demographic Database									
Sector	Public								
Sub-Sector	Total								
Industry	Total								
Size Class	Total								
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		90.360	87.726	92.246	94.057	94.792	95.295	4.935	
	AGR	0.1%	-2.9%	5.2%	2.0%	0.8%	0.5%	1.1%	
	Annual Change		-2.634	4.520	1.811	0.735	0.503		
Primary Firms (K)		89.661	87.048	91.580	93.407	94.157	94.671	5.010	
	AGR	0.1%	-2.9%	5.2%	2.0%	0.8%	0.5%	1.1%	
	Annual Change		-2.613	4.532	1.827	0.750	0.514		
Employees (K)		24.840	24.235	25.480	26.139	26.531	26.906	2.065.962	
	AGR	0.8%	-2.4%	5.1%	2.6%	1.5%	1.4%	1.6%	
	Annual Change		-605.112	1245.133	658.481	392.197	375.263		
Establishments (K)		240.445	231.244	241.272	245.246	247.423	249.496	9.051	
	AGR	0.3%	-3.8%	4.3%	1.6%	0.9%	0.8%	0.7%	
	Annual Change		-9.201	10.028	3.973	2.178	2.073		
Annual Payroll ($M)		1,409	1,405	1,511	1,587	1,650	1,715	306	
	AGR	3.0%	-0.2%	7.5%	5.0%	4.0%	3.9%	4.0%	
	Annual Change		-3	106	76	63	65		
Employees per Primary Firm		277.0	278.4	278.2	279.8	281.8	284.2	7.2	
	AGR	0.7%	0.5%	-0.1%	0.6%	0.7%	0.9%	0.5%	
	Annual Change		1.36	-0.18	1.61	1.94	2.43		
Establishments per Primary Firm		2.68	2.66	2.63	2.63	2.63	2.64	-0.05	
	AGR	0.3%	-0.9%	-0.8%	-0.3%	0.1%	0.3%	-0.3%	
	Annual Change		-0.03	-0.02	-0.01	0.00	0.01		
Annual Payroll ($1,000) per Employee		56.7	58.0	59.3	60.7	62.2	63.7	7.0	
	AGR	2.2%	2.2%	2.3%	2.4%	2.4%	2.5%	2.4%	
	Annual Change		1.27	1.33	1.41	1.48	1.53		
→ʃΔ Daniel Research Group ® (2020)									

Primary Firms for Governments are buying entities such as Agencies or Departments

By Sub-Sector – Public Sector

Business Economic Demographic Database

Sector	Public							
Sub-Sector	DoD Military							
Industry	Total							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	0.621	0.607	0.591	0.575	0.561	0.550	-0.071	
AGR	-1.6%	-2.2%	-2.6%	-2.8%	-2.4%	-1.9%	-2.4%	
Annual Change		-0.014	-0.016	-0.016	-0.014	-0.011		
Primary Firms (K)	0.001	0.001	0.001	0.001	0.001	0.001	0.000	
AGR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Annual Change		0.000	0.000	0.000	0.000	0.000		
Employees (K)	2.854	2.748	2.722	2.755	2.769	2.819	-34.837	
AGR	2.1%	-3.7%	-0.9%	1.2%	0.5%	1.8%	-0.2%	
Annual Change		-105.801	-25.973	32.894	14.332	49.711		
Establishments (K)	3.843	3.480	3.390	3.352	3.372	3.406	-0.437	
AGR	-3.9%	-9.5%	-2.6%	-1.1%	0.6%	1.0%	-2.4%	
Annual Change		-0.363	-0.090	-0.039	0.021	0.034		
Annual Payroll ($M)	157	151	150	153	154	157	0	
AGR	1.0%	-3.4%	-0.6%	1.5%	0.8%	2.1%	0.0%	
Annual Change		-5	-1	2	1	3		
Employees per Primary Firm	2,854,000.0	2,748,199.0	2,722,226.0	2,755,120.0	2,769,452.0	2,819,163.0	-34,837.0	
AGR	2.1%	-3.7%	-0.9%	1.2%	0.5%	1.8%	-0.2%	
Annual Change		-105,801.00	-25,973.00	32,894.00	14,332.00	49,711.00		
Establishments per Primary Firm	3,843.00	3,479.77	3,390.18	3,351.61	3,372.34	3,406.22	-436.78	
AGR	-3.9%	-9.5%	-2.6%	-1.1%	0.6%	1.0%	-2.4%	
Annual Change		-363.23	-89.60	-38.57	20.73	33.88		
Annual Payroll ($1,000) per Employee	54.9	55.0	55.2	55.4	55.5	55.7	0.8	
AGR	-1.1%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	
Annual Change		0.18	0.17	0.16	0.15	0.14		

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There is only one (1) primary firm for the DoD Sub-Sector, the DoD

Business Economic Demographic Database

Sector	Public							
Sub-Sector	Federal - Civilian							
Industry	Total							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	0.268	0.255	0.269	0.275	0.279	0.292	0.024	
AGR	-3.9%	-4.9%	5.5%	2.2%	1.5%	4.7%	1.7%	
Annual Change		-0.013	0.014	0.006	0.004	0.013		
Primary Firms (K)	0.268	0.255	0.269	0.275	0.280	0.293	0.025	
AGR	-3.9%	-4.9%	5.5%	2.2%	1.8%	4.6%	1.8%	
Annual Change		-0.013	0.014	0.006	0.005	0.013		
Employees (K)	1,442	1,417	1,503	1,546	1,574	1,598	156.037	
AGR	-0.2%	-1.7%	6.1%	2.9%	1.8%	1.5%	2.1%	
Annual Change		-25.139	85.776	43.067	28.032	24.301		
Establishments (K)	23.064	22.186	21.478	21.593	21.340	21.048	-2.016	
AGR	-3.2%	-3.8%	-3.2%	0.5%	-1.2%	-1.4%	-1.8%	
Annual Change		-0.878	-0.708	0.115	-0.253	-0.292		
Annual Payroll ($M)	129	130	142	150	158	166	36	
AGR	2.8%	0.7%	9.1%	5.9%	5.0%	4.9%	5.1%	
Annual Change		1	12	8	7	8		
Employees per Primary Firm	5,381.8	5,557.6	5,587.3	5,622.0	5,621.7	5,455.2	73.3	
AGR	3.9%	3.3%	0.5%	0.6%	0.0%	-3.0%	0.3%	
Annual Change		175.78	29.63	34.70	-0.28	-166.49		
Establishments per Primary Firm	86.06	87.00	79.84	78.52	76.21	71.84	-14.22	
AGR	0.8%	1.1%	-8.2%	-1.7%	-2.9%	-5.7%	-3.5%	
Annual Change		0.94	-7.16	-1.32	-2.31	-4.38		
Annual Payroll ($1,000) per Employee	89.6	91.9	94.5	97.3	100.4	103.6	14.0	
AGR	3.0%	2.5%	2.9%	3.0%	3.1%	3.3%	2.9%	
Annual Change		2.27	2.63	2.81	3.03	3.27		

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Sector: Public, Sub-Sector: Federal - Civilian, Industry: All, Size Class: All, Primary Firms (K) — CAGR: 1.8%

	Business Economic Demographic Database								
Sector	Public								
Sub-Sector	Federal - DoD Civilian								
Industry	Total								
Size Class	Total								
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		0.155	0.145	0.147	0.150	0.148	0.148	-0.007	
	AGR	0.6%	-6.5%	1.4%	2.0%	-1.3%	0.0%	-0.9%	
	Annual Change		-0.010	0.002	0.003	-0.002	0.000		
Primary Firms (K)		0.155	0.145	0.147	0.150	0.148	0.148	-0.007	
	AGR	0.6%	-6.5%	1.4%	2.0%	-1.3%	0.0%	-0.9%	
	Annual Change		-0.010	0.002	0.003	-0.002	0.000		
Employees (K)		784	696	715	733	744	759	-25.303	
	AGR	5.1%	-11.2%	2.8%	2.5%	1.5%	2.0%	-0.7%	
	Annual Change		-88.232	19.200	17.648	10.987	15.094		
Establishments (K)		1.225	0.430	0.440	0.512	0.572	0.653	-0.572	
	AGR	6.1%	-64.9%	2.3%	16.4%	11.7%	14.2%	-11.8%	
	Annual Change		-0.795	0.010	0.072	0.060	0.081		
Annual Payroll ($M)		66	60	63	65	67	70	4	
	AGR	4.6%	-8.7%	4.5%	4.2%	3.2%	3.8%	1.3%	
	Annual Change		-6	3	3	3	2		
Employees per Primary Firm		5,061.1	4,801.6	4,866.9	4,887.2	5,027.5	5,129.5	68.4	
	AGR	4.4%	-5.1%	1.4%	0.4%	2.9%	2.0%	0.3%	
	Annual Change		-259.46	65.28	20.32	140.28	101.99		
Establishments per Primary Firm		7.90	2.97	2.99	3.41	3.86	4.41	-3.49	
	AGR	5.4%	-62.5%	0.9%	14.0%	13.2%	14.2%	-11.0%	
	Annual Change		-4.94	0.03	0.42	0.45	0.55		
Annual Payroll ($1,000) per Employee		83.8	86.2	87.7	89.2	90.7	92.3	8.5	
	AGR	-0.5%	2.9%	1.7%	1.7%	1.7%	1.7%	1.9%	
	Annual Change		2.39	1.46	1.50	1.54	1.57		

Daniel Research Group ® (2020)

Sector: Public, Sub-Sector: Federal - DoD Civilian, Industry: All, Size Class: All, Primary Firms (K) — CAGR: -0.9%

	Business Economic Demographic Database							
Sector	Public							
Sub-Sector	State and Local							
Industry	Total							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	89.316	86.719	91.239	93.057	93.804	94.305	4.989	
AGR	0.1%	-2.9%	5.2%	2.0%	0.8%	0.5%	1.1%	
Annual Change		-2.597	4.520	1.818	0.747	0.501		
Primary Firms (K)	89.237	86.647	91.163	92.981	93.728	94.229	4.992	
AGR	0.1%	-2.9%	5.2%	2.0%	0.8%	0.5%	1.1%	
Annual Change		-2.590	4.516	1.818	0.747	0.501		
Employees (K)	19,759	19,373	20,540	21,104	21,443	21,729	1,970.065	
AGR	0.5%	-2.0%	6.0%	2.8%	1.6%	1.3%	1.9%	
Annual Change		-385.940	1166.130	564.872	338.846	286.157		
Establishments (K)	212.313	205.148	215.964	219.789	222.139	224.389	12.076	
AGR	0.8%	-3.4%	5.3%	1.8%	1.1%	1.0%	1.1%	
Annual Change		-7.165	10.816	3.825	2.350	2.250		
Annual Payroll ($M)	1,057	1,064	1,156	1,219	1,271	1,322	265	
AGR	3.3%	0.6%	8.7%	5.4%	4.3%	4.0%	4.6%	
Annual Change		7	92	63	52	51		
Employees per Primary Firm	221.4	223.6	225.3	227.0	228.8	230.6	9.2	
AGR	0.5%	1.0%	0.8%	0.7%	0.8%	0.8%	0.8%	
Annual Change		2.16	1.72	1.67	1.81	1.82		
Establishments per Primary Firm	2.38	2.37	2.37	2.36	2.37	2.38	0.00	
AGR	0.7%	-0.5%	0.1%	-0.2%	0.3%	0.5%	0.0%	
Annual Change		-0.01	0.00	-0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	53.5	54.9	56.3	57.7	59.3	60.8	7.3	
AGR	2.7%	2.6%	2.5%	2.6%	2.6%	2.7%	2.6%	
Annual Change		1.41	1.38	1.46	1.52	1.58		

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Sector: Public, Sub-Sector: State and Local, Industry: All, Size Class: All, Primary Firms (K) — CAGR: 1.1%

By Industry – Private Sector

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Accommodation, Food Services							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	529.002	390.300	418.814	412.370	387.916	363.236	-165.766	
AGR	0.1%	-26.2%	7.3%	-1.5%	-5.9%	-6.4%	-7.2%	
Annual Change		-138.702	28.514	-6.444	-24.454	-24.680		
Primary Firms (K)	522.584	385.553	413.702	407.290	383.094	358.673	-163.911	
AGR	0.1%	-26.2%	7.3%	-1.5%	-5.9%	-6.4%	-7.3%	
Annual Change		-137.031	28.149	-6.412	-24.196	-24.421		
Employees (K)	14.143	10.584	11.523	11.516	10.997	10.456	-3.686.239	
AGR	1.7%	-25.2%	8.9%	-0.1%	-4.5%	-4.9%	-5.9%	
Annual Change		-3558.147	938.513	-6.761	-519.002	-540.842		
Establishments (K)	719.591	533.160	575.040	567.870	536.143	505.926	-213.665	
AGR	0.4%	-25.9%	7.9%	-1.2%	-5.6%	-5.6%	-6.8%	
Annual Change		-186.431	41.880	-7.170	-31.727	-30.217		
Annual Payroll ($M)	296	228	255	262	257	251	-45	
AGR	4.3%	-23.1%	11.9%	2.7%	-1.8%	-2.2%	-3.2%	
Annual Change		-68	27	7	-5	-6		
Employees per Primary Firm	27.1	27.5	27.9	28.3	28.7	29.2	2.1	
AGR	1.6%	1.4%	1.5%	1.5%	1.5%	1.6%	1.5%	
Annual Change		0.39	0.40	0.42	0.43	0.45		
Establishments per Primary Firm	1.38	1.38	1.39	1.39	1.40	1.41	0.03	
AGR	0.4%	0.4%	0.5%	0.3%	0.4%	0.8%	0.5%	
Annual Change		0.01	0.01	0.00	0.01	0.01		
Annual Payroll ($1,000) per Employee	20.9	21.5	22.1	22.7	23.4	24.0	3.1	
AGR	2.6%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	
Annual Change		0.58	0.60	0.62	0.64	0.66		

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Sector: Private, Sub-Sector: Businesses, Industry Accommodation, Food Services, Size Class: All, Primary Firms (K) — CAGR: -7.3%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Administrative Support, Waste Management, Remediation Services							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	260.252	247.859	257.490	259.932	259.284	257.868	-2.384	
AGR	-1.8%	-4.8%	3.9%	0.9%	-0.2%	-0.5%	-0.2%	
Annual Change		-12.393	9.631	2.442	-0.648	-1.416		
Primary Firms (K)	257.009	244.773	254.290	256.688	256.040	254.633	-2.376	
AGR	-1.8%	-4.8%	3.9%	0.9%	-0.3%	-0.5%	-0.2%	
Annual Change		-12.236	9.517	2.398	-0.648	-1.407		
Employees (K)	9.343	9.099	9.668	9.996	10.216	10.413	1,070.230	
AGR	0.5%	-2.6%	6.3%	3.4%	2.2%	1.9%	2.2%	
Annual Change		-243.766	569.000	328.166	219.857	196.973		
Establishments (K)	317.830	304.036	316.982	321.329	322.387	322.770	4.940	
AGR	-1.5%	-4.3%	4.3%	1.4%	0.3%	0.1%	0.3%	
Annual Change		-13.794	12.946	4.347	1.058	0.383		
Annual Payroll ($M)	409	409	447	475	499	523	114	
AGR	3.1%	0.1%	9.2%	6.3%	5.1%	4.8%	5.0%	
Annual Change		0	38	28	24	24		
Employees per Primary Firm	36.4	37.2	38.0	38.9	39.9	40.9	4.5	
AGR	2.4%	2.3%	2.3%	2.4%	2.5%	2.5%	2.4%	
Annual Change		0.82	0.85	0.92	0.96	0.99		
Establishments per Primary Firm	1.24	1.24	1.25	1.25	1.26	1.27	0.03	
AGR	0.4%	0.4%	0.4%	0.4%	0.6%	0.7%	0.5%	
Annual Change		0.01	0.00	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	43.8	45.0	46.2	47.5	48.9	50.3	6.5	
AGR	2.6%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	
Annual Change		1.20	1.25	1.29	1.33	1.38		

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Sector: Private, Sub-Sector: Businesses, Industry Administrative Support, Waste Management, Remediation Services, Size Class: All, Primary Firms (K) — CAGR: -0.2%

Business Economic Demographic Database								

Sector	Private							
Sub-Sector	Total							
Industry	Arts, Entertainment, Recreation							
Size Class	Total							

Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	134.035	99.799	110.280	107.593	101.512	95.297	-38.738	
AGR	1.4%	-25.5%	10.5%	-2.4%	-5.7%	-6.1%	-6.6%	
Annual Change		-34.236	10.481	-2.687	-6.081	-6.215		
Primary Firms (K)	132.429	98.607	108.968	106.315	100.305	94.168	-38.261	
AGR	1.4%	-25.5%	10.5%	-2.4%	-5.7%	-6.1%	-6.6%	
Annual Change		-33.822	10.361	-2.653	-6.010	-6.137		
Employees (K)	2,433	1,826	2,037	2,008	1,919	1,827	-606.696	
AGR	2.1%	-25.0%	11.5%	-1.4%	-4.5%	-4.8%	-5.6%	
Annual Change		-607.180	210.314	-28.194	-89.602	-92.034		
Establishments (K)	150.045	112.517	125.206	123.180	117.397	111.356	-38.689	
AGR	2.0%	-25.0%	11.3%	-1.6%	-4.7%	-5.1%	-5.8%	
Annual Change		-37.528	12.689	-2.026	-5.783	-6.041		
Annual Payroll ($M)	93	71	81	82	81	79	-14	
AGR	4.3%	-23.2%	14.2%	1.1%	-2.0%	-2.3%	-3.2%	
Annual Change		-21	10	1	-2	-2		
Employees per Primary Firm	18.4	18.5	18.7	18.9	19.1	19.4	1.0	
AGR	0.8%	0.8%	0.9%	1.1%	1.3%	1.4%	1.1%	
Annual Change		0.15	0.17	0.20	0.24	0.27		
Establishments per Primary Firm	1.13	1.14	1.15	1.16	1.17	1.18	0.05	
AGR	0.6%	0.7%	0.7%	0.8%	1.0%	1.0%	0.9%	
Annual Change		0.01	0.01	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	38.1	39.0	39.9	40.9	42.0	43.1	5.0	
AGR	2.1%	2.4%	2.4%	2.5%	2.6%	2.7%	2.5%	
Annual Change		0.90	0.95	1.00	1.06	1.12		

∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Arts, Entertainment, Recreation, Size Class: All, Primary Firms (K) CAGR: -6.6%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Construction							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	761.239	699.704	748.227	762.658	768.407	771.368	10.129	
AGR	0.0%	-8.1%	6.9%	1.9%	0.8%	0.4%	0.3%	
Annual Change		-61.535	48.523	14.431	5.749	2.961		
Primary Firms (K)	752.017	691.210	739.110	753.284	758.882	761.719	9.702	
AGR	0.0%	-8.1%	6.9%	1.9%	0.7%	0.4%	0.3%	
Annual Change		-60.807	47.900	14.174	5.598	2.837		
Employees (K)	7,492	7,073	7,776	8,161	8,474	8,775	1,283.188	
AGR	2.8%	-5.6%	9.9%	5.0%	3.8%	3.6%	3.2%	
Annual Change		-418.505	702.102	385.027	313.150	301.414		
Establishments (K)	780.875	718.184	768.507	784.016	790.424	794.170	13.295	
AGR	0.1%	-8.0%	7.0%	2.0%	0.8%	0.5%	0.3%	
Annual Change		-62.691	50.323	15.509	6.408	3.746		
Annual Payroll ($M)	496	482	544	587	626	665	169	
AGR	5.5%	-2.9%	13.0%	7.8%	6.6%	6.3%	6.0%	
Annual Change		-15	62	43	39	39		
Employees per Primary Firm	10.0	10.2	10.5	10.8	11.2	11.5	1.6	
AGR	2.8%	2.7%	2.8%	3.0%	3.1%	3.2%	2.9%	
Annual Change		0.27	0.29	0.31	0.33	0.35		
Establishments per Primary Firm	1.04	1.04	1.04	1.04	1.04	1.04	0.00	
AGR	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	
Annual Change		0.00	0.00	0.00	0.00	0.00		
Annual Payroll ($1,000) per Employee	66.2	68.1	70.0	71.9	73.8	75.8	9.5	
AGR	2.7%	2.8%	2.8%	2.7%	2.7%	2.7%	2.7%	
Annual Change		1.86	1.88	1.91	1.94	1.96		

∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Construction, Size Class: All, Primary Firms (K)
CAGR: 0.3%

Year	Primary Firms (K)	Annual Growth Rate
2014	698.285	
2015	713.367	2.2%
2016	723.274	1.4%
2017	740.691	2.4%
2018	751.977	1.5%
2019	752.017	0.0%
2020	691.210	-8.1%
2021	739.110	6.9%
2022	753.284	1.9%
2023	758.882	0.7%
2024	761.719	0.4%

∫∆ Daniel Research Group ® (2020)   ■ Primary Firms (K)   — Annual Growth Rate

Business Economic Demographic Database

Sector	Private
Sub-Sector	Total
Industry	Education
Size Class	Total

Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	96.993	96.175	104.061	109.287	113.454	117.416	20.423	
AGR	2.2%	-0.8%	8.2%	5.0%	3.8%	3.5%	3.9%	
Annual Change		-0.818	7.886	5.226	4.167	3.962		
Primary Firms (K)	95.782	94.998	102.810	107.999	112.137	116.077	20.295	
AGR	2.2%	-0.8%	8.2%	5.0%	3.8%	3.5%	3.9%	
Annual Change		-0.784	7.812	5.189	4.138	3.940		
Employees (K)	3.765	3.695	3.960	4.119	4.239	4.350	585.469	
AGR	1.3%	-1.8%	7.1%	4.0%	2.9%	2.6%	2.9%	
Annual Change		-69.044	264.152	159.545	119.547	111.269		
Establishments (K)	110.147	108.937	117.617	123.216	127.675	131.929	21.782	
AGR	2.6%	-1.1%	8.0%	4.8%	3.6%	3.3%	3.7%	
Annual Change		-1.210	8.680	5.599	4.459	4.254		
Annual Payroll ($M)	157	158	173	184	195	205	48	
AGR	3.6%	0.5%	9.8%	6.6%	5.5%	5.2%	5.5%	
Annual Change		1	15	11	10	10		
Employees per Primary Firm	39.3	38.9	38.5	38.1	37.8	37.5	-1.8	
AGR	-0.9%	-1.0%	-1.0%	-1.0%	-0.9%	-0.9%	-0.9%	
Annual Change		-0.40	-0.39	-0.37	-0.34	-0.32		
Establishments per Primary Firm	1.15	1.15	1.14	1.14	1.14	1.14	-0.01	
AGR	0.4%	-0.3%	-0.2%	-0.3%	-0.2%	-0.2%	-0.2%	
Annual Change		0.00	0.00	0.00	0.00	0.00		
Annual Payroll ($1,000) per Employee	41.6	42.7	43.7	44.8	45.9	47.1	5.4	
AGR	2.2%	2.4%	2.5%	2.5%	2.5%	2.5%	2.5%	
Annual Change		1.01	1.05	1.08	1.12	1.16		

∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Education, Size Class: All, Primary Firms (K) — CAGR: 3.9%

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Primary Firms (K)	83.274	85.098	88.348	91.963	93.689	95.782	94.998	102.810	107.999	112.137	116.077
Annual Growth Rate		2.2%	3.8%	4.1%	1.9%	2.2%	-0.8%	8.2%	5.0%	3.8%	3.5%

∫Δ Daniel Research Group ® (2020)

Business Economic Demographic Database

Sector	Private
Sub-Sector	Total
Industry	Finance, Insurance
Size Class	Total

Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		232.123	226.999	233.295	235.311	234.631	233.212	1.089	
	AGR	-0.2%	-2.2%	2.8%	0.9%	-0.3%	-0.6%	0.1%	
	Annual Change		-5.124	6.296	2.016	-0.680	-1.419		
Primary Firms (K)		229.249	224.195	230.426	232.408	231.715	230.293	1.044	
	AGR	-0.2%	-2.2%	2.8%	0.9%	-0.3%	-0.6%	0.1%	
	Annual Change		-5.054	6.231	1.982	-0.693	-1.422		
Employees (K)		6.425	6.377	6.658	6.825	6.922	7.002	576.344	
	AGR	1.4%	-0.8%	4.4%	2.5%	1.4%	1.2%	1.7%	
	Annual Change		-48.666	281.216	166.752	97.021	80.021		
Establishments (K)		468.432	458.709	470.250	472.530	471.227	468.650	0.218	
	AGR	-0.1%	-2.1%	2.5%	0.5%	-0.3%	-0.5%	0.0%	
	Annual Change		-9.723	11.541	2.280	-1.303	-2.577		
Annual Payroll ($M)		695	707	756	793	824	853	159	
	AGR	3.8%	1.7%	7.0%	5.0%	3.9%	3.6%	4.2%	
	Annual Change		12	49	38	31	29		
Employees per Primary Firm		28.0	28.4	28.9	29.4	29.9	30.4	2.4	
	AGR	1.6%	1.5%	1.6%	1.6%	1.7%	1.8%	1.6%	
	Annual Change		0.41	0.45	0.47	0.51	0.53		
Establishments per Primary Firm		2.04	2.05	2.04	2.03	2.03	2.04	-0.01	
	AGR	0.1%	0.1%	-0.3%	-0.4%	0.0%	0.1%	-0.1%	
	Annual Change		0.00	-0.01	-0.01	0.00	0.00		
Annual Payroll ($1,000) per Employee		108.1	110.8	113.5	116.2	119.0	121.9	13.7	
	AGR	2.3%	2.5%	2.4%	2.4%	2.4%	2.4%	2.4%	
	Annual Change		2.67	2.70	2.74	2.79	2.85		

∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Finance, Insurance, Size Class: All, Primary Firms (K) — CAGR: 0.1%

		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Business Economic Demographic Database									
Sector	Private								
Sub-Sector	Total								
Industry	Forestry, Fishing, Hunting, Agriculture								
Size Class	Total								
Metric		**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Change / CAGR**	**Trends**
Firms (K)		324.991	320.554	337.045	348.350	355.567	361.331	36.340	
	AGR	-1.6%	-1.4%	5.1%	3.4%	2.1%	1.6%	2.1%	
	Annual Change		-4.437	16.491	11.305	7.217	5.764		
Primary Firms (K)		321.111	316.709	333.022	344.183	351.274	356.928	35.817	
	AGR	-1.6%	-1.4%	5.2%	3.4%	2.1%	1.6%	2.1%	
	Annual Change		-4.402	16.313	11.161	7.091	5.654		
Employees (K)		2,425	2,373	2,479	2,550	2,591	2,624	198.914	
	AGR	0.0%	-2.1%	4.5%	2.8%	1.6%	1.3%	1.6%	
	Annual Change		-51.573	105.911	70.406	41.151	33.019		
Establishments (K)		337.533	332.890	349.605	360.991	368.724	374.978	37.445	
	AGR	-1.5%	-1.4%	5.0%	3.3%	2.1%	1.7%	2.1%	
	Annual Change		-4.643	16.715	11.386	7.733	6.254		
Annual Payroll ($M)		111	112	121	128	134	140	29	
	AGR	1.8%	1.1%	7.8%	6.1%	4.7%	4.2%	4.8%	
	Annual Change		1	9	7	6	6		
Employees per Primary Firm		7.6	7.5	7.4	7.4	7.4	7.4	-0.2	
	AGR	1.6%	-0.8%	-0.7%	-0.5%	-0.4%	-0.3%	-0.5%	
	Annual Change		-0.06	-0.05	-0.04	-0.03	-0.02		
Establishments per Primary Firm		1.05	1.05	1.05	1.05	1.05	1.05	0.00	
	AGR	0.1%	0.0%	-0.1%	-0.1%	0.1%	0.1%	0.0%	
	Annual Change		0.00	0.00	0.00	0.00	0.00		
Annual Payroll ($1,000) per Employee		45.6	47.1	48.6	50.2	51.7	53.2	7.6	
	AGR	1.8%	3.3%	3.2%	3.1%	3.0%	2.9%	3.1%	
	Annual Change		1.52	1.52	1.52	1.51	1.50		

⇥∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Forestry, Fishing, Hunting, Agriculture, Size Class: All, Primary Firms (K — CAGR: 2.1%

	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Health Care, Social Assistance							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	665.377	641.119	662.005	671.673	672.404	670.443	5.066	
AGR	-0.1%	-3.6%	3.3%	1.5%	0.1%	-0.3%	0.2%	
Annual Change		-24.258	20.886	9.668	0.731	-1.961		
Primary Firms (K)	657.220	633.233	653.833	663.317	663.969	661.951	4.731	
AGR	-0.1%	-3.6%	3.3%	1.5%	0.1%	-0.3%	0.1%	
Annual Change		-23.987	20.600	9.484	0.652	-2.018		
Employees (K)	20,413	20,179	21,417	22,372	23,094	23,776	3,363.828	
AGR	2.5%	-1.1%	6.1%	4.5%	3.2%	3.0%	3.1%	
Annual Change		-233.884	1238.454	954.666	722.694	681.898		
Establishments (K)	945.623	926.933	975.377	1,009.382	1,031.604	1,051.235	105.612	
AGR	1.5%	-2.0%	5.2%	3.5%	2.2%	1.9%	2.1%	
Annual Change		-18.690	48.444	34.005	22.222	19.631		
Annual Payroll ($M)	1,046	1,059	1,152	1,233	1,306	1,380	333	
AGR	4.7%	1.2%	8.7%	7.1%	5.9%	5.7%	5.7%	
Annual Change		13	93	82	73	74		
Employees per Primary Firm	31.1	31.9	32.8	33.7	34.8	35.9	4.9	
AGR	2.6%	2.6%	2.8%	3.0%	3.1%	3.3%	3.0%	
Annual Change		0.81	0.89	0.97	1.06	1.14		
Establishments per Primary Firm	1.44	1.46	1.49	1.52	1.55	1.59	0.15	
AGR	1.7%	1.7%	1.9%	2.0%	2.1%	2.2%	2.0%	
Annual Change		0.02	0.03	0.03	0.03	0.03		
Annual Payroll ($1,000) per Employee	51.3	52.5	53.8	55.1	56.5	58.0	6.8	
AGR	2.2%	2.4%	2.5%	2.5%	2.6%	2.6%	2.5%	
Annual Change		1.23	1.29	1.35	1.42	1.49		

∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Health Care, Social Assistance, Size Class: All, Primary Firms (K) — CAGR: 0.1%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Information							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	65.814	63.461	67.316	69.798	71.866	73.310	7.496	
AGR	1.5%	-3.6%	6.1%	3.7%	2.7%	2.3%	2.2%	
Annual Change		-2.353	3.855	2.482	1.868	1.644		
Primary Firms (K)	64.750	62.432	66.218	68.646	70.470	72.072	7.322	
AGR	1.4%	-3.6%	6.1%	3.7%	2.7%	2.3%	2.2%	
Annual Change		-2.318	3.786	2.428	1.824	1.602		
Employees (K)	2.860	2.735	2.881	2.969	3.032	3.088	228.164	
AGR	0.7%	-4.4%	5.3%	3.1%	2.1%	1.9%	1.5%	
Annual Change		-124.775	145.320	88.167	63.192	56.260		
Establishments (K)	131.050	127.905	139.003	147.258	155.040	163.181	32.131	
AGR	2.9%	-2.4%	8.7%	5.9%	5.3%	5.3%	4.5%	
Annual Change		-3.145	11.098	8.255	7.782	8.141		
Annual Payroll ($M)	332	335	372	404	434	466	134	
AGR	6.1%	0.9%	11.0%	8.6%	7.6%	7.3%	7.0%	
Annual Change		3	37	32	31	32		
Employees per Primary Firm	44.2	43.8	43.5	43.2	43.0	42.8	-1.3	
AGR	-0.7%	-0.8%	-0.7%	-0.6%	-0.5%	-0.4%	-0.6%	
Annual Change		-0.36	-0.31	-0.25	-0.22	-0.18		
Establishments per Primary Firm	2.02	2.05	2.10	2.15	2.20	2.26	0.24	
AGR	1.4%	1.2%	2.5%	2.2%	2.6%	2.9%	2.3%	
Annual Change		0.02	0.05	0.05	0.05	0.06		
Annual Payroll ($1,000) per Employee	116.0	122.4	129.0	136.0	143.3	150.9	34.8	
AGR	5.3%	5.5%	5.4%	5.4%	5.3%	5.3%	5.4%	
Annual Change		6.35	6.65	6.98	7.27	7.60		

∼∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Information, Size Class: All, Primary Firms (K) — CAGR: 2.2%

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Primary Firms (K)	58.426	59.342	60.731	62.999	63.841	64.750	62.432	66.218	68.646	70.470	72.072
Annual Growth Rate		1.6%	2.3%	3.7%	1.3%	1.4%	1.6%	6.1%	3.7%	2.7%	2.3%

⊸∫Δ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

Business Economic Demographic Database

Sector	Private								
Sub-Sector	Total								
Industry	Management of Companies, Enterprises								
Size Class	Total								

Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		17.899	17.320	17.493	17.708	17.757	17.796	-0.103	
	AGR	-0.4%	-3.2%	1.0%	1.2%	0.3%	0.2%	-0.1%	
	Annual Change		-0.579	0.173	0.215	0.049	0.039		
Primary Firms (K)		6.377	6.266	6.437	6.567	6.624	6.669	0.292	
	AGR	0.9%	-1.7%	2.7%	2.0%	0.9%	0.7%	0.9%	
	Annual Change		-0.111	0.171	0.130	0.057	0.045		
Employees (K)		2,427	2,410	2,502	2,571	2,614	2,651	223.552	
	AGR	2.3%	-0.7%	3.8%	2.8%	1.7%	1.4%	1.8%	
	Annual Change		-17.338	91.607	68.847	43.414	37.022		
Establishments (K)		39.139	38.782	39.926	41.102	42.102	43.120	3.981	
	AGR	1.6%	-0.9%	2.9%	2.9%	2.4%	2.4%	2.0%	
	Annual Change		-0.357	1.144	1.176	1.000	1.018		
Annual Payroll ($M)		264	261	270	276	279	281	17	
	AGR	1.7%	-1.2%	3.3%	2.2%	1.1%	0.8%	1.2%	
	Annual Change		-3	9	6	3	2		
Employees per Primary Firm		380.6	384.6	388.6	391.4	394.6	397.5	16.9	
	AGR	1.3%	1.0%	1.0%	0.7%	0.8%	0.7%	0.9%	
	Annual Change		3.98	4.01	2.79	3.19	2.89		
Establishments per Primary Firm		6.14	6.19	6.20	6.26	6.36	6.47	0.33	
	AGR	0.7%	0.8%	0.2%	0.9%	1.6%	1.7%	1.0%	
	Annual Change		0.05	0.01	0.06	0.10	0.11		
Annual Payroll ($1,000) per Employee		106.9	108.4	107.8	107.2	106.6	105.9	-2.9	
	AGR	-0.6%	-0.5%	-0.5%	-0.6%	-0.6%	-0.6%	-0.5%	
	Annual Change		-0.50	-0.55	-0.60	-0.63	-0.66		
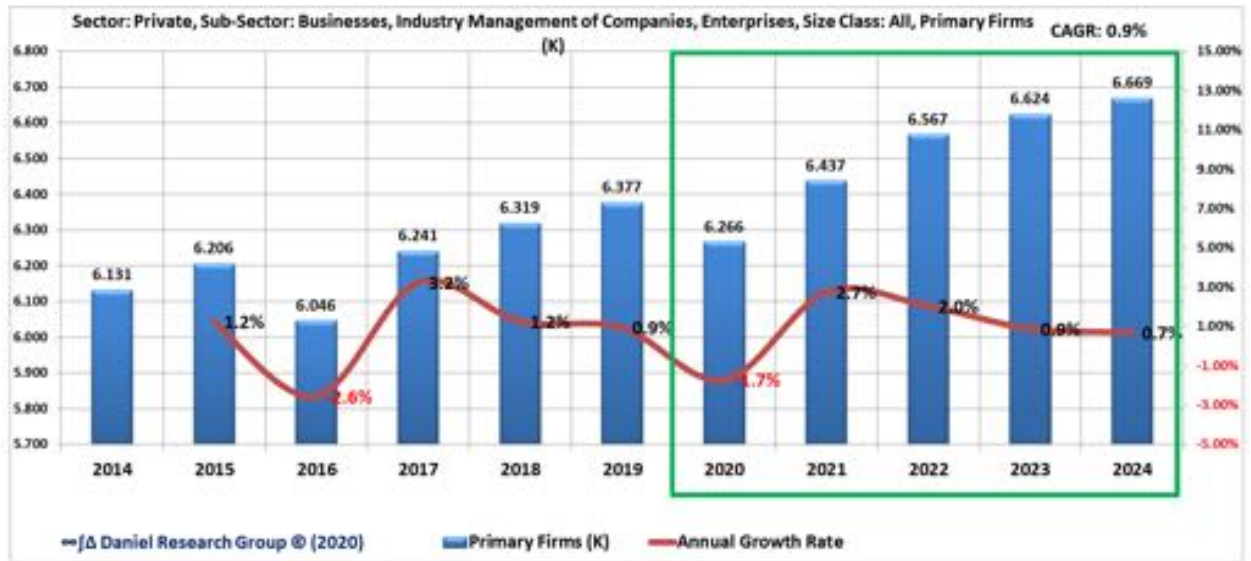
⊸∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Manufacturing, Size Class: All, Primary Firms (K) — CAGR: -0.2%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Mining							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		25.507	24.470	26.655	28.833	30.915	33.053	7.546	
	AGR	3.8%	-4.1%	8.9%	8.2%	7.2%	6.9%	5.3%	
	Annual Change		-1.037	2.185	2.178	2.082	2.138		
Primary Firms (K)		25.039	24.028	26.177	28.323	30.382	32.491	7.452	
	AGR	3.7%	-4.0%	8.9%	8.2%	7.3%	6.9%	5.3%	
	Annual Change		-1.011	2.149	2.146	2.059	2.109		
Employees (K)		735	683	720	755	783	811	75.965	
	AGR	1.1%	-7.1%	5.4%	4.7%	3.8%	3.5%	2.0%	
	Annual Change		-51.840	37.193	34.158	28.913	27.541		
Establishments (K)		35.202	34.058	37.410	40.864	43.943	47.466	12.264	
	AGR	4.8%	-3.2%	9.8%	9.2%	7.5%	8.0%	6.2%	
	Annual Change		-1.144	3.352	3.454	3.079	3.523		
Annual Payroll ($M)		67	62	66	70	74	77	11	
	AGR	1.6%	-6.3%	6.4%	5.8%	5.0%	4.8%	3.0%	
	Annual Change		-4	4	4	4	4		
Employees per Primary Firm		29.4	28.4	27.5	26.6	25.8	25.0	-4.4	
	AGR	-2.5%	-3.1%	-3.2%	-3.2%	-3.2%	-3.2%	-3.2%	
	Annual Change		-0.92	-0.91	-0.89	-0.85	-0.83		
Establishments per Primary Firm		1.41	1.42	1.43	1.44	1.45	1.46	0.06	
	AGR	1.0%	0.8%	0.8%	1.0%	0.2%	1.0%	0.8%	
	Annual Change		0.01	0.01	0.01	0.00	0.01		
Annual Payroll ($1,000) per Employee		90.8	91.5	92.3	93.2	94.2	95.4	4.6	
	AGR	0.5%	0.8%	0.9%	1.0%	1.1%	1.2%	1.0%	
	Annual Change		0.69	0.81	0.93	1.04	1.15		

∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Mining, Size Class: All, Primary Firms (K) — CAGR: 5.3%

Year	Primary Firms (K)	Annual Growth Rate
2014	26.324	
2015	23.799	-9.6%
2016	22.823	-4.1%
2017	21.957	-3.8%
2018	24.135	9.9%
2019	25.039	3.7%
2020	24.028	-4.0%
2021	26.1 / 8.9%	
2022	28.323	8.2%
2023	30.382	7.3%
2024	32.491	6.9%

∫Δ Daniel Research Group ® (2020)

Business Economic Demographic Database

Sector	Private							
Sub-Sector	Total							
Industry	Other Services							
Size Class	Total							

Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		734.079	656.034	706.932	716.963	713.674	707.897	-26.182	
	AGR	0.6%	-10.6%	7.8%	1.4%	-0.5%	-0.8%	-0.7%	
	Annual Change		-78.045	50.898	10.031	-3.289	-5.777		
Primary Firms (K)		725.176	648.052	698.325	708.182	704.901	699.138	-26.038	
	AGR	0.6%	-10.6%	7.8%	1.4%	-0.5%	-0.8%	-0.7%	
	Annual Change		-77.124	50.273	9.857	-3.281	-5.763		
Employees (K)		5.893	5.286	5.720	5.829	5.834	5.823	-70.368	
	AGR	1.1%	-10.3%	8.2%	1.9%	0.1%	-0.2%	-0.2%	
	Annual Change		-607.269	433.805	109.235	5.531	-11.670		
Establishments (K)		813.149	729.370	787.571	801.747	800.533	798.756	-14.393	
	AGR	0.8%	-10.3%	8.0%	1.8%	-0.2%	-0.2%	-0.4%	
	Annual Change		-83.779	58.201	14.176	-1.214	-1.777		
Annual Payroll ($M)		208	192	214	224	231	237	29	
	AGR	3.7%	-7.8%	11.3%	4.8%	3.0%	2.7%	2.6%	
	Annual Change		-16	22	10	7	6		
Employees per Primary Firm		8.1	8.2	8.2	8.2	8.3	8.3	0.2	
	AGR	0.5%	0.4%	0.4%	0.5%	0.6%	0.6%	0.5%	
	Annual Change		0.03	0.03	0.04	0.05	0.05		
Establishments per Primary Firm		1.12	1.13	1.13	1.13	1.14	1.14	0.02	
	AGR	0.3%	0.4%	0.2%	0.4%	0.3%	0.6%	0.4%	
	Annual Change		0.00	0.00	0.00	0.00	0.01		
Annual Payroll ($1,000) per Employee		35.4	36.3	37.4	38.4	39.5	40.7	5.4	
	AGR	2.6%	2.8%	2.8%	2.9%	2.9%	2.9%	2.9%	
	Annual Change		0.99	1.02	1.07	1.11	1.16		

∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Other Services, Size Class: All, Primary Firms (K)   CAGR: -0.7%

Bar chart values (Primary Firms K):
- 2014: 696.227
- 2015: 703.825
- 2016: 709.301
- 2017: 718.878
- 2018: 721.073
- 2019: 725.176
- 2020: 648.052
- 2021: 698.315
- 2022: 708.182
- 2023: 704.901
- 2024: 699.138

Annual Growth Rate: 1.1%, 0.8%, 1.4%, 0.3%, 0.6%, -10.6%, 7.8%, 1.4%, -0.5%, -0.8%

Legend: ∫Δ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

Business Economic Demographic Database

Sector	Private								
Sub-Sector	Total								
Industry	Professional, Scientific, Technical Services								
Size Class	Total								
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		852.274	822.859	868.437	895.454	913.528	928.824	76.550	
	AGR	1.8%	-3.5%	5.5%	3.1%	2.0%	1.7%	1.7%	
	Annual Change		-29.415	45.578	27.017	18.074	15.296		
Primary Firms (K)		841.953	812.879	857.893	884.522	902.315	917.368	75.415	
	AGR	1.8%	-3.5%	5.5%	3.1%	2.0%	1.7%	1.7%	
	Annual Change		-29.074	45.014	26.629	17.793	15.053		
Employees (K)		9.543	9.290	9.891	10.293	10.605	10.898	1,355.496	
	AGR	2.8%	-2.6%	6.5%	4.1%	3.0%	2.8%	2.7%	
	Annual Change		-252.751	600.642	402.227	312.618	292.760		
Establishments (K)		973.531	944.451	1,001.259	1,038.031	1,065.030	1,089.009	115.478	
	AGR	2.3%	-3.0%	6.0%	3.7%	2.6%	2.3%	2.3%	
	Annual Change		-29.080	56.808	36.772	26.999	23.979		
Annual Payroll ($M)		861	858	935	996	1,051	1,105	244	
	AGR	5.1%	-0.3%	9.0%	6.5%	5.5%	5.2%	5.1%	
	Annual Change		-3	77	61	54	54		
Employees per Primary Firm		11.3	11.4	11.5	11.6	11.8	11.9	0.5	
	AGR	1.0%	0.8%	0.9%	0.9%	1.0%	1.1%	0.9%	
	Annual Change		0.09	0.10	0.11	0.12	0.13		
Establishments per Primary Firm		1.16	1.16	1.17	1.17	1.18	1.19	0.03	
	AGR	0.5%	0.5%	0.5%	0.6%	0.6%	0.6%	0.5%	
	Annual Change		0.01	0.01	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee		90.2	92.4	94.6	96.8	99.1	101.4	11.2	
	AGR	2.3%	2.4%	2.4%	2.4%	2.4%	2.3%	2.4%	
	Annual Change		2.17	2.20	2.24	2.28	2.32		

∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Real Estate, Rental, Leasing, Size Class: All, Primary Firms (K) — CAGR: 2.6%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Retail							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		632.234	591.675	623.346	630.113	626.972	621.988	-10.246	
	AGR	-1.9%	-6.4%	5.4%	1.1%	-0.5%	-0.8%	-0.3%	
	Annual Change		-40.559	31.671	6.767	-3.141	-4.984		
Primary Firms (K)		624.569	584.493	615.763	622.407	619.260	614.293	-10.276	
	AGR	-1.9%	-6.4%	5.3%	1.1%	-0.5%	-0.8%	-0.3%	
	Annual Change		-40.076	31.270	6.644	-3.147	-4.967		
Employees (K)		15.644	14.762	15.684	15.996	16.064	16.090	446.245	
	AGR	-0.9%	-5.6%	6.2%	2.0%	0.4%	0.2%	0.8%	
	Annual Change		-882.486	921.994	312.880	68.103	25.754		
Establishments (K)		1,044.545	978.430	1,033.174	1,045.110	1,043.067	1,036.177	-8.368	
	AGR	-1.8%	-6.3%	5.6%	1.2%	-0.2%	-0.7%	-0.2%	
	Annual Change		-66.115	54.744	11.936	-2.043	-6.890		
Annual Payroll ($M)		474	458	497	519	533	547	73	
	AGR	1.2%	-3.5%	8.7%	4.4%	2.8%	2.5%	2.9%	
	Annual Change		-17	40	22	14	13		
Employees per Primary Firm		25.0	25.3	25.5	25.7	25.9	26.2	1.1	
	AGR	1.0%	0.8%	0.9%	0.9%	0.9%	1.0%	0.9%	
	Annual Change		0.21	0.21	0.23	0.24	0.25		
Establishments per Primary Firm		1.67	1.67	1.68	1.68	1.68	1.69	0.01	
	AGR	0.1%	0.1%	0.2%	0.1%	0.3%	0.1%	0.2%	
	Annual Change		0.00	0.00	0.00	0.01	0.00		
Annual Payroll ($1,000) per Employee		30.3	31.0	31.7	32.5	33.2	34.0	3.7	
	AGR	2.1%	2.3%	2.3%	2.3%	2.3%	2.3%	2.3%	
	Annual Change		0.69	0.71	0.73	0.75	0.77		

∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Retail, Size Class: All, Primary Firms (K)

CAGR: -0.3%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Transportation, Warehousing							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	207.853	187.659	200.930	206.187	207.476	208.116	0.263	
AGR	2.1%	-9.7%	7.1%	2.6%	0.6%	0.3%	0.0%	
Annual Change		-20.194	13.271	5.257	1.289	0.640		
Primary Firms (K)	205.047	185.151	198.280	203.498	204.799	205.456	0.409	
AGR	2.2%	-9.7%	7.1%	2.6%	0.6%	0.3%	0.0%	
Annual Change		-19.895	13.129	5.218	1.301	0.657		
Employees (K)	5.618	5.136	5.570	5.797	5.922	6.035	416.496	
AGR	3.5%	-8.6%	8.4%	4.1%	2.2%	1.9%	1.4%	
Annual Change		-482.370	433.801	227.305	125.586	112.174		
Establishments (K)	269.717	244.493	263.453	271.958	275.168	278.011	8.294	
AGR	2.6%	-9.4%	7.8%	3.2%	1.2%	1.0%	0.6%	
Annual Change		-25.224	18.960	8.505	3.210	2.843		
Annual Payroll ($M)	306	288	321	344	361	379	73	
AGR	6.2%	-6.0%	11.5%	7.1%	5.1%	4.9%	4.4%	
Annual Change		-18	33	23	18	18		
Employees per Primary Firm	27.4	27.7	28.1	28.5	28.9	29.4	2.0	
AGR	1.3%	1.2%	1.3%	1.4%	1.5%	1.6%	1.4%	
Annual Change		0.34	0.35	0.40	0.43	0.45		
Establishments per Primary Firm	1.32	1.32	1.33	1.34	1.34	1.35	0.04	
AGR	0.4%	0.4%	0.6%	0.6%	0.5%	0.7%	0.6%	
Annual Change		0.01	0.01	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	54.5	56.0	57.6	59.3	61.0	62.8	8.3	
AGR	2.6%	2.8%	2.8%	2.9%	2.9%	2.9%	2.9%	
Annual Change		1.53	1.59	1.66	1.72	1.80		

∽∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Transportation, Warehousing, Size Class: All, Primary Firms (K)   CAGR: 0.0%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Utilities							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		5.037	4.624	5.073	5.263	5.403	5.533	0.496	
	AGR	-1.1%	-8.2%	9.7%	3.7%	2.7%	2.4%	1.9%	
	Annual Change		-0.413	0.449	0.190	0.140	0.130		
Primary Firms (K)		4.903	4.496	4.930	5.113	5.247	5.372	0.469	
	AGR	-1.1%	-8.3%	9.7%	3.7%	2.6%	2.4%	1.8%	
	Annual Change		-0.407	0.434	0.183	0.134	0.125		
Employees (K)		549	504	554	576	592	607	58.124	
	AGR	-0.8%	-8.1%	9.9%	3.8%	2.8%	2.6%	2.0%	
	Annual Change		-44.582	49.800	21.303	16.384	15.219		
Establishments (K)		16.715	16.009	17.642	18.725	19.907	19.965	3.250	
	AGR	0.8%	-4.2%	10.2%	6.1%	6.3%	0.3%	3.6%	
	Annual Change		-0.706	1.633	1.083	1.182	0.058		
Annual Payroll ($M)		62	58	66	70	73	77	15	
	AGR	1.5%	-5.8%	12.6%	6.4%	5.4%	5.1%	4.6%	
	Annual Change		-4	7	4	4	4		
Employees per Primary Firm		112.0	112.2	112.4	112.6	112.8	113.0	1.0	
	AGR	0.3%	0.2%	0.2%	0.1%	0.2%	0.2%	0.2%	
	Annual Change		0.22	0.22	0.14	0.25	0.21		
Establishments per Primary Firm		3.41	3.56	3.58	3.66	3.79	3.72	0.31	
	AGR	2.0%	4.4%	0.5%	2.3%	3.6%	-2.0%	1.7%	
	Annual Change		0.15	0.02	0.08	0.13	-0.06		
Annual Payroll ($1,000) per Employee		112.6	115.4	118.2	121.2	124.2	127.2	14.7	
	AGR	2.3%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	
	Annual Change		2.80	2.87	2.93	3.00	3.07		

=∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Utilities, Size Class: All, Primary Firms (K) — CAGR: 1.8%

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Total							
Industry	Wholesale							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		273.669	255.567	268.283	268.740	268.240	262.797	-10.872	
	AGR	-1.4%	-6.6%	5.0%	0.2%	-0.9%	-1.3%	-0.8%	
	Annual Change		-18.102	12.716	0.457	-2.500	-3.443		
Primary Firms (K)		269.593	251.659	264.053	264.363	261.751	258.205	-11.388	
	AGR	-1.5%	-6.7%	4.9%	0.1%	-1.0%	-1.4%	-0.9%	
	Annual Change		-17.934	12.394	0.310	-2.612	-3.546		
Employees (K)		5.903	5.649	6.082	6.254	6.367	6.465	561.642	
	AGR	1.1%	-4.3%	7.7%	2.8%	1.8%	1.5%	1.8%	
	Annual Change		-254.430	433.521	171.013	113.247	98.291		
Establishments (K)		383.762	361.246	383.130	387.629	388.076	387.767	4.005	
	AGR	-0.6%	-5.9%	6.1%	1.2%	0.1%	-0.1%	0.2%	
	Annual Change		-22.516	21.884	4.499	0.447	-0.309		
Annual Payroll ($M)		442	429	468	487	502	516	74	
	AGR	2.4%	-3.0%	9.1%	4.1%	3.1%	2.7%	3.1%	
	Annual Change		-13	39	19	15	14		
Employees per Primary Firm		21.9	22.4	23.0	23.7	24.3	25.0	3.1	
	AGR	2.6%	2.5%	2.6%	2.7%	2.8%	2.9%	2.7%	
	Annual Change		0.55	0.59	0.62	0.67	0.71		
Establishments per Primary Firm		1.42	1.44	1.45	1.47	1.48	1.50	0.08	
	AGR	0.9%	0.8%	1.1%	1.1%	1.1%	1.3%	1.1%	
	Annual Change		0.01	0.02	0.02	0.02	0.02		
Annual Payroll ($1,000) per Employee		74.9	76.0	77.0	77.9	78.9	79.8	4.9	
	AGR	1.3%	1.4%	1.3%	1.3%	1.2%	1.2%	1.3%	
	Annual Change		1.04	1.01	0.98	0.95	0.93		

∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry Wholesale, Size Class: All, Primary Firms (K) — CAGR: -0.9%
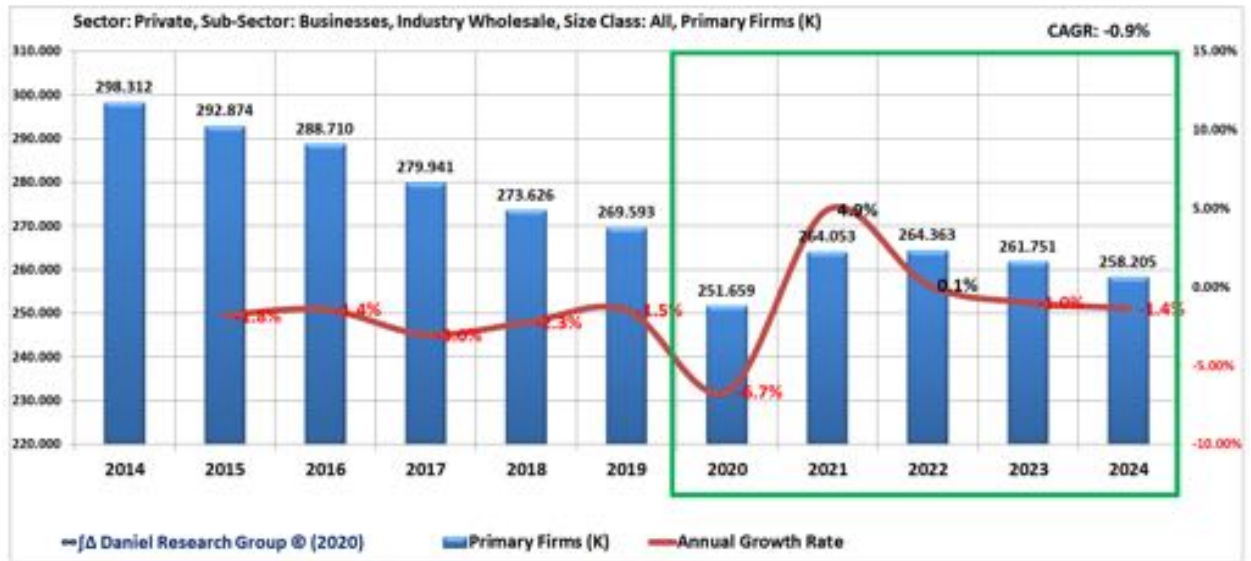
By Industry – Public Sector

Business Economic Demographic Database									
Sector	Public								
Sub-Sector	Total								
Industry	Administrative Support, Waste Management, Remediation Services								
Size Class	Total								
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		1.013	0.968	0.995	0.994	0.982	0.967	-0.046	
	AGR	-1.5%	-4.4%	2.8%	-0.1%	-1.2%	-1.5%	-0.9%	
	Annual Change		-0.045	0.027	-0.001	-0.012	-0.015		
Primary Firms (K)		1.012	0.967	0.994	0.993	0.981	0.966	-0.046	
	AGR	-1.5%	-4.4%	2.8%	-0.1%	-1.2%	-1.5%	-0.9%	
	Annual Change		-0.045	0.027	-0.001	-0.012	-0.015		
Employees (K)		694	675	701	719	730	742	48.606	
	AGR	9.1%	-2.6%	3.9%	2.5%	1.5%	1.7%	1.4%	
	Annual Change		-18.225	26.093	17.607	10.724	12.407		
Establishments (K)		3.529	2.935	2.990	3.036	3.300	3.315	-0.214	
	AGR	1.7%	-16.8%	1.9%	1.5%	8.7%	0.5%	-1.2%	
	Annual Change		-0.594	0.055	0.046	0.264	0.015		
Annual Payroll ($M)		53	52	55	57	59	61	8	
	AGR	9.1%	-1.1%	5.3%	4.2%	3.3%	3.6%	3.0%	
	Annual Change		-1	3	2	2	2		
Employees per Primary Firm		685.3	698.4	705.6	724.1	743.9	768.3	83.0	
	AGR	10.7%	1.9%	1.0%	2.6%	2.7%	3.3%	2.3%	
	Annual Change		13.04	7.28	18.44	19.79	24.39		
Establishments per Primary Firm		3.49	3.04	3.01	3.06	3.36	3.43	-0.06	
	AGR	3.2%	-13.0%	-0.9%	1.6%	10.0%	2.0%	-0.3%	
	Annual Change		-0.45	-0.03	0.05	0.31	0.07		
Annual Payroll ($1,000) per Employee		76.0	77.2	78.3	79.6	81.0	82.5	6.5	
	AGR	0.0%	1.6%	1.4%	1.7%	1.7%	1.8%	1.6%	
	Annual Change		1.19	1.10	1.33	1.38	1.48		
←∫Δ Daniel Research Group ® (2020)									

Sector: Public, Sub-Sector: Selected, Industry Administrative Support, Waste Management, Remediation Services, Size Class: All, Primary Firms (K) — CAGR: -0.9%

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Arts, Entertainment, Recreation							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	0.912	0.794	0.870	0.880	0.869	0.856	-0.056	
AGR	-1.1%	-12.9%	9.6%	1.1%	-1.3%	-1.5%	-1.3%	
Annual Change		-0.118	0.076	0.010	-0.011	-0.013		
Primary Firms (K)	0.911	0.794	0.870	0.880	0.869	0.856	-0.055	
AGR	-1.1%	-12.8%	9.6%	1.1%	-1.3%	-1.5%	-1.2%	
Annual Change		-0.117	0.076	0.010	-0.011	-0.013		
Employees (K)	492	453	522	557	581	604	112.193	
AGR	0.6%	-8.0%	15.4%	6.6%	4.3%	4.0%	4.2%	
Annual Change		-39.364	69.514	34.454	24.204	23.385		
Establishments (K)	2.223	2.060	2.407	2.637	2.838	3.063	0.840	
AGR	3.4%	-7.3%	16.8%	9.6%	7.5%	8.0%	6.6%	
Annual Change		-0.163	0.347	0.230	0.199	0.227		
Annual Payroll ($M)	17	16	19	20	22	23	7	
AGR	2.9%	-5.8%	18.4%	9.4%	7.2%	6.9%	6.9%	
Annual Change		-1	3	2	1	2		
Employees per Primary Firm	540.3	570.3	600.4	632.7	668.6	706.0	165.8	
AGR	1.7%	5.6%	5.3%	5.4%	5.7%	5.6%	5.5%	
Annual Change		30.03	30.08	32.33	35.86	37.47		
Establishments per Primary Firm	2.44	2.59	2.77	3.00	3.26	3.58	1.14	
AGR	4.5%	6.3%	6.6%	8.3%	8.9%	9.6%	8.0%	
Annual Change		0.15	0.17	0.23	0.27	0.31		
Annual Payroll ($1,000) per Employee	33.9	34.7	35.6	36.5	37.5	38.5	4.7	
AGR	2.2%	2.3%	2.6%	2.6%	2.7%	2.6%	2.6%	
Annual Change		0.80	0.91	0.94	0.99	1.04		

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Sector: Public, Sub-Sector: Selected, Industry Arts, Entertainment, Recreation, Size Class: All, Primary Firms (K)

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Construction							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	7.061	6.673	7.017	7.094	7.081	7.044	-0.017	
AGR	-1.4%	-5.5%	5.2%	1.1%	-0.2%	-0.5%	0.0%	
Annual Change		-0.388	0.344	0.077	-0.013	-0.037		
Primary Firms (K)	7.053	6.667	7.011	7.088	7.075	7.038	-0.015	
AGR	-1.4%	-5.5%	5.2%	1.1%	-0.2%	-0.5%	0.0%	
Annual Change		-0.386	0.344	0.077	-0.013	-0.037		
Employees (K)	554	536	578	599	615	628	74.141	
AGR	-3.4%	-3.2%	7.8%	3.7%	2.5%	2.3%	2.5%	
Annual Change		-17.814	41.664	21.119	15.240	13.932		
Establishments (K)	9.293	8.765	9.248	9.409	9.278	9.251	-0.042	
AGR	-1.2%	-5.7%	5.5%	1.7%	-1.4%	-0.3%	-0.1%	
Annual Change		-0.528	0.483	0.161	-0.131	-0.027		
Annual Payroll ($M)	33	33	36	38	40	42	9	
AGR	-2.3%	-0.8%	10.4%	6.2%	5.0%	4.7%	5.0%	
Annual Change		0	3	2	2	2		
Employees per Primary Firm	78.6	80.5	82.5	84.5	86.9	89.3	10.7	
AGR	-1.9%	2.4%	2.5%	2.5%	2.7%	2.8%	2.6%	
Annual Change		1.88	1.99	2.08	2.31	2.44		
Establishments per Primary Firm	1.32	1.31	1.32	1.33	1.31	1.31	0.00	
AGR	0.3%	-0.2%	0.3%	0.6%	-1.2%	0.2%	0.0%	
Annual Change		0.00	0.00	0.01	-0.02	0.00		
Annual Payroll ($1,000) per Employee	59.3	60.7	62.2	63.7	65.3	66.9	7.6	
AGR	1.1%	2.5%	2.5%	2.4%	2.4%	2.4%	2.4%	
Annual Change		1.46	1.49	1.52	1.55	1.57		

Sector: Public, Sub-Sector: Selected, Industry Construction, Size Class: All, Primary Firms (K) — CAGR: -0.0%

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Education							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		60.751	59.322	62.491	63.848	64.478	64.928	4.177	
	AGR	0.2%	-2.4%	5.3%	2.2%	1.0%	0.7%	1.3%	
	Annual Change		-1.429	3.169	1.357	0.630	0.450		
Primary Firms (K)		60.698	59.272	62.439	63.796	64.426	64.877	4.179	
	AGR	0.2%	-2.3%	5.3%	2.2%	1.0%	0.7%	1.3%	
	Annual Change		-1.426	3.167	1.357	0.630	0.451		
Employees (K)		10.568	10.362	10.959	11.244	11.411	11.550	981.856	
	AGR	0.5%	-1.9%	5.8%	2.6%	1.5%	1.2%	1.8%	
	Annual Change		-205.737	596.570	284.492	167.297	139.234		
Establishments (K)		102.125	98.735	103.016	104.410	104.715	104.819	2.694	
	AGR	1.6%	-3.3%	4.3%	1.4%	0.3%	0.1%	0.5%	
	Annual Change		-3.390	4.281	1.394	0.305	0.104		
Annual Payroll ($M)		505	507	549	577	601	624	119	
	AGR	2.8%	0.4%	8.4%	5.2%	4.1%	3.8%	4.3%	
	Annual Change		2	42	28	23	23		
Employees per Primary Firm		174.1	174.8	175.5	176.2	177.1	178.0	3.9	
	AGR	0.3%	0.4%	0.4%	0.4%	0.5%	0.5%	0.4%	
	Annual Change		0.72	0.69	0.73	0.87	0.91		
Establishments per Primary Firm		1.68	1.67	1.65	1.64	1.63	1.62	-0.07	
	AGR	1.4%	-1.0%	-1.0%	-0.8%	-0.7%	-0.6%	-0.8%	
	Annual Change		-0.02	-0.02	-0.01	-0.01	-0.01		
Annual Payroll ($1,000) per Employee		47.7	48.9	50.1	51.3	52.7	54.0	6.3	
	AGR	2.3%	2.4%	2.5%	2.5%	2.5%	2.6%	2.5%	
	Annual Change		1.15	1.20	1.25	1.31	1.36		

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Sector: Public, Sub-Sector: Selected, Industry Education, Size Class: All, Primary Firms (K)

CAGR: 1.3%

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Finance, Insurance							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	0.059	0.056	0.056	0.056	0.056	0.055	-0.004	
AGR	0.0%	-5.1%	0.0%	0.0%	0.0%	-1.8%	-1.4%	
Annual Change		-0.003	0.000	0.000	0.000	-0.001		
Primary Firms (K)	0.059	0.056	0.056	0.056	0.056	0.055	-0.004	
AGR	0.0%	-5.1%	0.0%	0.0%	0.0%	-1.8%	-1.4%	
Annual Change		-0.003	0.000	0.000	0.000	-0.001		
Employees (K)	779	770	811	831	842	852	72.702	
AGR	1.8%	-1.2%	5.4%	2.4%	1.4%	1.1%	1.8%	
Annual Change		-9.653	41.354	19.745	11.603	9.653		
Establishments (K)	14.322	13.522	12.032	12.069	11.721	10.629	-3.693	
AGR	-5.1%	-5.6%	-11.0%	0.3%	-2.9%	-9.3%	-5.8%	
Annual Change		-0.800	-1.490	0.037	-0.348	-1.092		
Annual Payroll ($M)	62	62	65	67	69	70	8	
AGR	3.4%	-0.8%	5.9%	3.0%	2.0%	1.8%	2.4%	
Annual Change		0	4	2	1	1		
Employees per Primary Firm	13,206.4	13,741.5	14,479.9	14,832.5	15,039.7	15,488.7	2,282.3	
AGR	1.8%	4.1%	5.4%	2.4%	1.4%	3.0%	3.2%	
Annual Change		535.11	738.46	352.59	207.20	448.96		
Establishments per Primary Firm	242.75	241.46	214.86	215.52	209.30	193.25	-49.49	
AGR	-5.1%	-0.5%	-11.0%	0.3%	-2.9%	-7.7%	-4.5%	
Annual Change		-1.28	-26.61	0.66	-6.21	-16.05		
Annual Payroll ($1,000) per Employee	79.9	80.3	80.7	81.1	81.6	82.2	2.3	
AGR	1.6%	0.5%	0.5%	0.6%	0.6%	0.7%	0.6%	
Annual Change		0.39	0.41	0.45	0.49	0.54		

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Sector: Public, Sub-Sector: Selected, Industry Finance, Insurance, Size Class: All, Primary Firms (K)   CAGR: -1.4%

		Business Economic Demographic Database						
Sector	Public							
Sub-Sector	Total							
Industry	Health Care, Social Assistance							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		2.425	2.327	2.390	2.396	2.372	2.346	-0.079	
	AGR	-2.8%	-4.0%	2.7%	0.3%	-1.0%	-1.1%	-0.7%	
	Annual Change		-0.098	0.063	0.006	-0.024	-0.026		
Primary Firms (K)		2.423	2.326	2.389	2.395	2.371	2.345	-0.078	
	AGR	-2.8%	-4.0%	2.7%	0.3%	-1.0%	-1.1%	-0.7%	
	Annual Change		-0.097	0.063	0.006	-0.024	-0.026		
Employees (K)		2.676	2.630	2.766	2.841	2.885	2.923	247.055	
	AGR	0.5%	-1.7%	5.1%	2.7%	1.6%	1.3%	1.8%	
	Annual Change		-45.897	135.323	75.218	44.553	37.858		
Establishments (K)		2.877	2.676	2.702	2.684	2.650	2.606	-0.271	
	AGR	-2.0%	-7.0%	1.0%	-0.7%	-1.3%	-1.7%	-2.0%	
	Annual Change		-0.201	0.026	-0.018	-0.034	-0.044		
Annual Payroll ($M)		166	168	181	191	199	207	41	
	AGR	2.4%	0.8%	7.9%	5.4%	4.3%	4.1%	4.5%	
	Annual Change		1	13	10	8	8		
Employees per Primary Firm		1,104.5	1,130.8	1,157.6	1,186.1	1,216.9	1,246.5	142.1	
	AGR	3.5%	2.4%	2.4%	2.5%	2.6%	2.4%	2.5%	
	Annual Change		26.33	26.82	28.51	30.80	29.64		
Establishments per Primary Firm		1.19	1.15	1.13	1.12	1.12	1.11	-0.08	
	AGR	0.8%	-3.1%	-1.7%	-0.9%	-0.3%	-0.6%	-1.3%	
	Annual Change		-0.04	-0.02	-0.01	0.00	-0.01		
Annual Payroll ($1,000) per Employee		62.1	63.7	65.4	67.1	68.9	70.8	8.7	
	AGR	1.9%	2.6%	2.6%	2.7%	2.7%	2.7%	2.7%	
	Annual Change		1.60	1.67	1.73	1.81	1.88		

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Sector: Public, Sub-Sector: Selected, Industry Health Care, Social Assistance, Size Class: All, Primary Firms (K) — CAGR: -0.7%

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Information							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		5.140	4.989	5.267	5.410	5.514	5.616	0.476	
	AGR	4.7%	-2.9%	5.6%	2.7%	1.9%	1.8%	1.8%	
	Annual Change		-0.151	0.278	0.143	0.104	0.102		
Primary Firms (K)		5.135	4.985	5.263	5.406	5.510	5.612	0.477	
	AGR	4.7%	-2.9%	5.6%	2.7%	1.9%	1.9%	1.8%	
	Annual Change		-0.150	0.278	0.143	0.104	0.102		
Employees (K)		275	267	281	289	294	298	23.084	
	AGR	0.6%	-2.8%	5.3%	2.7%	1.7%	1.5%	1.6%	
	Annual Change		-7.734	14.116	7.521	4.854	4.327		
Establishments (K)		7.673	7.334	7.535	7.615	7.625	7.616	-0.057	
	AGR	-1.6%	-4.4%	2.7%	1.1%	0.1%	-0.1%	-0.1%	
	Annual Change		-0.339	0.201	0.080	0.010	-0.009		
Annual Payroll ($M)		13	13	14	14	15	16	3	
	AGR	1.7%	-0.7%	7.6%	5.1%	4.2%	4.1%	4.0%	
	Annual Change		0	1	1	1	1		
Employees per Primary Firm		53.5	53.6	53.4	53.4	53.3	53.1	-0.4	
	AGR	-3.9%	0.1%	-0.3%	0.0%	-0.2%	-0.4%	-0.2%	
	Annual Change		0.06	-0.15	-0.02	-0.13	-0.20		
Establishments per Primary Firm		1.49	1.47	1.43	1.41	1.38	1.36	-0.14	
	AGR	-6.0%	-1.5%	-2.7%	-1.6%	-1.8%	-1.9%	-1.9%	
	Annual Change		-0.02	-0.04	-0.02	-0.02	-0.03		
Annual Payroll ($1,000) per Employee		46.3	47.3	48.4	49.5	50.7	52.0	5.8	
	AGR	1.1%	2.2%	2.2%	2.4%	2.5%	2.6%	2.4%	
	Annual Change		1.02	1.05	1.16	1.22	1.30		

∫∆ Daniel Research Group ® (2020)

Sector: Public, Sub-Sector: Selected, Industry Information, Size Class: All, Primary Firms (K) — CAGR: 1.8%

						Business Economic Demographic Database				
Sector	Public									
Sub-Sector	Total									
Industry	National Defense									
Size Class	Total									
Metric		**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Change / CAGR**		**Trends**
Firms (K)		0.621	0.607	0.591	0.575	0.561	0.550	-0.071		
	AGR	-1.6%	-2.2%	-2.6%	-2.8%	-2.4%	-1.9%	-2.4%		
	Annual Change		-0.014	-0.016	-0.016	-0.014	-0.011			
Primary Firms (K)		0.001	0.001	0.001	0.001	0.001	0.001	0.000		
	AGR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
	Annual Change		0.000	0.000	0.000	0.000	0.000			
Employees (K)		2,854	2,748	2,722	2,755	2,769	2,819	-34,837		
	AGR	2.1%	-3.7%	-0.9%	1.2%	0.5%	1.8%	-0.2%		
	Annual Change		-105,801	-25,973	32,894	14,332	49,711			
Establishments (K)		3,843	3,480	3,390	3,352	3,372	3,406	-0.457		
	AGR	-3.9%	-9.5%	-2.6%	-1.1%	0.6%	1.0%	-2.4%		
	Annual Change		-0.363	-0.090	-0.039	0.021	0.034			
Annual Payroll ($M)		157	151	150	153	154	157	0		
	AGR	1.0%	-3.4%	-0.6%	1.5%	0.8%	2.1%	0.0%		
	Annual Change		-5	-1	2	1	3			
Employees per Primary Firm		2,854.000.0	2,748,199.0	2,722,226.0	2,755,120.0	2,769,452.0	2,819,163.0	-34,837.0		
	AGR	2.1%	-3.7%	-0.9%	1.2%	0.5%	1.8%	-0.2%		
	Annual Change		-105,801.00	-25,973.00	32,894.00	14,332.00	49,711.00			
Establishments per Primary Firm		3,843.00	3,479.77	3,390.18	3,351.61	3,372.34	3,406.22	-436.78		
	AGR	-3.9%	-9.5%	-2.6%	-1.1%	0.6%	1.0%	-2.4%		
	Annual Change		-363.23	-89.60	-38.57	20.73	33.88			
Annual Payroll ($1,000) per Employee		54.9	55.0	55.2	55.4	55.5	55.7	0.8		
	AGR	-1.1%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%		
	Annual Change		0.18	0.17	0.16	0.15	0.14			

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There is only one (1) primary firm for the DoD Sub-Sector, the DoD

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Professional, Scientific, Technical Services							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	3.800	3.693	3.871	3.951	3.983	4.011	0.211	
AGR	-0.5%	-2.8%	4.8%	2.1%	0.8%	0.7%	1.1%	
Annual Change		-0.107	0.178	0.080	0.032	0.028		
Primary Firms (K)	3.797	3.690	3.868	3.948	3.981	4.009	0.212	
AGR	-0.5%	-2.8%	4.8%	2.1%	0.8%	0.7%	1.1%	
Annual Change		-0.107	0.178	0.080	0.033	0.028		
Employees (K)	1,031	1,011	1,073	1,107	1,131	1,153	121.638	
AGR	-0.9%	-2.0%	6.1%	3.2%	2.2%	1.9%	2.3%	
Annual Change		-20.644	62.128	34.381	24.018	21.755		
Establishments (K)	19.085	18.858	20.509	21.229	21.456	22.815	3.730	
AGR	2.4%	-1.2%	8.8%	3.5%	1.1%	6.3%	3.6%	
Annual Change		-0.227	1.651	0.720	0.227	1.359		
Annual Payroll ($M)	84	86	95	103	110	117	33	
AGR	4.4%	2.1%	10.8%	7.8%	6.8%	6.6%	6.8%	
Annual Change		2	9	7	7	7		
Employees per Primary Firm	271.7	273.9	277.4	280.5	284.2	287.6	16.0	
AGR	-0.4%	0.8%	1.3%	1.1%	1.3%	1.2%	1.1%	
Annual Change		2.28	3.46	3.09	3.71	3.44		
Establishments per Primary Firm	5.03	5.11	5.30	5.38	5.39	5.69	0.66	
AGR	3.0%	1.7%	3.8%	1.4%	0.2%	5.6%	2.5%	
Annual Change		0.08	0.19	0.07	0.01	0.30		
Annual Payroll ($1,000) per Employee	81.7	85.1	88.9	92.8	97.0	101.5	19.8	
AGR	5.4%	4.2%	4.4%	4.4%	4.5%	4.6%	4.4%	
Annual Change		3.45	3.76	3.95	4.19	4.44		
∽∫Δ Daniel Research Group ® (2020)								

Sector: Public, Sub-Sector: Selected, Industry Professional, Scientific, Technical Services, Size Class: All, Primary Firms (K)   CAGR: 1.1%

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Retail							
Size Class	Total							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	0.108	0.102	0.108	0.110	0.110	0.111	0.003	
AGR	-0.9%	-5.6%	5.9%	1.9%	0.0%	0.9%	0.5%	
Annual Change		-0.006	0.006	0.002	0.000	0.001		
Primary Firms (K)	0.108	0.102	0.108	0.110	0.110	0.111	0.003	
AGR	-0.9%	-5.6%	5.9%	1.9%	0.0%	0.9%	0.5%	
Annual Change		-0.006	0.006	0.002	0.000	0.001		
Employees (K)	14	13	14	15	15	15	1.399	
AGR	0.7%	-2.6%	6.7%	2.9%	1.6%	1.3%	1.9%	
Annual Change		-0.357	0.905	0.420	0.233	0.198		
Establishments (K)	0.654	0.578	0.567	0.531	0.482	0.438	-0.216	
AGR	-5.2%	-11.6%	-1.9%	-6.3%	-9.2%	-9.1%	-7.7%	
Annual Change		-0.076	-0.011	-0.036	-0.049	-0.044		
Annual Payroll ($M)	0	0	0	0	1	1	0	
AGR	-5.4%	-1.1%	8.9%	5.5%	4.7%	5.0%	4.5%	
Annual Change		0	0	0	0	0		
Employees per Primary Firm	128.0	132.0	133.1	134.5	136.6	137.1	9.1	
AGR	1.6%	3.1%	0.8%	1.1%	1.6%	0.4%	1.4%	
Annual Change		4.03	1.05	1.40	2.12	0.55		
Establishments per Primary Firm	6.06	5.67	5.25	4.83	4.38	3.95	-2.11	
AGR	-4.3%	-6.4%	-7.4%	-8.1%	-9.2%	-9.9%	-8.2%	
Annual Change		-0.39	-0.42	-0.42	-0.45	-0.44		
Annual Payroll ($1,000) per Employee	30.7	31.2	31.8	32.6	33.6	34.9	4.1	
AGR	-6.0%	1.5%	2.0%	2.5%	3.1%	3.6%	2.5%	
Annual Change		0.46	0.62	0.80	1.00	1.22		

∫Δ Daniel Research Group ® (2020)

Sector: Public, Sub-Sector: Selected, Industry Retail, Size Class: All, Primary Firms (K) — CAGR: 0.5%

∫Δ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
				Business Economic Demographic Database					
Sector	Public								
Sub-Sector	Total								
Industry	Transportation, Warehousing								
Size Class	Total								
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		1.628	1.515	1.585	1.597	1.582	1.565	-0.063	
	AGR	-2.1%	-6.9%	4.6%	0.8%	-0.9%	-1.1%	-0.8%	
	Annual Change		-0.113	0.070	0.012	-0.015	-0.017		
Primary Firms (K)		1.627	1.514	1.584	1.596	1.581	1.564	-0.063	
	AGR	-2.1%	-6.9%	4.6%	0.8%	-0.9%	-1.1%	-0.8%	
	Annual Change		-0.113	0.070	0.012	-0.015	-0.017		
Employees (K)		477	457	490	509	521	533	56.187	
	AGR	1.6%	-4.3%	7.2%	3.9%	2.4%	2.3%	2.3%	
	Annual Change		-20.350	32.962	19.144	12.386	12.045		
Establishments (K)		6.676	6.169	6.745	6.976	7.074	7.243	0.567	
	AGR	-0.7%	-7.6%	9.3%	3.4%	1.4%	2.4%	1.6%	
	Annual Change		-0.507	0.576	0.231	0.098	0.169		
Annual Payroll ($M)		37	37	41	44	46	49	11	
	AGR	5.2%	-1.3%	10.5%	7.2%	5.7%	5.6%	5.5%	
	Annual Change		0	4	3	3	3		
Employees per Primary Firm		293.1	301.6	309.0	318.7	329.6	340.9	47.7	
	AGR	3.8%	2.9%	2.5%	3.1%	3.4%	3.4%	3.1%	
	Annual Change		8.44	7.48	9.67	10.86	11.28		
Establishments per Primary Firm		4.10	4.07	4.26	4.37	4.47	4.63	0.53	
	AGR	1.4%	-0.7%	4.5%	2.6%	2.4%	3.5%	2.4%	
	Annual Change		-0.03	0.18	0.11	0.10	0.16		
Annual Payroll ($1,000) per Employee		78.5	80.9	83.4	86.1	88.8	91.7	13.2	
	AGR	3.6%	3.1%	3.1%	3.1%	3.2%	3.3%	3.2%	
	Annual Change		2.44	2.50	2.63	2.76	2.89		

∫Δ Daniel Research Group ® (2020)

Sector: Public, Sub-Sector: Selected, Industry Transportation, Warehousing, Size Class: All, Primary Firms (K) — CAGR: -0.8%

∫Δ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

Business Economic Demographic Database								
Sector	Public							
Sub-Sector	Total							
Industry	Utilities							
Size Class	Total							
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		0.616	0.582	0.623	0.636	0.643	0.651	0.035	
	AGR	-0.3%	-5.5%	7.0%	2.1%	1.1%	1.2%	1.1%	
	Annual Change		-0.034	0.041	0.013	0.007	0.008		
Primary Firms (K)		0.616	0.582	0.623	0.636	0.643	0.651	0.035	
	AGR	-0.2%	-5.5%	7.0%	2.1%	1.1%	1.2%	1.1%	
	Annual Change		-0.034	0.041	0.013	0.007	0.008		
Employees (K)		304	290	312	322	329	334	30.852	
	AGR	0.7%	-4.5%	7.7%	3.1%	2.0%	1.8%	2.0%	
	Annual Change		-13.638	22.424	9.667	6.581	5.818		
Establishments (K)		7.333	6.687	8.220	7.809	8.298	8.793	1.460	
	AGR	2.4%	-8.8%	22.9%	-5.0%	6.3%	6.0%	3.7%	
	Annual Change		-0.646	1.533	-0.411	0.489	0.495		
Annual Payroll ($M)		22	22	24	25	27	28	6	
	AGR	3.8%	-2.0%	10.5%	5.7%	4.7%	4.4%	4.6%	
	Annual Change		0	2	1	1	1		
Employees per Primary Firm		492.8	498.1	501.3	506.3	511.0	513.7	20.9	
	AGR	0.8%	1.1%	0.6%	1.0%	0.9%	0.5%	0.8%	
	Annual Change		5.36	3.21	4.95	4.72	2.66		
Establishments per Primary Firm		11.90	11.49	13.19	12.28	12.91	13.51	1.60	
	AGR	2.6%	-3.5%	14.8%	-6.9%	5.1%	4.7%	2.6%	
	Annual Change		-0.41	1.70	-0.92	0.63	0.60		
Annual Payroll ($1,000) per Employee		72.9	74.8	76.7	78.7	80.7	82.7	9.8	
	AGR	3.1%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	
	Annual Change		1.88	1.92	1.97	2.01	2.06		
←∫∆ Daniel Research Group ® (2020)								

Business Economic Demographic Database									
Sector	Public								
Sub-Sector	Total								
Industry	Public Administration								
Size Class	Total								
Metric		2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)		6.225	6.097	6.381	6.509	6.560	6.594	0.369	
	AGR	-0.3%	-2.1%	4.7%	2.0%	0.8%	0.5%	1.2%	
	Annual Change		-0.128	0.284	0.128	0.051	0.034		
Primary Firms (K)		6.220	6.091	6.373	6.501	6.552	6.585	0.365	
	AGR	-0.4%	-2.1%	4.6%	2.0%	0.8%	0.5%	1.1%	
	Annual Change		-0.129	0.282	0.128	0.051	0.033		
Employees (K)		4.122	4.022	4.250	4.352	4.408	4.453	331.084	
	AGR	0.5%	-2.4%	5.7%	2.4%	1.3%	1.0%	1.6%	
	Annual Change		-99.896	228.051	101.818	56.172	44.939		
Establishments (K)		60.810	59.443	61.910	63.488	64.615	65.501	4.691	
	AGR	-0.4%	-2.2%	4.2%	2.5%	1.8%	1.4%	1.5%	
	Annual Change		-1.367	2.467	1.578	1.127	0.886		
Annual Payroll ($M)		260	260	282	297	309	321	61	
	AGR	3.9%	-0.1%	8.5%	5.2%	4.1%	3.8%	4.3%	
	Annual Change		0	22	15	12	12		
Employees per Primary Firm		662.7	660.3	666.9	669.4	672.8	676.2	13.5	
	AGR	0.9%	-0.4%	1.0%	0.4%	0.5%	0.5%	0.4%	
	Annual Change		-2.37	6.56	2.53	3.36	3.45		
Establishments per Primary Firm		9.78	9.76	9.71	9.77	9.86	9.95	0.17	
	AGR	0.0%	-0.2%	-0.5%	0.5%	1.0%	0.9%	0.3%	
	Annual Change		-0.02	-0.04	0.05	0.10	0.09		
Annual Payroll ($1,000) per Employee		63.1	64.6	66.4	68.2	70.1	72.0	9.0	
	AGR	3.3%	2.4%	2.7%	2.8%	2.8%	2.8%	2.7%	
	Annual Change		1.53	1.78	1.83	1.89	1.96		
∫∆ Daniel Research Group ® (2020)									

Sector: Public, Sub-Sector: Selected, Industry Public Administration, Size Class: All, Primary Firms (K) — CAGR: 1.1%
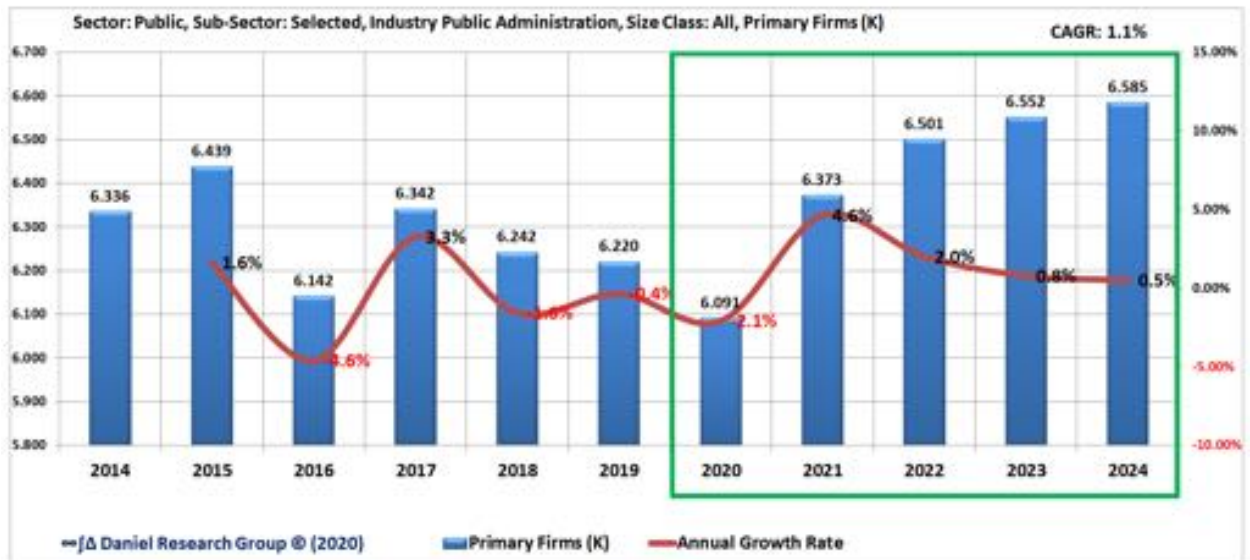
By Size Class, Private, Businesses

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	Less than 5							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	3,954.834	3,682.811	3,894.873	3,966.029	3,979.663	3,980.031	25.197	
AGR	0.3%	-6.9%	5.8%	1.8%	0.3%	0.0%	0.1%	
Annual Change		-272.023	212.062	71.156	13.634	0.368		
Primary Firms (K)	3,930.211	3,659.972	3,870.879	3,941.739	3,955.434	3,955.935	25.724	
AGR	0.3%	-6.9%	5.8%	1.8%	0.3%	0.0%	0.1%	
Annual Change		-270.239	210.907	70.860	13.695	0.501		
Employees (K)	6,260	5,785	6,080	6,153	6,138	6,106	-153.663	
AGR	-0.3%	-7.6%	5.1%	1.2%	-0.2%	-0.5%	-0.5%	
Annual Change		-474.488	294.892	72.905	-14.650	-32.322		
Establishments (K)	3,978.074	3,704.953	3,919.065	3,991.444	4,006.110	4,007.474	29.400	
AGR	0.3%	-6.9%	5.8%	1.8%	0.4%	0.0%	0.1%	
Annual Change		-273.121	214.112	72.379	14.666	1.364		
Annual Payroll ($M)	317	302	327	341	351	360	44	
AGR	2.6%	-4.4%	8.2%	4.3%	2.9%	2.6%	2.6%	
Annual Change		-14	25	14	10	9		
Employees per Primary Firm	1.6	1.6	1.6	1.6	1.6	1.5	0.0	
AGR	-0.6%	-0.8%	-0.6%	-0.6%	-0.6%	-0.5%	-0.6%	
Annual Change		-0.01	-0.01	-0.01	-0.01	-0.01		
Establishments per Primary Firm	1.01	1.01	1.01	1.01	1.01	1.01	0.00	
AGR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Annual Change		0.00	0.00	0.00	0.00	0.00		
Annual Payroll ($1,000) per Employee	50.6	52.3	53.8	55.5	57.2	59.0	8.4	
AGR	3.0%	3.4%	2.9%	3.1%	3.1%	3.1%	3.1%	
Annual Change		1.71	1.52	1.66	1.74	1.79		

⌠∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class Less than 5, Primary Firms (K) — CAGR: 0.1%

⌠∫∆ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	5 to 9							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	1,051.781	958.580	1,005.098	1,011.507	1,001.723	989.006	-62.775	
AGR	-0.8%	-8.9%	4.9%	0.6%	-1.0%	-1.3%	-1.2%	
Annual Change		-93.201	46.518	6.409	-9.784	-12.717		
Primary Firms (K)	1,048.000	955.057	1,001.344	1,007.654	997.824	985.071	-62.929	
AGR	-0.8%	-8.9%	4.8%	0.6%	-1.0%	-1.3%	-1.2%	
Annual Change		-92.943	46.287	6.310	-9.830	-12.753		
Employees (K)	6,971	6,363	6,688	6,749	6,704	6,640	-331.449	
AGR	-0.5%	-8.7%	5.1%	0.9%	-0.7%	-1.0%	-1.0%	
Annual Change		-607.866	325.151	61.179	-45.049	-64.864		
Establishments (K)	1,067.730	973.647	1,021.347	1,028.369	1,018.986	1,006.613	-61.117	
AGR	-0.7%	-8.8%	4.9%	0.7%	-0.9%	-1.2%	-1.2%	
Annual Change		-94.083	47.700	7.022	-9.383	-12.373		
Annual Payroll ($M)	287	273	293	303	310	315	28	
AGR	1.8%	-5.0%	7.4%	3.5%	2.1%	1.8%	1.9%	
Annual Change		-14	20	10	6	6		
Employees per Primary Firm	6.7	6.7	6.7	6.7	6.7	6.7	0.1	
AGR	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	
Annual Change		0.01	0.02	0.02	0.02	0.02		
Establishments per Primary Firm	1.02	1.02	1.02	1.02	1.02	1.02	0.00	
AGR	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	
Annual Change		0.00	0.00	0.00	0.00	0.00		
Annual Payroll ($1,000) per Employee	41.2	42.9	43.8	45.0	46.2	47.5	6.3	
AGR	2.3%	4.0%	2.1%	2.6%	2.8%	2.8%	2.9%	
Annual Change		1.67	0.92	1.14	1.26	1.29		

∽∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 5 to 9, Primary Firms (K) — CAGR: -1.2%

∽∫Δ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	10 to 19							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	668.022	608.147	647.758	660.617	662.351	662.349	-5.673	
AGR	0.6%	-9.0%	6.5%	2.0%	0.3%	0.0%	-0.2%	
Annual Change		-59.875	39.611	12.859	1.734	-0.002		
Primary Firms (K)	663.425	603.846	643.095	655.748	657.343	657.214	-6.211	
AGR	0.6%	-9.0%	6.5%	2.0%	0.2%	0.0%	-0.2%	
Annual Change		-59.579	39.249	12.653	1.595	-0.129		
Employees (K)	8.999	8.200	8.755	8.952	8.999	9.025	25.167	
AGR	0.9%	-8.9%	6.8%	2.2%	0.5%	0.3%	0.1%	
Annual Change		-799.907	555.248	196.772	47.623	25.431		
Establishments (K)	703.302	641.636	683.762	698.403	701.433	702.671	-0.631	
AGR	0.6%	-8.8%	6.6%	2.1%	0.4%	0.2%	0.0%	
Annual Change		-61.666	42.126	14.641	3.030	1.238		
Annual Payroll ($M)	381	362	391	407	418	428	47	
AGR	2.4%	-5.1%	8.1%	4.1%	2.6%	2.3%	2.3%	
Annual Change		-20	29	16	11	10		
Employees per Primary Firm	13.6	13.6	13.6	13.7	13.7	13.7	0.2	
AGR	0.3%	0.1%	0.3%	0.3%	0.3%	0.3%	0.2%	
Annual Change		0.01	0.03	0.04	0.04	0.04		
Establishments per Primary Firm	1.06	1.06	1.06	1.07	1.07	1.07	0.01	
AGR	0.1%	0.2%	0.1%	0.2%	0.2%	0.2%	0.2%	
Annual Change		0.00	0.00	0.00	0.00	0.00		
Annual Payroll ($1,000) per Employee	42.4	44.1	44.7	45.5	46.5	47.4	5.0	
AGR	1.5%	4.1%	1.3%	1.8%	2.1%	2.1%	2.3%	
Annual Change		1.75	0.56	0.82	0.96	0.96		

⊶∫∆ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 10 to 19, Primary Firms (K)   CAGR: -0.2%

⊶∫∆ Daniel Research Group ® (2020)   ■ Primary Firms (K)   ━ Annual Growth Rate

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	20 to 99							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	586.338	530.474	565.924	577.002	577.563	576.377	-9.961	
AGR	0.9%	-9.5%	6.7%	2.0%	0.1%	-0.2%	-0.3%	
Annual Change		-55.864	35.450	11.078	0.561	-1.186		
Primary Firms (K)	569.089	514.675	549.128	559.722	560.082	558.738	-10.351	
AGR	0.9%	-9.6%	6.7%	1.9%	0.1%	-0.2%	-0.4%	
Annual Change		-54.414	34.453	10.594	0.360	-1.344		
Employees (K)	22.427	20.340	21.743	22.221	22.304	22.323	-103.953	
AGR	1.1%	-9.3%	6.9%	2.2%	0.4%	0.1%	-0.1%	
Annual Change		-2086.882	1402.409	478.206	82.952	19.362		
Establishments (K)	776.675	711.288	761.546	783.148	791.499	797.771	21.096	
AGR	1.3%	-8.4%	7.1%	2.8%	1.1%	0.8%	0.5%	
Annual Change		-65.387	50.258	21.602	8.351	6.272		
Annual Payroll ($M)	1,038	985	1,068	1,114	1,146	1,174	136	
AGR	2.8%	-5.1%	8.4%	4.3%	2.8%	2.5%	2.5%	
Annual Change		-53	83	46	31	29		
Employees per Primary Firm	39.4	39.5	39.6	39.7	39.8	40.0	0.5	
AGR	0.3%	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	
Annual Change		0.11	0.07	0.10	0.12	0.13		
Establishments per Primary Firm	1.36	1.38	1.39	1.40	1.41	1.43	0.06	
AGR	0.5%	1.3%	0.3%	0.9%	1.0%	1.0%	0.9%	
Annual Change		0.02	0.00	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	46.3	48.4	49.1	50.1	51.4	52.6	6.3	
AGR	1.6%	4.7%	1.4%	2.1%	2.4%	2.4%	2.6%	
Annual Change		2.16	0.69	1.02	1.22	1.23		

∾∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 20 to 99, Primary Firms (K)   CAGR: -0.4%

∾∫Δ Daniel Research Group ® (2020)   ■Primary Firms (K)   ▬Annual Growth Rate

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	100 to 499							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	115.502	108.010	115.063	118.125	119.556	120.693	5.191	
AGR	1.1%	-6.5%	6.5%	2.7%	1.2%	1.0%	0.9%	
Annual Change		-7.492	7.053	3.062	1.431	1.137		
Primary Firms (K)	94.997	88.816	94.873	97.505	98.777	99.818	4.821	
AGR	1.3%	-6.5%	6.8%	2.8%	1.3%	1.1%	1.0%	
Annual Change		-6.181	6.057	2.632	1.272	1.041		
Employees (K)	18.729	17.544	18.805	19.407	19.745	20.043	1,314.020	
AGR	1.7%	-6.3%	7.2%	3.2%	1.7%	1.5%	1.4%	
Annual Change		-1184.972	1260.332	601.988	338.200	298.472		
Establishments (K)	393.473	368.225	392.630	404.779	411.363	416.961	23.488	
AGR	1.3%	-6.4%	6.6%	3.1%	1.6%	1.4%	1.2%	
Annual Change		-25.248	24.405	12.149	6.584	5.598		
Annual Payroll ($M)	1,018	993	1,090	1,155	1,210	1,264	246	
AGR	4.2%	-2.4%	9.8%	6.0%	4.7%	4.5%	4.4%	
Annual Change		-25	97	66	55	54		
Employees per Primary Firm	197.2	197.5	198.2	199.0	199.9	200.8	3.6	
AGR	0.4%	0.2%	0.3%	0.4%	0.4%	0.5%	0.4%	
Annual Change		0.38	0.67	0.82	0.86	0.91		
Establishments per Primary Firm	4.14	4.15	4.14	4.15	4.16	4.18	0.04	
AGR	0.0%	0.1%	-0.2%	0.3%	0.3%	0.3%	0.2%	
Annual Change		0.00	-0.01	0.01	0.01	0.01		
Annual Payroll ($1,000) per Employee	54.3	56.6	57.9	59.5	61.3	63.1	8.7	
AGR	2.5%	4.2%	2.4%	2.7%	2.9%	2.9%	3.0%	
Annual Change		2.26	1.36	1.59	1.75	1.78		

⤳∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 100 to 499, Primary Firms (K) — CAGR: 1.0%

Business Economic Demographic Database

Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	500 to 999							

Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	16.798	15.810	16.719	17.127	17.320	17.497	0.699	
AGR	1.4%	-5.9%	5.7%	2.4%	1.1%	1.0%	0.8%	
Annual Change		-0.988	0.909	0.408	0.193	0.177		
Primary Firms (K)	10.065	9.420	10.026	10.291	10.393	10.499	0.434	
AGR	1.2%	-6.4%	6.4%	2.6%	1.0%	1.0%	0.8%	
Annual Change		-0.645	0.606	0.265	0.102	0.106		
Employees (K)	7.077	6.639	7.106	7.326	7.443	7.541	464.611	
AGR	2.4%	-6.2%	7.0%	3.1%	1.6%	1.3%	1.3%	
Annual Change		-437.467	466.625	220.198	117.012	98.243		
Establishments (K)	142.818	133.357	142.339	146.519	147.904	149.508	6.690	
AGR	2.0%	-6.6%	6.7%	2.9%	0.9%	1.1%	0.9%	
Annual Change		-9.461	8.982	4.180	1.385	1.604		
Annual Payroll ($M)	400	390	426	450	470	489	89	
AGR	4.5%	-2.5%	9.3%	5.7%	4.4%	4.1%	4.1%	
Annual Change		-10	36	24	20	19		
Employees per Primary Firm	703.1	704.8	708.7	711.9	716.2	718.3	15.2	
AGR	1.2%	0.2%	0.6%	0.4%	0.6%	0.3%	0.4%	
Annual Change		1.70	3.94	3.15	4.27	2.13		
Establishments per Primary Firm	14.19	14.16	14.20	14.24	14.23	14.24	0.05	
AGR	0.8%	-0.2%	0.3%	0.3%	0.0%	0.1%	0.1%	
Annual Change		-0.03	0.04	0.04	-0.01	0.01		
Annual Payroll ($1,000) per Employee	56.5	58.7	59.9	61.5	63.1	64.9	8.4	
AGR	2.1%	3.9%	2.2%	2.5%	2.7%	2.7%	2.8%	
Annual Change		2.22	1.26	1.51	1.68	1.72		

⌠∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 500 to 999, Primary Firms (K) — CAGR: 0.8%

⌠∫Δ Daniel Research Group ® (2020)   ■ Primary Firms (K)   — Annual Growth Rate

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	1000 to 2499							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	11.576	10.878	11.586	12.103	12.593	13.085	1.509	
AGR	0.5%	-6.0%	6.5%	4.5%	4.0%	3.9%	2.5%	
Annual Change		-0.698	0.708	0.517	0.490	0.492		
Primary Firms (K)	6.059	5.765	6.251	6.544	6.793	7.030	0.971	
AGR	5.3%	-4.9%	8.4%	4.7%	3.8%	3.5%	3.0%	
Annual Change		-0.294	0.486	0.293	0.249	0.237		
Employees (K)	8.962	8.397	8.943	9.184	9.297	9.386	423.251	
AGR	1.4%	-6.3%	6.5%	2.7%	1.2%	1.0%	0.9%	
Annual Change		-565.873	546.936	240.448	112.832	88.908		
Establishments (K)	169.686	159.852	169.959	174.700	178.102	180.897	11.211	
AGR	1.8%	-5.8%	6.3%	2.8%	1.9%	1.6%	1.3%	
Annual Change		-9.834	10.107	4.741	3.402	2.795		
Annual Payroll ($M)	546	533	581	613	639	665	119	
AGR	3.6%	-2.4%	9.0%	5.5%	4.3%	4.0%	4.0%	
Annual Change		-13	48	32	26	26		
Employees per Primary Firm	1,479.2	1,456.5	1,430.7	1,403.4	1,368.6	1,335.1	-144.1	
AGR	-3.8%	-1.5%	-1.8%	-1.9%	-2.5%	-2.4%	-2.0%	
Annual Change		-22.72	-25.74	-27.32	-34.83	-33.49		
Establishments per Primary Firm	28.01	27.73	27.19	26.70	26.22	25.73	-2.27	
AGR	-3.4%	-1.0%	-1.9%	-1.8%	-1.8%	-1.9%	-1.7%	
Annual Change		-0.28	-0.54	-0.49	-0.48	-0.49		
Annual Payroll ($1,000) per Employee	60.9	63.5	64.9	66.7	68.7	70.8	9.9	
AGR	2.2%	4.2%	2.3%	2.8%	3.0%	3.0%	3.1%	
Annual Change		2.56	1.46	1.79	2.01	2.09		

∾∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 1000 to 2499, Primary Firms (K)   CAGR: 3.0%

∾∫Δ Daniel Research Group ® (2020)   ■ Primary Firms (K)   — Annual Growth Rate

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	2500 to 4999							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	5.017	4.641	4.797	4.813	4.747	4.668	-0.349	
AGR	-1.1%	-7.5%	3.4%	0.3%	-1.4%	-1.7%	-1.4%	
Annual Change		-0.376	0.156	0.016	-0.066	-0.079		
Primary Firms (K)	1.940	1.809	1.913	1.952	1.959	1.962	0.022	
AGR	0.5%	-6.8%	5.7%	2.0%	0.4%	0.2%	0.2%	
Annual Change		-0.131	0.104	0.039	0.007	0.003		
Employees (K)	6.812	6.345	6.695	6.819	6.846	6.854	42.577	
AGR	0.5%	-6.9%	5.5%	1.8%	0.4%	0.1%	0.1%	
Annual Change		-467.057	350.574	123.847	26.842	8.371		
Establishments (K)	142.942	135.198	145.007	150.624	154.464	158.427	15.485	
AGR	1.6%	-5.4%	7.3%	3.9%	2.5%	2.6%	2.1%	
Annual Change		-7.744	9.809	5.617	3.840	3.963		
Annual Payroll ($M)	439	426	459	479	494	508	69	
AGR	2.8%	-3.0%	7.6%	4.4%	3.1%	2.9%	2.9%	
Annual Change		-13	33	20	15	14		
Employees per Primary Firm	3,511.1	3,507.2	3,499.8	3,493.3	3,494.5	3,493.5	-17.7	
AGR	0.0%	-0.1%	-0.2%	-0.2%	0.0%	0.0%	-0.1%	
Annual Change		-3.92	-7.41	-6.49	1.22	-1.08		
Establishments per Primary Firm	73.68	74.74	75.80	77.16	78.85	80.75	7.07	
AGR	1.1%	1.4%	1.4%	1.8%	2.2%	2.4%	1.8%	
Annual Change		1.05	1.06	1.36	1.68	1.90		
Annual Payroll ($1,000) per Employee	64.5	67.2	68.5	70.2	72.2	74.1	9.6	
AGR	2.3%	4.1%	2.0%	2.5%	2.7%	2.7%	2.8%	
Annual Change		2.65	1.35	1.71	1.92	1.97		
∫∆ Daniel Research Group ® (2020)								

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 2500 to 4999, Primary Firms (K) — CAGR: 0.2%

∫∆ Daniel Research Group ® (2020) — Primary Firms (K) — Annual Growth Rate

Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	5000 to 9999							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	3.425	3.232	3.400	3.447	3.470	3.480	0.055	
AGR	0.7%	-5.6%	5.2%	1.4%	0.7%	0.3%	0.3%	
Annual Change		-0.193	0.168	0.047	0.023	0.010		
Primary Firms (K)	1.019	0.962	1.028	1.055	1.074	1.090	0.071	
AGR	1.8%	-5.6%	6.9%	2.6%	1.8%	1.5%	1.4%	
Annual Change		-0.057	0.066	0.027	0.019	0.016		
Employees (K)	7,034	6,627	7,081	7,303	7,434	7,553	519.718	
AGR	1.4%	-5.8%	6.9%	3.1%	1.8%	1.6%	1.4%	
Annual Change		-406.883	454.418	222.218	130.410	119.555		
Establishments (K)	138.940	131.020	141.421	145.225	148.795	153.282	14.342	
AGR	2.5%	-5.7%	7.9%	2.7%	2.5%	3.0%	2.0%	
Annual Change		-7.920	10.401	3.804	3.570	4.487		
Annual Payroll ($M)	475	467	510	541	567	594	119	
AGR	3.9%	-1.8%	9.3%	6.0%	4.9%	4.8%	4.6%	
Annual Change		-8	43	31	26	27		
Employees per Primary Firm	6,902.4	6,888.4	6,888.2	6,922.6	6,921.5	6,929.6	27.2	
AGR	-0.4%	-0.2%	0.0%	0.5%	0.0%	0.1%	0.1%	
Annual Change		-13.98	-0.21	34.35	-1.04	8.08		
Establishments per Primary Firm	136.35	136.20	137.57	137.65	138.54	140.63	4.28	
AGR	0.7%	-0.1%	1.0%	0.1%	0.6%	1.5%	0.6%	
Annual Change		-0.15	1.37	0.08	0.89	2.08		
Annual Payroll ($1,000) per Employee	67.5	70.4	72.0	74.1	76.3	78.7	11.1	
AGR	2.4%	4.3%	2.3%	2.8%	3.1%	3.1%	3.1%	
Annual Change		2.88	1.62	2.02	2.26	2.37		

Business Economic Demographic Database

∽∫∆ Daniel Research Group ® (2020)

Business Economic Demographic Database								
Sector	Private							
Sub-Sector	Businesses							
Industry	Total							
Size Class	10000 or more							
Metric	2019	2020	2021	2022	2023	2024	Change / CAGR	Trends
Firms (K)	5.068	4.889	5.221	5.424	5.572	5.748	0.680	
AGR	2.2%	-3.5%	6.8%	3.9%	2.7%	3.2%	2.6%	
Annual Change		-0.179	0.332	0.203	0.148	0.176		
Primary Firms (K)	1.098	1.060	1.149	1.205	1.249	1.295	0.197	
AGR	3.3%	-3.5%	8.4%	4.9%	3.7%	3.7%	3.4%	
Annual Change		-0.038	0.089	0.056	0.044	0.046		
Employees (K)	37,500	35,869	38,723	40,392	41,548	42,643	5,142.500	
AGR	2.4%	-4.4%	8.0%	4.3%	2.9%	2.6%	2.6%	
Annual Change		-1631.443	2854.126	1668.566	1156.156	1095.095		
Establishments (K)	787.414	756.670	819.946	856.542	881.506	911.908	124.494	
AGR	2.3%	-3.9%	8.4%	4.5%	2.9%	3.4%	3.0%	
Annual Change		-30.744	63.276	36.596	24.964	30.402		
Annual Payroll ($M)	2,341	2,329	2,566	2,745	2,903	3,062	720	
AGR	5.0%	-0.5%	10.2%	7.0%	5.7%	5.5%	5.5%	
Annual Change		-12	237	180	157	159		
Employees per Primary Firm	34,153.3	33,838.6	33,701.5	33,520.0	33,264.8	32,928.8	-1,224.5	
AGR	-0.8%	-0.9%	-0.4%	-0.5%	-0.8%	-1.0%	-0.7%	
Annual Change		-314.73	-137.08	-181.51	-255.18	-335.97		
Establishments per Primary Firm	717.13	713.84	713.62	710.82	705.77	704.18	-12.90	
AGR	-0.9%	-0.5%	0.0%	-0.4%	-0.7%	-0.2%	-0.4%	
Annual Change		-3.30	-0.22	-2.79	-5.05	-1.59		
Annual Payroll ($1,000) per Employee	62.4	64.9	66.3	68.0	69.9	71.8	9.4	
AGR	2.5%	4.0%	2.0%	2.6%	2.8%	2.8%	2.8%	
Annual Change		2.50	1.33	1.71	1.89	1.94		

⟿∫Δ Daniel Research Group ® (2020)

Sector: Private, Sub-Sector: Businesses, Industry: All, Size Class 10000 or more, Primary Firms (K) — CAGR: 3.4%

⟿∫Δ Daniel Research Group ® (2020) ■ Primary Firms (K) — Annual Growth Rate

DRG US Business Economic Demographic Database (BEDD)
November 2020 Update

Context

At some point in the forecasting process for products and services marketed to business and employees, the size and growth of the Total Available Market (TAM) must be estimated. For most enterprise technology products and services, the user and/or buying decision maker is an employee, the business or a sub-unit within the business. Daniel Research Group (**DRG**) maintains and continually updates a **Business Economic Demographic Database (BEDD)** that contains the history from 1998 and a forecast to 2026 of Employees, Businesses, Establishments, and Payroll by Sector (Public and Private), Industry and Business size by number of employees.

BEDD is a TAM database. It counts and forecasts buyer and/or users in the Enterprise Private and Public Sectors, TAM units can be Employees, Business or Government entities, or sites/locations. The TAM for a product or services in the Public (Government) and Private Enterprise Sectors are defined by the product or service produced and offered by the buyers and users of those products and services, i.e. industries and government entities, as well as the size of those business and agencies. Businesses and employees working in the Manufacturing industry will have different needs that those in the Construction Sector.

Sources

The tables and charts in this report were created from the current database for the United States. The overall economic trends reflect the most current forecast published by **the Congressional Budget (CBO).** The industry trends reflect the most current industry level forecasts published by the **Bureau of Labor Statistics (BLS),** as well as **DRGs** own analysis. The Private Sector trends are derived by **DRG** analysis of the most current data from the **US Census Bureau,** as well as the **BLS.**

Public Sector historical data comes from the **Office of Personnel Management FedScope** Database, **State and Local Government** by Function data from the **US Census Bureau**, the **Department of Defense** Base Structure Reports and Green Book Budget Reports, as well as the US Budget report from the **White House**

DRGs integrates these various data sources into a cohesive historical database and applies various trend analysis and forecasting methodologies, including its own qualitative assessments of the factors and trends influencing the economy and the structure of the economy to produce the **BEDD.**   The **BEDD** is updated periodically when significant new data becomes available from the various sources.

BEDD Structure

Taxonomies

Sectors and Sub-Sectors

Sector	Sub-Sector
Private	Businesses
	Government Owned
Public	DoD Military
	Federal - Civilian
	Federal - DoD Civilian

Industries

NAICS	Industry
11	Forestry, Fishing, Hunting, Agriculture
21	Mining
22	Utilities
23	Construction
31	Manufacturing
42	Wholesale
44	Retail
48	Transportation, Warehousing
51	Information
52	Finance, Insurance
53	Real Estate, Rental, Leasing
54	Professional, Scientific, Technical Services
55	Management of Companies, Enterprises
56	Administrative Support, Waste Management, Remediation Services
61	Education
62	Health Care, Social Assistance
71	Arts, Entertainment, Recreation
72	Accommodation, Food Services
81	Other Services
92	National Defense
	Public Administration

Size Class

Size Code	Size Class
101	Less than 5
102	5 to 9
103	10 to 19
104	20 to 99
105	100 to 499
106	500 to 999
107	1000 to 2499
108	2500 to 4999
109	5000 to 9999
110	10000 or more

Metrics

Employees
Firms
Primary Firms
Establishments
Annual Payroll

C19UER Database Structure
Taxonomies
Time

Month
Quarter
Annual

Industries

NAICS	Industry
11	Forestry, Fishing, Hunting, Agriculture
21	Mining
22	Utilities
23	Construction
31	Manufacturing
42	Wholesale
44	Retail
48	Transportation, Warehousing
51	Information
52	Finance, Insurance
53	Real Estate, Rental, Leasing
54	Professional, Scientific, Technical Services
55	Management of Companies, Enterprises
56	Administrative Support, Waste Management, Remediation Services
61	Education
62	Health Care, Social Assistance
71	Arts, Entertainment, Recreation
72	Accommodation, Food Services
81	Other Services
99	Public Administration

Occupations

11-0000	Management occupations
11-1000	Top executives
11-2000	Advertising, marketing, promotions, public relations, and sales managers
11-3000	Operations specialties managers
11-9000	Other management occupations
13-0000	Business and financial operations occupations
13-1000	Business operations specialists
13-2000	Financial specialists
15-1100	Computer occupations
15-2000	Mathematical science occupations
17-1000	Architects, surveyors, and cartographers
17-2000	Engineers
17-3000	Drafters, engineering technicians, and mapping technicians
19-0000	Life, physical, and social science occupations
19-1000	Life scientists
19-1030	Conservation scientists and foresters
19-2000	Physical scientists
19-3000	Social scientists and related workers
19-4000	Life, physical, and social science technicians
21-1000	Counselors, social workers, and other community and social service specialists
21-2000	Religious workers
23-1000	Lawyers, judges, and related workers
23-2000	Legal support workers
25-1000	Postsecondary teachers
25-2000	Preschool, primary, secondary, and special education school teachers
25-3000	Other teachers and instructors
25-4000	Librarians, curators, and archivists
25-9000	Other education, training, and library occupations
27-1000	Art and design workers
27-2000	Entertainers and performers, sports and related workers
27-3000	Media and communication workers
27-4000	Media and communication equipment workers
29-1000	Health diagnosing and treating practitioners
29-2000	Health technologists and technicians

29-9000	Other healthcare practitioners and technical occupations
31-1000	Nursing, psychiatric, and home health aides
31-2000	Occupational therapy and physical therapist assistants and aides
31-9000	Other healthcare support occupations
33-0000	Protective service occupations
33-1000	Supervisors of protective service workers
33-2000	Firefighting and prevention workers
33-3000	Law enforcement workers
33-9000	Other protective service workers
33-9030	Security guards and gaming surveillance officers
35-1000	Supervisors of food preparation and serving workers
35-2000	Cooks and food preparation workers
35-3000	Food and beverage serving workers
35-9000	Other food preparation and serving related workers
37-0000	Building and grounds cleaning and maintenance occupations
37-1000	Supervisors of building and grounds cleaning and maintenance workers
37-2000	Building cleaning and pest control workers
37-2010	Building cleaning workers
37-3000	Grounds maintenance workers
39-1000	Supervisors of personal care and service workers
39-2000	Animal care and service workers
39-3000	Entertainment attendants and related workers
39-4000	Funeral service workers
39-5000	Personal appearance workers
39-6000	Baggage porters, bellhops, and concierges
39-7010	Tour and travel guides
39-9000	Other personal care and service workers
41-0000	Sales and related occupations
41-1000	Supervisors of sales workers
41-2000	Retail sales workers
41-3000	Sales representatives, services
41-4000	Sales representatives, wholesale and manufacturing
41-9000	Other sales and related workers
43-0000	Office and administrative support occupations
43-1000	Supervisors of office and administrative support workers

43-2000	Communications equipment operators
43-3000	Financial clerks
43-4000	Information and record clerks
43-5000	Material recording, scheduling, dispatching, and distributing workers
43-6000	Secretaries and administrative assistants
43-9000	Other office and administrative support workers
45-1000	Supervisors of farming, fishing, and forestry workers
45-2000	Agricultural workers
45-4000	Forest, conservation, and logging workers
47-0000	Construction and extraction occupations
47-1000	Supervisors of construction and extraction workers
47-2000	Construction trades workers
47-2070	Construction equipment operators
47-3000	Helpers, construction trades
47-4000	Other construction and related workers
47-5000	Extraction workers
49-0000	Installation, maintenance, and repair occupations
49-1000	Supervisors of installation, maintenance, and repair workers
49-2000	Electrical and electronic equipment mechanics, installers, and repairers
49-3000	Vehicle and mobile equipment mechanics, installers, and repairers
49-3040	Heavy vehicle and mobile equipment service technicians and mechanics
49-9000	Other installation, maintenance, and repair occupations
49-9090	Miscellaneous installation, maintenance, and repair workers
51-0000	Production occupations
51-1000	Supervisors of production workers
51-2000	Assemblers and fabricators
51-3000	Food processing workers
51-4000	Metal workers and plastic workers
51-5100	Printing workers
51-6000	Textile, apparel, and furnishings workers
51-7000	Woodworkers
51-7040	Woodworking machine setters, operators, and tenders
51-8000	Plant and system operators

51-9000	Other production occupations
53-0000	Transportation and material moving occupations
53-1000	Supervisors of transportation and material moving workers
53-2000	Air transportation workers
53-3000	Motor vehicle operators
53-3030	Driver/sales workers and truck drivers
53-4000	Rail transportation workers
53-5000	Water transportation workers
53-6000	Other transportation workers
53-7000	Material moving workers
53-7060	Laborers and material movers, hand

Metrics

Labor Force
Employment

Availability

The **DRG U.S. Business Demographic Baseline and Forecast database**, as well as the new **C19UER and WFH databases** are available for client use under a number of licensing and deliverable arrangements. Clients may license the entire database, or request custom subsets. The database or subsets may also be incorporated into custom market sizing and forecasting models designed and developed for clients. Additional data at more granular levels in the industry taxonomy, or other metrics can be provided upon request. The Baseline and Forecast is **updated periodically** when new data is released from the various U.S. government sources.

> For more information about the **DRG U.S. Business Demographic Baseline and Forecast**, the **DRG C19UER** database, or **the DRG US Personal Device Forecast** availability, prices, or development methodology please contact Daniel Research Group.

About Daniel Research Group

Daniel Research Group (DRG) offers consulting and market research services to clients whose products and services are primarily technology based or enabled. The primary focus is on providing results, solutions, consulting and training to clients that have strategic and tactical decisions that require Forecast, Segmentation, Market Share, and other market modeling requirements.

The full range of traditional market research data gathering and analysis services support these engagements, including quantitative and qualitative surveys, focus groups, demographic and firmographic data acquisition and analysis, as well as input from technology and industry experts. While the emphasis is on delivering data and actionable recommendations, **DRG** often designs and develops custom models and modeling tools for client use, as well as providing training and education in these areas.

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2) The Decision of Streaming vs. Theater is Fading for Consumers, Andy Marken, andy@markencom.com

Source - "The Ritual," Entertainment One

"There are some, Phil, who consider this character building." **– Dom, "*The Ritual*," Entertainment One, 2017**

Netflix's Reid Hastings had the streaming stage to himself since about 2000 but it got so crowded that this year, the board "encouraged" Ted Sandaros to join him as co-CEO and the two are confident the stage can hold all the new folks that joined them.

First, it was just the new members of the FAANGD mob ((Facebook, Amazon, Apple, Google/YouTube, Netflix, Disney) and China's BAT squad (Baidu, Alibaba, Tencent); but it didn't take much for everyone in the M&E industry to figure out that this streaming thing was here to stay.

Even the grossly undernourished AMC theater chain figured out that instead of kicking dirt at Universal for taking *Trolls World Tour* direct to the consumer first before letting theaters have it, they would join the streaming crowd and offer up a PVOD package and ultimately give folks a choice – put your seat in our seats or enjoy the stuff at home.

Source – THR

Coming off a quarterly loss of $170M and barely a glimmer of light for theater openings, Cinemark is… *"In discussions."*

Since seemingly the beginning of time, studios had essentially released their films first in theaters for several months before making them available to "second class" video outlets.

In fact, a pre-qualification to be considered for an Academy Award is that film is released to a commercial theater in Los Angeles County for at least seven days and be shown three times a day.

No ifs, no ands, no buts … though this year, it's *"a little tough."*

For folks like Universal's, *Trolls, a* PVOD take of $100M isn't a big thing but they broke (at least cracked) one of Hollywood's greatest taboos.

Who knows, it could turn out to be a good disaster for the entire industry.

Source – Disney

"Suddenly there are no rules," Michael Goodman, Strategy Analytics' Director of TV & Media Strategies, said. *"We're in a new Wild West with cinemas shuttered by months of*

pandemic, a world of entertainment hungry/bored people and a constantly shifting schedule of major and minor theater (audience)-ready films."

The realignment of the theatrical/home release dates has been one which Netflix has long insisted needs to change and the pandemic disruption could help all parties realign their positions/goals.

The unplanned shift could be an opportunity for content creators/distributors, cinema chains and VOD services to take a closer look at the best way to get in touch and stay in touch with customers.

The tough part for industry players to remember is that delivering content directly to a person's screen doesn't make them a target but a partner in ***their*** new M&E ecosystem.

With consumers stuck at home and studios making recent releases available for at-home viewing, VOD climbed 30 percent and TOD rentals 13 percent year over year

Average transactions per subscriber household in March

■ 2019   ■ 2020

Video on Demand	Free-on Demand	Subscription Video on Demand	Transactional on Demand
12.39 / 16.09	9.34 / 11.32	2.82 / 4.32	0.23 / 0.26

Source – Commscore

> ***Across the Board*** *– Video on demand (ad-supported, subscription and transaction) expanded rapidly following the pandemic lockdown while PayTV continued its decline.*

"All major streamers saw their subscription numbers increase during the lockdown," Goodman noted.

According to Morning Consult, nearly half of consumers (49 percent) say they are streaming more since the outbreak with 21 percent of adults subscribing to new services.

The subscribers predominantly flocked to a few streaming providers -- Netflix, Disney+, Hulu and Amazon Prime Video accounted for about a quarter of the new subscriptions.

Awareness

% of respondents who have heard of each service

Service	%
Netflix	92.8%
Hulu	86.4%
Disney Plus	79.9%
Amazon Video	71.4%
Apple TV Plus	64.2%
HBO Max	60.6%
Peacock	26.8%
Quibi	24.8%
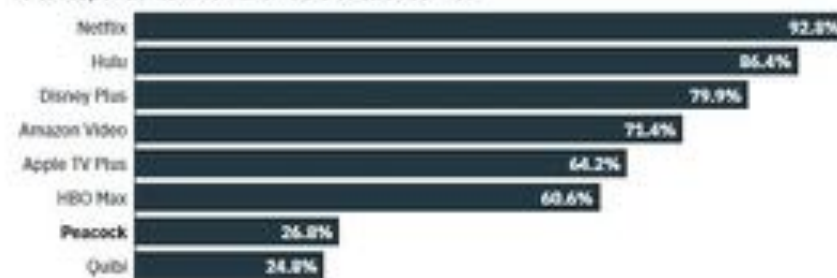
Source – YouGov

> ***Leaderboard** – Netflix maintained its streaming leadership over the other major streaming outlets (Hulu, Amazon Prime, Disney+) and an aggressive number of new subscription and ad-supported options entered the picture.*

"Netflix has dominated the streaming landscape for years," Goldman commented, "and they continue to be the target everyone is aiming at having added a record 15.8M new subscribers just in Q1 with a global total of 183M subscribers.

Co-CEOs Reid Hastings and Ted Sarandos emphasized that home entertainment services such as Netflix were temporarily higher because of the lockdown but that the company has a strong inventory of new content scheduled through next year to ensure they remain number one globally.

Title average vs total demand for digital original genres in the United States
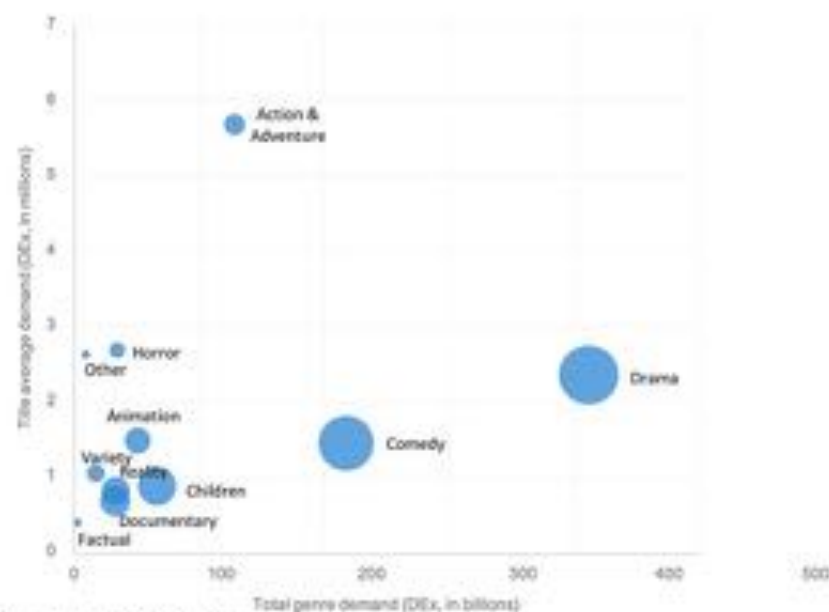
Source – Parrot Analytics

> ***Entertainment Options** – Streaming services have expanded individual and family entertainment options with rich libraries of adult, family-oriented,*

children, superhero, horror and documentary options. People can find the type of entertainment that best meets their entertainment interests relatively easily.

One of the major advantages Netflix has is a wide and deep treasure trove of viewing data that enables them to ensure they always have a healthy balance of genre topics to meet existing and prospective subscriber tastes.

People are attracted to streaming services by social media, but the personal recommendations of friends and family convince people to subscribe to specific SVODs and their entertainment offerings.

With 78 percent of Disney+'s new subscribers and 75 percent or more of Hulu's and Amazon Prime Video's, they continue to keep a sharp eye on the folks planning to expand their entertainment options in their rearview mirror.

At the same time, Disney+ is expanding at a breakneck speed with a growing base of viewers in the Americas as well as successfully debuting in a number of European countries and India.

In India Hotstar, Disney+'s premium online service, drew eight million subscribers in the first week, placing increased pressure on Netflix in a country that is important to both firms since it is the third largest entertainment market in the world behind the US and China respectively.

StrategicAnalytics' Goodman estimates that India's online offerings will account for more than $4B in revenue by 2025.

With ARPU (average revenue per user) of $1, Disney+Hotstar could reach $587M in subscription revenues during the same period plus $314M in ad sales to become India's second largest online video service behind YouTube.

Source – Disney

With their parks division taking a $3.5B hit, Disneyland Paris and Disneyland Orlando as well as parks in China have been partially reopened. With a large number of questions surrounding when cinemas will open and the rush for seats in seats, Disney+ took a lesson

from Universal, moving the widely anticipated and promoted *Mulan* to a $29.99 PVOD showing in the US and select markets.

Already delayed multiple times because of the pandemic, the $200M film was shown in cinemas in countries where it isn't available on video on demand.

In addition to rolling out an aggressive – and widely enjoyed – roster of streaming entertainment to more than 70M subscribers worldwide, Disney also has major films they would still like to get into global cinemas.

Streaming All the Way to the Bank
Theatrical releases are the gold standard, but studios generally see a bigger share of the coin through at-home viewing

Source – Credit Suisse
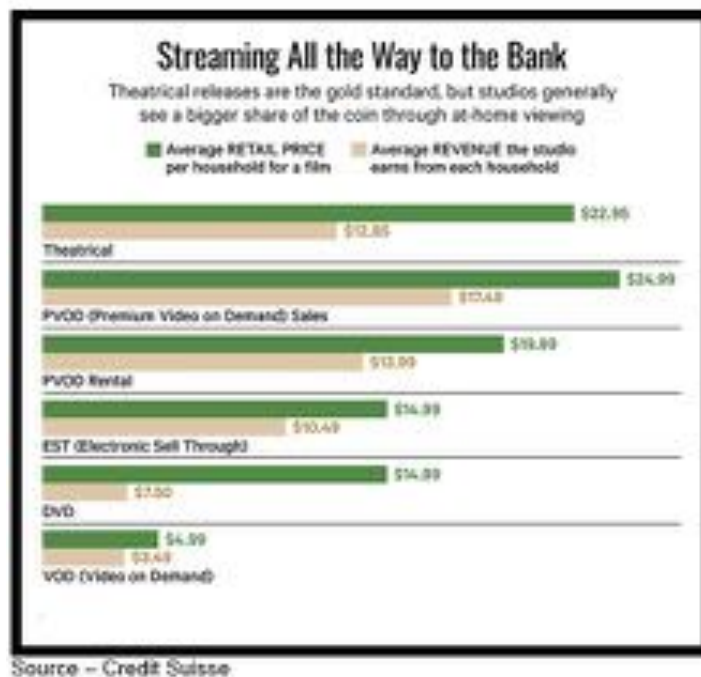
> ***Window Change*** *– While studios and theaters have long disagreed on the length of the exclusivity showing window and the division of box office receipts, the growth of streaming content and global shutdown of entertainment venues changed the flow of the discussion, which ultimately will be best for everyone including the consumer.*

Disney, like all of the studios, has been less than optimistic about cinemas reopening, how audiences will respond to the viewing restrictions that are being laid out (attendance in Japan and China has been remarkably unimpressive) and how consumers will respond if a second wave of infections force theaters to close yet again.

"While all of the studios are committed to seeing cinemas reopen and become an integral part of the M&E scene, there are practical business decisions that have to be made with the number of tentpole and secondary films that are gathering dust in their libraries," Goodman commented. *"The libraries represent major financial investments that need to be covered and recovered.*

"The pandemic's new realities forced everyone in the M&E ecosystem into experimenting with new tech-driven home-centric entertainment," he continued. *"The out-of-home entertainment experiences won't disappear once we can open our doors and smell the fresh air. Most of us still like to get out, rub shoulders and travel in addition to going out for the evening, having a good dinner and attending a good movie.*

"The big question marks for all of us are when can we do it and how long we'll feel comfortable doing it," he noted.

"Movie theaters won't vanish as a result of the new realities," Goodman emphasized. *"They will just be different ... a lot different."*

Ampere reported that titles that are expected to gain the largest international box office revenues (over $700M) have not been released on PVOD including such titles as *Wonder Woman 1984, No Time to Die, A Quiet Place II, Fast and Furious 9, Antlers, Black Widow, Thor: Love and Thunder, Jurassic World: Dominion* and other major projects that are still scheduled to be experienced first in the theater.

Slightly lower-earning films ($400 - $750 M) will be squeezed into the cinematic schedule or offered PVOD.

In the Americas and Europe, digital transaction – PVOD – is accepted and viable avenue for gaining added income.

However, about 40 per cent of box office revenues come from markets like China, Brazil and India, where box office is more widely accepted, so PVOD probably won't be adopted globally.

But for the longer term, the option of theater-first alternatives will place added pressure on cinema chains to become more flexible on the exclusivity window and the division of box office receipts.

Source - 'The Ritual,' Entertainment One

The new normal is anything but normal and all of the participants will have to test and experiment to find the options that work best for them in satisfying the consumer's entertainment appetite.

The industry has to keep in mind Dom's observation in *The Ritual* when he said, *"My old scoutmaster used to say 'If the shortcut was a shortcut, it wouldn't be called a shortcut, it would be called a route."*

# # #

Andy Marken – andy@markencom.com - is an author of more than 600 articles on management, marketing, communications and industry trends in media & entertainment, as well as consumer electronics, software and applications. An internationally recognized marketing/communications consultant with a broad range of technical and industry expertise in storage, storage management and film/video production fields; he has an extended range of relationships with business, industry trade press, online media and industry analysts/consultants.

3) A 5G Network Can Be a Blessing and a Curse, So Platy NIce, Andy Marken, andy@markencom.com

Source - "The World is not Enough," MGM

"Yes, well, life is full of small challenges." – **James Bond, "*The World is not Enough*," MGM, 1999**

The other day, we were watching a movie on our smartphone. 30-minutes in this huge buffering wheel filled the screen.

Then … stutter, stop, spin, stutter, stop, spin.

A few months back, the EU asked Netflix; Amazon; YouTube and Disney to cut their streams back to HD video to save precious bandwidth.

The only person we know who recognized the difference and quietly complained was industry tracker Bob Raikes, managing director of Meko publishers of *Display Daily*.

Ordinary folks didn't notice the difference. As long as the screen had the 4K logo in the corner, they were watching in 4K

Hype seems to work well for telco marketeers too – broadest coverage, fastest, most reliable, 5G E, whatever.

5G wireless is selectively available … **at best.**

The global lockdown didn't help - equipment production slowdowns, delivery hang-ups, installation, testing, on-lining delays and seemingly rational people burning down towers because there was obviously a straight line between 5G and Covid-19.

It honest to gawd doesn't folks…honest!

Back in 1918, people said radio brought on the flu pandemic, in WW II the pandemic was caused by radar, the 1968 flu was caused by satellite "bombardment."

The solution then as now … turn the clock back.

Source – IrishTimes

The problem is the good 'ol days weren't that good.

In addition, the negative 5G noise is just **wrong** -- https://bit.ly/2L0LeH5 and https://nyti.ms/2W6PWtx - so let's move forward because we're going to need it … eventually.

People love to say 5G is here so buy your new (expensive) phone and enjoy all the rich benefits even though it will take time to build out the local, state, national, global wired/wireless distribution infrastructure just as it takes time to get the content industry moving in the same direction.

5G Coverage and Adoption
Global forecast

Source – GSMA
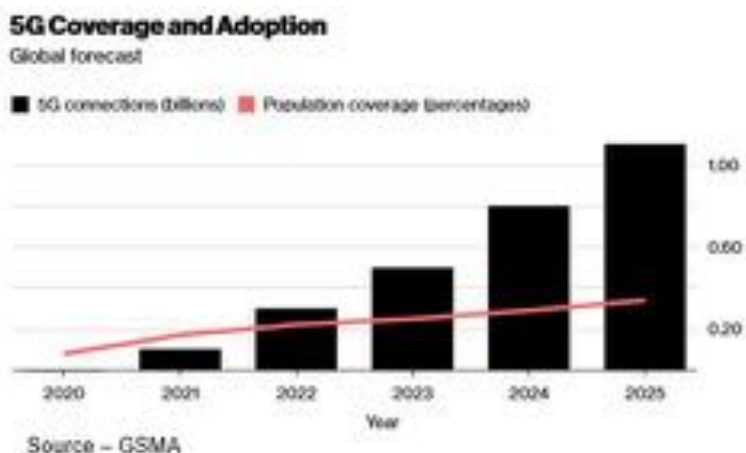
Global Expansion – The global buildout of tomorrow's 5G infrastructure will take a little time to get strong coverage of the population because the major focus will be on large population centers.

Don't get us wrong, having 5G to stream your content is important (to you) but the world is going to need the speed and capacity for darn near everything else – improved healthcare/telemedicine, home safety/security/convenience, better remote meetings, autonomous transportation and high-quality immersive entertainment/gaming.

To support just about everything everywhere, we'll need the better wired/wireless network performance/capacity that 5G was designed to deliver:

- Latency as low as 1ms

- 3X improvement in spectrum efficiency

- Ability to handle 100X more traffic

- 10X improvement in network throughput

- 100X improvement in network efficiency

The weird thing that rose during the lockdown for the first time in years was phone calls. You know, pick up the phone, tap nine numbers (10 if you count 1 at the beginning) and actually talk to someone on the other end of the line.

Weird!

The other thing people "discovered" was that they really could work away from the office, stay in touch with everyone and keep (most) business activities moving forward with daily, hourly video conferences – Zoom, MS Teams, Google Meet, Skype, GoToMeeting, WebEx, Verizon BlueJeans and more.

In other words, 5G is good. Wi-Fi 6 is good. The two together…great!

Source – Qualcomm

Complimentary – *While 5G technology may grab most of the news coverage, the availability of high-speed Wi-Fi 6 service will happen more quickly. Both will be required in tomorrow's connected world.*

Don't give us the flack that you only care about how quickly your telco is going to deliver 5G so you can buy those outlandishly expensive 5G phones.

The two services – Wi-Fi 6 and 5G – will become vital in meeting tomorrow's data rich requirements.

Five plus years ago, connectivity wasn't as ubiquitous and was less reliable than it is today.

It would have been difficult, if not impossible, to seamlessly and reliably connect homes, businesses, education and healthcare institutions.

Faster speeds and increased capacity enabled large segments of the world to meet the dramatic shift in demand almost overnight.

Had the pandemic occurred five years from now the impact – hopefully – would have been much less and certainly less disruptive.

Source – Ericsson
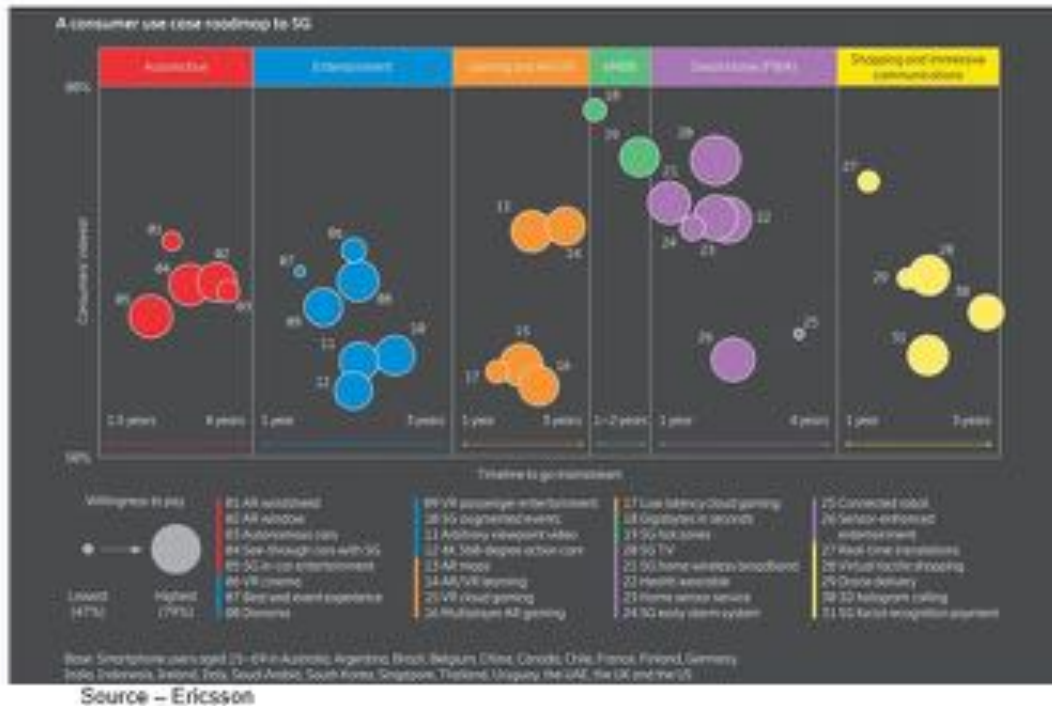
> ***Priorities –*** *Everything has a budget – time, money – that helps people decide which technology they want first and how much they are willing to pay. Healthcare and home applications of 5G technology are projected to get most of the attention and support over the next few years.*

By then, businesses and institutions will be in an even stronger position to meet the challenges head-on.

Mission-critical services have been the primary reasons industry leaders – Qualcomm, Ericsson, Nokia, Cisco, their partners and telcos – have been moving to deliver the services despite the hurdles.

Source – NYTimes

Source – NPR

> ***Health, Safety –*** *The Covid-19 pandemic proved the importance of high-capacity, high-speed communications in health emergencies. At the same time, fast; safe and reliable distribution of goods and support for people*

became increasingly important around the globe. Nearly 60 percent of goods are transported by truck, making healthcare and trucking higher priorities for 5G technology than streaming your entertainment.

Major applications such as moving goods quickly and effectively from the point of production to the user will help control costs.

Moving volumes of vital clinical, healthcare data from first responders to hospitals to diagnostic organizations isn't just nice, it's increasingly a matter of life and death.

As Geoff Blader, VP of CCS Insight research, noted A virtualized, intelligent 5G network will enable more flexible adjustment to capacity as well as prioritization of traffic using network slicing.

He added that the significance of the overnight rise in data traffic is now a leading case study for the importance of network transformation to a more flexible, software-based network.

Source – NordicTimes   Source – Mantecatimes

Infrastructure Buildout – Even during the pandemic (which wasn't caused by 5G), installation crews around the globe have been building and installing long distance 5G tower networks and urban/suburban cell networks to deliver fast, high-capacity 5G service to people.

The pandemic highlighted the importance of accessibility and availability of connectivity around the globe including rural communities and areas of the world that have minimal communications.

In industrialized countries, especially in major cities and population concentrations, fiber infrastructure is important for backhaul support.

But wired fiber is impractical everywhere in a country, a state or even in a major city.

To meet the service needs, communications crews have been building out their network of towers for reliable, economic, long-range distribution as well as small cells strategically located throughout urban and suburban centers during the pandemic and the ridiculous/unfounded claims that the sickness was all the result of 5G service introduction.

This global infrastructure ensures widespread access and enhanced reliable service.

Source – Ericsson   Source – ccnwireless
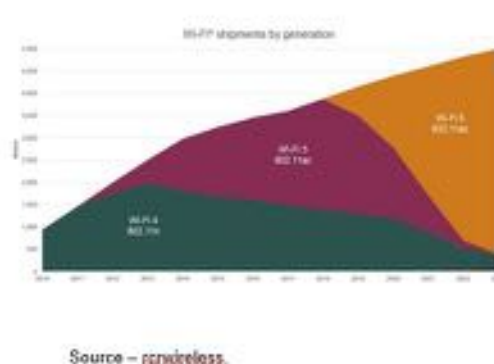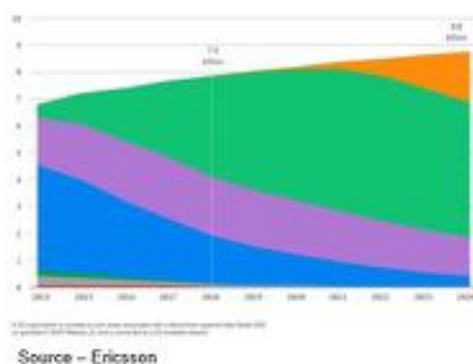
> **Takes Time –** *It's always interesting how much time goes by between the introduction of a technology and when it is in widespread, common use. While 5G wireless has been so widely promoted that people feel it is everywhere, most people around the globe will be using 4G LTE and Wi-Fi 6 will be used in home and business applications.*

Wi-Fi 6 will expand more rapidly and broadly as businesses and organizations as well as working away from the office and video conferencing/meetings become a normal part of our professional activities.

It will also enhance team contributions and productivity so projects can be completed more efficiently and effectively.

The broad availability of 5G service – low-, mid- and high-band spectrum – in addition to being properly priced and structured without premium charges and/or usage caps (which were suspended during the pandemic) will expedite global adoption.

Based on the growing demand for high-speed, reliable communications service and the performance of early trials, Ericsson increased its forecast for 5G subscriptions to 2.8B by 2025, thanks in no small part to the aggressive deployment of tomorrow's infrastructure.

Wi-Fi 6 has a powerful role to play alongside tomorrow's tower and small cell technologies in delivering key use cases going forward in the 5G Era.

Source – Ericsson
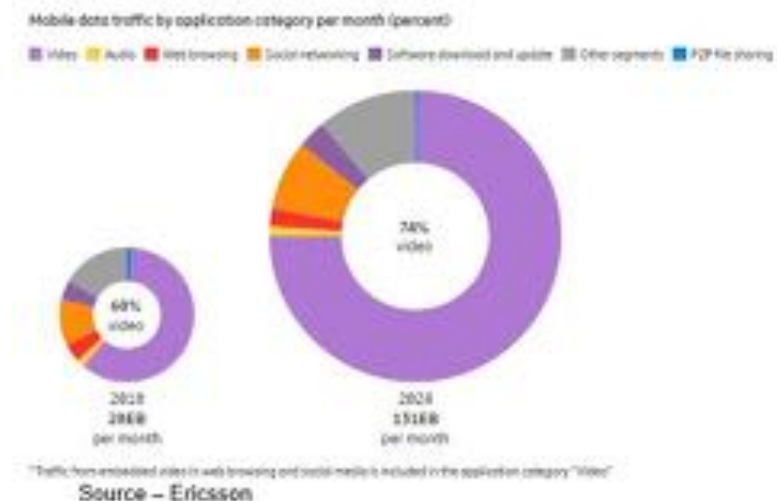
All About You – *While 5G technology will change and improve things in almost every segment of business and personal life, it's the streaming content that people are really looking forward to using…everywhere. Almost every video storyteller has a plan in the works on how to get her/his content in front of the demanding public.*

Wired and wireless services have been rigorously tested by billions of people around the globe who worked from home and were sheltering with family members. Not fun without a good entertainment break (or 2 or 3 or …).

Watching video stories on any screen has become more than a way to take a break or to occupy the kids, it has become a vital stress release for everyone in the household.

Streaming video content from Netflix, Disney +, Apple TV +, Amazon Prime, Baidu, Alibaba, Tencent and the thousands of OTT services around the globe, already accounts for more than 65 percent of all mobile traffic.

More than 25 percent of the worldwide mobile traffic comes from YouTube, while Facebook Video has grown to over 17 percent of the traffic volume.

With TikTok recently signing Disney's Kevin Mayer as CEO (then he left and governments got into a name calling match), you can bet the company has its eyes set on extending its reach and influence in the mobile video entertainment and advertising arena in the next few years.

With so many people working from home, security has become a major concern for businesses, entertainment streaming services and households.

Security officials at Thrive emphasize that Forrest Research's John Kindervag model of Zero Trust is even more vital today – assume everything around the network is hostile and that anything/everything has to be verified.

Expanding on the need for Zero Trust, Microsoft's CEO Satya Nadella recently said, *"We've seen two years' worth of digital transformation in two months."*

As a result, everyone – including every company team member – has to be more aware of the challenges and the risks since cybercriminals and nation-state groups are increasing their attacks across the Internet to "acquire" data and assets, including video content.

While SVOD credential sharing or accessing content from BitTorrent sites may seem to be harmless freeways for people to enjoy movies and series, people need to understand and appreciate that most of the time, these services also give you something extra--malware that opens your system and network(s) to criminals.

It's important to remember that the high-speed, high-capacity global network is also a two-way highway that can benefit you … and them.

Source - *"The World is not Enough,"* MGM

As James Bond said in "The World Is Not Enough," *"There's one critical element here I may have overlooked."*

# # #

Andy Marken – andy@markencom.com - is an author of more than 700 articles on management, marketing, communications, industry trends in media & entertainment, consumer electronics, software and applications. He is an internationally recognized marketing/communications consultant with a broad range of technical and industry expertise especially in storage, storage management and film/video production fields. This has led to the development of an extended range of relationships with consumer, business, industry trade press, online media and industry analysts/consultants.

4) TIFF Highlights Equality in Your Entertainment , Andy Marken, andy@markencom.com

Source – "The Two Popes," Netflix

"When no one is to blame, everyone is to blame." – **Pope Francis, "*The Two Popes*," Netflix, 2019**

Because of the global pandemic, we were unable to go to this year's Venice Film Festival.

Couldn't go in years past because we couldn't afford it.

Nice to have a new reason.

Actually, we've never minded missing over the top film festivals like Venice and Cannes. But having to pass up September's TIFF (Toronto International Film Festival) hurt.

Next to Sundance, TIFF is one of the events where they really focus on new, different and great indie filmmaker projects.

Plus, it reminded us we weren't able to visit Amsterdam and IBC.

Next year?

BAM! we're there.

But for this year, we were more than satisfied with the virtual event because we didn't have to fight the throngs of lookie-looks.

We were able to focus on the messages the panel/Q&A sessions that participants were sharing and their anecdotes/experiences.

We got to see great flicks without cramming into the huge Ryerson Theater with a mob of folks who weren't there to celebrate indie's work but to be entertained … or not.

The things you miss most are the cheers and chatter that validated your opinion…***darn that was good or not!***

We still haven't decided if we like the fact that TIFF showcased what judges thought were the 50 films this year rather than the firehose of 333 last year.

The 50 were good, some great even, but the other creative teams will miss the key reason for submitting to film festivals…the event's buzz that buyers need to reinforce their acquisition opinions/decisions.

As for the parade of Emmy/Oscar contenders and personalities, they can stay in Cannes and Venice because we feel film festivals should be reserved for indies, not studios.

Studios and networks focus on safe ideas like remakes, franchise extensions.

Heck, they probably rejected 80 percent of the story ideas that folks just "had to make," like natural films about racial and sexual equality.

Of course, if they happen to buy one, guess who becomes the leader of the shift?

Yeah!

Source – Concrete Cowboy

> ***Different Twist –*** *It's surprising and understandable that something as minor as sitting astride a horse can change the vision of the rider and the perception of the viewer, but it works – beautifully.*

Our first surprise was *Concrete Cowboy,* the story of a father trying to build a connection with his son in Philly.

We thought it was going to be a documentary based on the book about Southern California's *Compton Cowboys;* but instead, it followed the father/son struggle

formula but with an enlightening twist. It was about getting by in the inner city, the subtle and not so subtle challenges of being black and the understanding of just being on a horse set people on an equal footing with people they encountered.

It turns out there's a serious lack of movies about black cowboys who did so much to open this country but were largely ignored or overlooked when the stories were told.

It always makes us wonder what else we don't know about appreciating our diversity.

Can't wait to see it again on one of our streaming services; and heck, who knows, maybe even in a theater … someday. We'll just have to see who snaps it up.

Source – Variety

Power Evening – *It's interesting to think of four of the most visible black men in recent years together in the same evening. You can't help but be drawn in by their views of today, tomorrow and life in general.*

We're not certain if *One Night in Miami* is as advertised – inspired by true events – but Regina King in her directorial debut did a fantastic job of making it feel as though it really happened or should have happened.

It's difficult to imagine four iconic and different black men coming together – Casius Clay, Malcolm X, Sam Cooke and James Brown; but seeing/hearing them share their personal experiences of black struggles was enlightening.

Ms. King struck just the right tone in showing their self-doubts and pride in heroes we never really knew.

The great thing is we'll be able to see it again on Amazon Prime and share/better understand how much further we have to go to really be anti-racist. It's a convincing case for an organic debate in which the stakes are personal for each of the participants and the issues no less relevant today.

While the Academy still struggles to get past its whitish male views of the world, events like TIFF give the community a great platform to prove that women are equal and often superior in telling compelling visual stories.

Fresh from its win in Venice, Chloe Zhoa's *Nomadland* had its premiere at TIFF plus a Telluride drive-in premiere in LA.

It's an intriguing and captivating look at how an older widow finds new life on the road during the Great Depression. Frances McDormand makes you think about what happened to America, the land of promise, and how the American dream got lost.

It will be interesting to see how the film that was snapped up by Searchlight Pictures actually does in theaters in December.

Source – Hollywood Pipeline

Battler – *Working behind and in front of the camera, Haley Barry strives to show the raw side of handling life, society and family in* **Bruised***.*

After hearing Halle Berry talk about her directorial debut with *Bruised*, we're looking forward to seeing the film on Netflix.

It was interesting to hear her discuss gender parity, skills development and the potential for female creators during TIFF's *Share Her Journey.*

 Obviously attractive and talented, it will probably be uncomfortable to watch her struggle to succeed in something as brutal as MMA while balancing her outside chaotic life. We're sure we'll enjoy her triumphs (hopefully it has a happy ending) but the idea of a woman – any woman – getting beat up isn't our idea of *fun* entertainment.

The rumor is Netflix dropped $20M for the rights and that was just one of the big checks they signed at TIFF.

But since the Hastings/Sarandos team had a large number of international productions put on hold because of the pandemic, they've been really aggressive about grabbing original features that are already "in the can."

Source – History

***Everyone In** – After showing the content industry how to reach and retain viewers around the globe, every studio and content owner is suiting up for the market share battle. Few appreciate the value of listening to customers first.*

And with folks like Disney+, Amazon Prime and the horde of other streamers getting beat-up by shareholders to duplicate their global reach (currently 183M plus), it's a good thing they have one thing going for them … subscriber data.

While TIFF was different this year, it did meet its "obligation" … highlighting indies and projects that may not have been mainstream or gotten the exposure they needed to be appreciated.

Film festivals like studios, networks, content owners and distributors miss something when they get distracted by the bright lights and big names of the tentpoles.

While a budget of $10M for most indies we know is only a dream, they still create the lion's share of good stuff that doesn't get the marketing push and visibility to be seen and appreciated.

Time and opportunities need to be set aside for these smaller indies that either have a compelling (and well executed) story or expose/educate people that diversity and equality are important.

If you think about it; the different, even quirky, films are the reason TIFF, Telluride, Sundance, Tribeca, Berlin, Atlanta and smaller festivals around the globe exist.

For all the talent in the industry, it still boils down to being in the right place at the right time with just the right message to gain "instant" stardom/acclaim.

It's a poorly kept secret that cinemas are having "modest" turnouts; and with second wave Covid-19 illnesses popping up around the globe, it is painfully obvious that only the brave (or foolhardy) will hesitantly put seats in seats.

Public Doesn't Want to See New Films Until Next Year

Respondents who said movie premieres in 2020 should be delayed
were asked when release dates should be shifted to

	SEPT.	OCT.	NOV.	DEC.	SOMETIME IN 2021		Don't know/ No comment
All adults	6%	11%	8%	8%		54%	12%
Frequent moviegoers	8%	18%	9%	11%		45%	9%

Source – Morning Consult
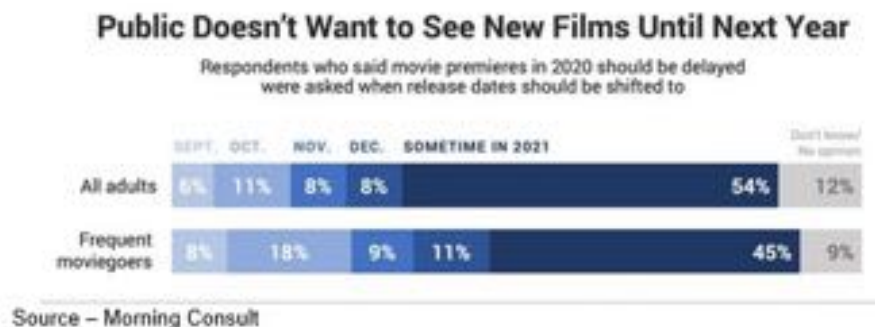
We'll Wait – Theater owners don't want to hear it but although most folks want to go to the movies, they're waiting until next year.

Of course, the financially starved chains insist things are good and getting better if only the studios would quit looking at viewer options.

While the CinemaSafe guidelines that theater chains all agreed to were designed to assure/reassure frequent and occasional moviegoers that it's safe to return to their former evening out entertainment habit, it isn't quite working.

Even with nationally recognized epidemiologists and infectious disease experts endorsing a safe, enjoyable return, it just isn't working.

That's because entertainment viewers have options and they're ready, willing and able to use them.

The business model of cinemas will need to significantly adapt

Source – Stephen Follows
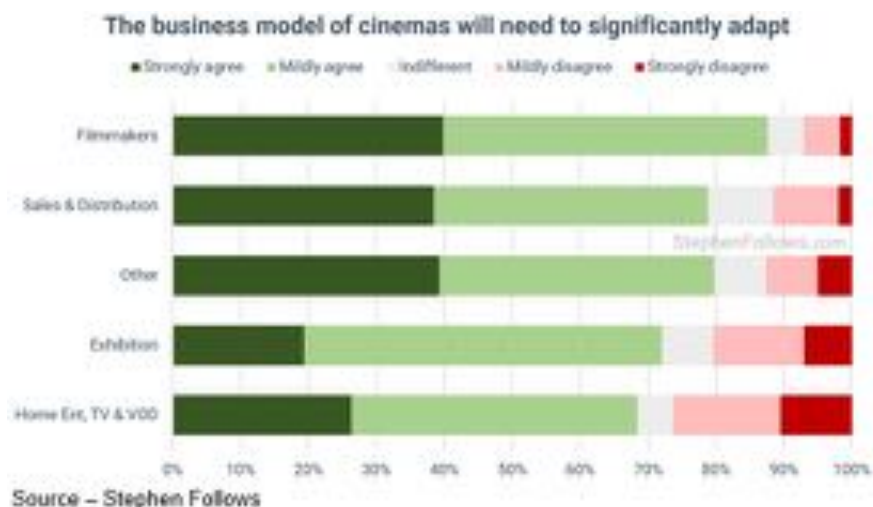
***New Normal** – Now that consumers have multiple ways of seeing movies, especially tentpoles, theater owners are having to "adjust" their business model to attract content and viewers.*

Seeing an opportunity (and sluggish reception), studios were finally able to revisit the time-honored theatrical exclusivity window.

Recognizing that only about 60 percent of the public went to the cinema even before the pandemic, the shortened window enables them to put "really wanna see it" content on their streaming services earlier to grow their subscription base.

Perennial box office champion Disney (a long-time champion of the traditional theatrical window) broke ranks, announcing it would bypass theaters and offer live-action *Mulan* to consumers in the home next month.

Nathanson said the theatrical business has been Disney's domain for years (64 percent of all industry pre-tax earnings in 2019, according to Nathanson), and CEO Bob Chapek's decision to alter traditional distribution models will "ripple" through the industry (including home video) for years to come. The analyst contends the country has too many movie screens operating under current market conditions.

"The number [of screens] has to fall," he said in response to the slate of original movies moving to SVOD and other digital channels. The analyst said that trend will accelerate as studios and their media parents roll out digital distribution platforms such as HBO Max, Peacock and Disney+.

Nathanson said he believes Disney has no plans to abandon the theatrical window altogether since the studio makes money ($1.4 billion operating profit) on most of its major releases at the box office. And theatrical releases often inspire amusement park rides and consumer goods.

Audiences Most Likely to Turn to Subscription Streaming Services for New Films Within the Next Month

Respondents were asked their likelihood of seeing new film via the following methods sometime in the next month:

Source – Morning Consult
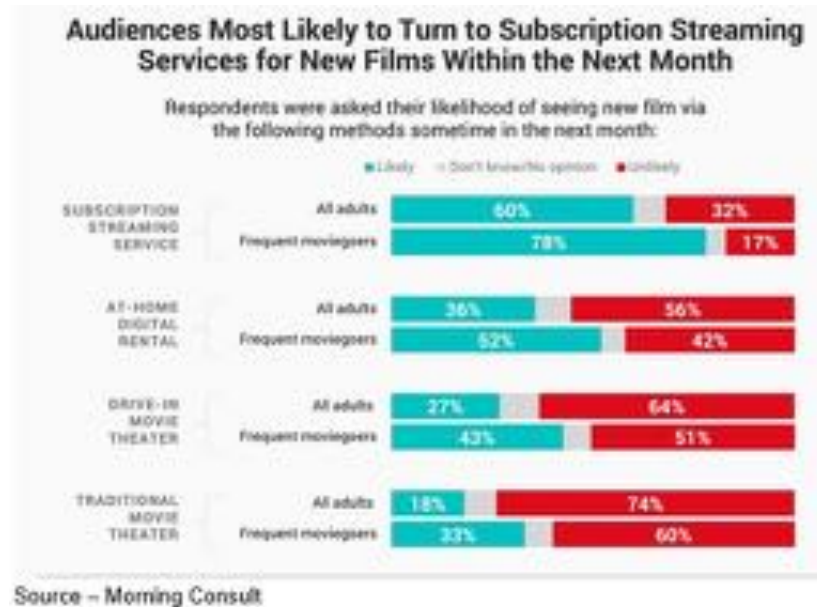
> **Options** – *With the global lockdown, consumers are learning that they can still enjoy great entertainment – at a pretty reasonable cost, in the comfort of their home. The trend will continue.*

In some ways, the pandemic did indies a favor since the major studios were venturing out cautiously because management answers to "a higher power" – shareholders.

Hard-working, talented people aren't burdened by this overhead.

Last year, more than 532 scripted projects were produced, broadcast or streamed in the US (5K more globally); and this year, even the reserves have been pressed into action.

Folks like Warner (HBO Max), Disney +, Paramount +, Peacock, CBS All Access, Canal, Sky, TF1, BBC, Stan, Hotstar, Foxtel, 7 Network and thousands of content owners brag about their extensive library of content even as their viewers tell them they want/expect new, unique, special content or …

Gauging the Appetite for Streaming Independent Films Amid the Coronavirus Pandemic

Source -THR
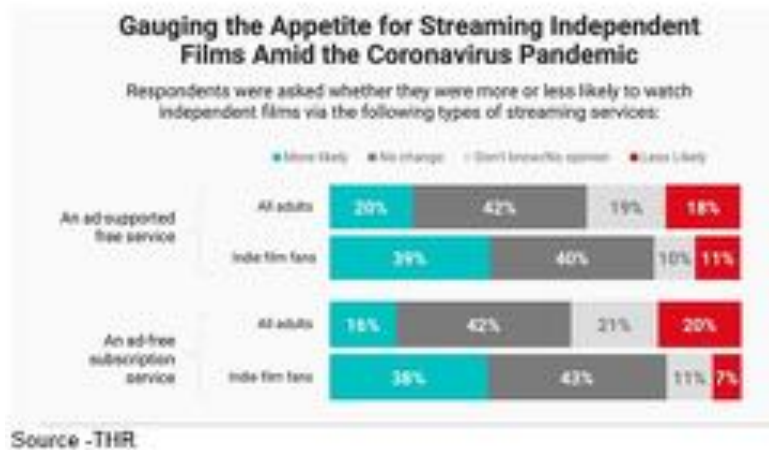
Good Stuff – *The pandemic has given consumers a welcome choice of content with ads or ad-free. While ad-supported content is still working to figure out the right mix/formula, it is working better and better.*

The dearth of new content at theaters, networks and streamers has opened the door for indie filmmakers with micro to mid-level budget projects to explore a wide range of relationship opportunities around the globe.

Non-blockbuster projects will have increasing opportunities with the screen service providers but as TIFF and other festivals have indicated, it may not be that video story that has been gathering dust in the back of your closet.

Female cinema-goers – such as our workout friend, Sharon – are increasingly selective of the films they will pay to see.

The same is true of the person who controls the remote or web pointer.

They don't mind a little testosterone, but they also expect ethnic and sexual parity or move on.

With the growing acceptance of AVOD services – Tubi, Pluto, Peacock, Vudu, Roku, Hulu, YouTube, Facebook Watch, Rakuten, Youku, Tencent Video, iQiyi, and other national/regional channels – there is increasing use of revenue-sharing vs. licensing.

Of course, that throws the marketing push back in the filmmakers' lap, but no one ever said this industry was easy just fun … most of the time.

Source - "The Two Popes," Netflix

But what TIFF and the other film festivals around the globe are showing us is that diversity and parity can be interesting, fun.

What we're proving is exactly what Pope Francis said in *The Two Popes, "We need bridges, not walls."*

Looking forward to seeing more bridges at next year's TIFF and IBC.

A lot more exciting than five nights of Emmys…

Or as climate advocate Greta Thunberg said during her TIFF discussion, *this celebrity culture is really absurd!*

# # #
Andy Marken – andy@markencom.com - is an author of more than 800 articles on management, marketing, communications and industry trends in media & entertainment, as well as consumer electronics, software and applications. An internationally recognized marketing/communications consultant with a broad range of technical and industry expertise in storage, storage management and film/video production fields; he has an extended range of relationships with business, industry trade press, online media and industry analysts/consultants.

5) Why Did Intel Sell its SSD Business, Jim Handy, Objective Analysis, 11/9/20
Intel recently sold its NAND flash business, which was mainly producing SSDs, to SK hynix, a Korean competitor. Some people have asked the SSD Guy why did Intel do this? The company had highly-regarded products that could command top prices. Since Intel's NAND flash fab is in Dalian, China, one person even asked if the divestiture could have been in response to the US-China trade war.

A better question is: "Why did Intel get <u>into</u> NAND in the first place?" NAND flash is a very bad fit for the company since it reduces Intel's profit margins and, from a business standpoint, it behaves erratically by ricocheting back and forth between losses and profits. Investors admire Intel for its predictable profitability, and NAND flash simply doesn't fit that description.

It seems that Intel entered NAND back in 2004 for two reasons:

1. Intel was trying to gain control over the inconsistent interfaces provided by NAND makers. The company established a standard interface earlier by creating ONFi, but only Hynix and Micron, two minor NAND makers, committed to use it.
2. The company hoped to ride the NAND flash revenue growth wave. Remember that NAND flash revenues have enjoyed the fastest growth in the history of the semiconductor market, and this growth threatened to propel Samsung ahead of Intel to become the highest-revenue chip maker, a title that Intel had held since about 1993.

The interface situation sorted itself out. As for that NAND wave, Intel temporarily lost its #1 title to Samsung for a couple of quarters in 2018 only to win it back again when the DRAM market collapsed. With both of those issues behind them, there was no reason for Intel to remain in the NAND business.

The chart below compares the operating margins of the world's leading NAND flash makers. That's shown in the columns. The line shows Intel's corporate operating margin, the combined margin of all of Intel's businesses combined.

Note how consistent Intel's corporate margins have been compared to the up and down behavior of the columns. Yes, in 2017 & 2018 there is a period when many companies' margins exceeded Intel's corporate margins, but that was an extremely unusual period of profitability for the NAND flash and DRAM businesses that is unlikely to occur again within the next decade or more. A reasonable projection for the NAND flash market is that it will behave more like 2019 & 2020, with margins oscillating between 0-30%.

I must disclose that this chart is far from perfect. The margins of Samsung, SK hynix, and Micron are for their entire business which is both DRAM and NAND flash (including SSDs). Also, Western Digital's (WDC) margin is the gross margin for the company's flash business, which it reports every quarter. WDC doesn't reveal its flash business' operating margin. Finally, the Intel columns show the operating margin for Intel's Non-volatile Solutions Group, or NSG, which was producing NAND flash chips, NAND-based SSDs, and Optane SSDs. The almost-constant losses that NSG suffered can be attributed to the phenomenal cost of making Optane into a reality. So there's a lot of mixed-up data in the chart.

But the basic argument that the chart supports is that NAND flash profits are less predictable than Intel's overall profits, and that they are generally a "drag" on profits (as investors say): NAND flash usually reduces Intel's overall profitability.

Note that NSG only accounts for 5-8% of Intel's corporate revenues, so the influence of NSG on corporate margins is small. Still, it's a drag on profits, and it's a business that Intel doesn't need to participate in.

NAND flash is a good business for Intel to leave to other companies. And that's exactly why the company decided to sell that business to SK hynix.

Over time I expect for Intel to sell off its Optane business too, but that will come later for reasons that I won't go into here.

Let me just finish this post by saying that this is the kind of information that my company, Objective Analysis, regularly feeds to our clients to help them understand the players in this business. If you understand their strategy then you can work out ways to benefit from the players' most likely moves. If you want to understand the players' strategies then come to us. We can help.

Company Announcements

Caringo Launches Swarm 12 (Company PR, 11/10/20)
Caringo, Inc. announced the launch of Swarm 12. The enhanced solution extends functionality to enable more flexible distributed protection and immediate global content use across geographically dispersed sites, integration into single sign-on (SSO) platforms and a simplified web-based UI so end-users can quickly find, organize and share files. Swarm 12 includes support for S3 Glacier and S3 Glacier Deep Archive as well as capacity and performance optimizations for dense storage nodes and flash.

Today, organizations that are enabling distributed, content-based workflows and services are using various tiers of storage, asset management solutions and backup applications. At the heart of these workflows is the ability to access content and data over HTTP. Many turn to cloud services; however, the compounding, unpredictable recurring costs of public cloud storage and the inability to meet performance requirements often present a challenge. Swarm 12 solves these problems by providing an on-premise solution that radically simplifies the ability to manage, store and protect data while providing access to any application, device or end user. Swarm 12 transforms what was once considered an "archive" into a flexible, reliable and immediately accessible content library that enables remote workflows and on- demand access.

Swarm 12 brings enterprise-cloud storage and data management services to any organization. The benefits of Swarm 12 include:

- Automated management of distributed synchronous workflows via remote synchronous write policies
- Ease of use for end-users as they store, organize, find and share files through an updated user interface (UI) that includes drag & drop, multi-upload and hierarchical bucket listings
- Simple, authorized user administration via single sign-on (SSO) with SAML 2.0 supporting platforms like Okta, OneLogin and Google GSuite
- Cost optimization for long-term (cold) storage leveraging tape through S3 Glacier and S3 Glacier Deep Archive support and certification with FUJIFILM *Object Archive* (a tape object solution)
- Maximum utilization of chassis space and number of cores enabled by architectural optimizations

    for flash and dense storage nodes

IMT SoDA Software Simplifies AI/ML in the Cloud with Dalet Ooyala Flex Integration (Company PR, 10/27/20)

IMT Software, a division of Integrated Media Technologies, Inc. (IMT), announced an API-based integrated solution with Dalet's Ooyala Flex Media Platform that provides seamless and automated data movement to simplify the secure transfer of artificial intelligence and machine learning workflow content to the cloud.

The integration of IMT SoDA software and Dalet's Ooyala Flex Media Platform will be offered in the United States and Europe. The joint solution will address media asset data management requirements by streamlining the transfer of large data workflows while delivering a simplified data movement approach for creative content. Post production and media services customers will be able to predict the cost and time to move files before a storage transfer enabling them to make smart decisions on data management and to keep project costs at or below budget.

As organizations embrace the cloud to drive rapid innovation, there is concern over hidden costs. The integrated solution provides customers with the actual cost of data retrieval and offers alternate options to keep overall spend down. Benefits include:
- Seamlessly automates data movements to the cloud
- Real-time insight into monthly cloud spend
- Dry-run feature allowing for insight into retrieval costs before execution
- Job tracking and progress for moving content
- Cloud-ready assets for artificial intelligence and machine learning workflows

iXsystems Expands TrueNAS Product Line with R-Series Systems and Scale-out Software (Company PR, 10/20/20)

The [TrueNAS](#) Open Storage portfolio has been expanded with the TrueNAS R-Series Storage systems and the TrueNAS SCALE Open Source HyperConverged Infrastructure (HCI) Platform. The new R-Series storage systems include four models designed for maximum density, performance, Open Storage flexibility, and cost savings. TrueNAS SCALE introduces easy to manage scale-out hyperconverged infrastructure based on OpenZFS.

The TrueNAS R-Series combines the advantages of purpose-built storage systems with the flexibility of TrueNAS Open Storage, including the ability to run either:

- **TrueNAS CORE:** The most popular Community edition that is succeeding FreeNAS. As with all TrueNAS editions, it supports File, Block, Object, and Application storage.
- **TrueNAS Enterprise:** The feature-rich Enterprise edition with Enterprise-grade support provides additional security and Enterprise integrations.
- **TrueNAS SCALE:** The new hyperconverged edition includes scaleout ZFS, KVM, and Kubernetes.

Unlike proprietary alternatives, the R-Series delivers industry-leading CapEx/OpEx storage economics with unmatched Open Storage performance, deployment flexibility, and storage density. Coupled with the High availability TrueNAS M-Series and X-Series, the TrueNAS family is fundamentally more agile than comparable systems, allowing organizations to outmaneuver the competition with unique use case scenarios that solve the most difficult IT storage challenges.

Each of the TrueNAS R-Series models can be configured with processing, memory, and networking needed to deliver up to 10GB/s via a single power-efficient controller. Designed to provide performance and capacity in a dense and compact footprint, the TrueNAS R-Series includes the following all-flash and hybrid models:

- **TrueNAS R50**: This is a 4U, 48 x 3.5" / 4 x 2.5" NVMe Bay system which features up to 16 CPU cores and a maximum capacity of 890TB that starts at $9,990 MSRP.
- **TrueNAS R40**: This is a high-density 2U all-flash system with 48 x 2.5" and 7mm Bays, up to 16 CPU cores and 360TB of Flash Storage with a starting price of $8,990 MSRP.
- **TrueNAS R20**: This system is 2U with 12 x 3.5" and 2 x 2.5" Bays, up to 16 CPU cores and 230TB capacity with pricing that begins at $4,990 MSRP.
- **TrueNAS R10**: The R10 provides a compact 1U all-flash system with 16 x 2.5" and 7mm Bays, up to 10 CPU cores, and 120TB of capacity for a starting MSRP of $5,990.

Introducing operators to hyperconverged storage capabilities across the entire TrueNAS portfolio, the company is also announcing the first release (20.10 was

released on October 6) of TrueNAS SCALE. TrueNAS SCALE is a unique, easy to manage and scale-out HCI platform for converged compute and scale-out Open ZFS storage. TrueNAS SCALE is available as Open Source Debian-Linux based software or as an appliance-based solution that combines TrueNAS SCALE with purpose-built systems including High-Availability (HA) systems like the X20, M40, M50, and M60, and the new R-Series systems. The Open Source economics of TrueNAS SCALE changes the existing HCI playing field.

New Avid NEXIS 2020 Collaborative Storage Unveiled for Today's Demanding Media Workflows (Company PR, 8/25/20)
Media organizations, broadcasters, TV and film post-production facilities and other content creators will achieve unsurpassed reliability, openness and cost-efficiency in their workflows with [Avid®'s (NASDAQ: AVID)](#) newest collaborative storage release, [Avid NEXIS® 2020](#), a purpose-built solution for production teams of all sizes that need to keep working from anywhere to stay ahead of surging demand for new content. Workflow gains coming from Avid NEXIS 2020 include up to 40 percent more shared storage in the same footprint; optimized content mirroring to eliminate downtime and data loss; flexible storage tiering that combines on-premises and cloud resources; and broader support for third-party tools.

New Avid NEXIS 2020 features include "All-Mirror" high-availability engines to protect workflows against the widest range of conditions for failure, including network disruptions, disk loss or the loss of an entire engine. For time-sensitive broadcast news, enterprise post-production and live events, All-Mirror engines provide the highest level of redundancy at the lowest price point, ensuring teams will avoid workflow disruption and meet their deadlines.

Avid NEXIS 2020 also debuts with larger capacity drives that enable workflows to scale more substantially and cost-effectively. New 140 TB and 160 TB media packs provide higher density storage at a lower cost, raising the total storage capacity up to 40 percent per engine, while decreasing the dollars per terabyte to store, manage, and edit content. In addition to providing the industry's first software-defined media storage, Avid NEXIS 2020 now offers even greater flexibility through storage tiering, which can secure media across a single pool of mixed resources, both on-premises and in the cloud, that can include flash, online, nearline and archive.

Qumulo Introduces New Suite of Data Services to Radically Simplify File Data Management at Scale (Company PR, 11/9/20)
Qumulo announced a new suite of data services that radically simplify managing massive amounts of file data. Qumulo unveiled two new data services, Qumulo® Secure and Qumulo Dynamic Scale, and introduced advancements including Instant Software Upgrade to Qumulo Core®, the industry's first NVMe Cached Performance and Qumulo Shift's new visual interface.

NVMe Cached Performance: Significantly lowering the cost of performance

Although many workloads, such as data analytics, research computing, and rich media content creation, benefit from low latency and massive throughput, access to the most performant leading-edge technologies has historically been accessible only to specialized workloads with large budgets.

Qumulo has broken this paradigm, introducing the file industry's first software to provide machine learning optimized read and write cache leveraging NVMe. The intelligent cache manages data on the optimal storage media to get both high performance and cost-effective capacity. With the introduction of the latest release of Qumulo Core software and two new qualified hardware options (C-192T and C-432T), Qumulo now offers NVMe performance at the price of disk.

"The new Qumulo Core capability to use NVMe as cache enables us to meet our performance and budget needs by providing great economics from very dense hard drives combined with its great caching capabilities on extremely fast NVMe drives," said Serkan Yalcin, Director of IT, Infrastructure Dev/Ops, Institute for Health Metrics and Evaluation. "Qumulo's intelligent caching, without managing policies, has been great and provides even more value for us with NVMe as the caching layer. These features, combined with their great customer success experience, really empower us to focus on our mission of bringing population health data to the world."

Qumulo Dynamic Scale: Leverage new processor, storage and memory innovation to scale existing deployments

Data is growing more rapidly every year. Users need access to new technology to keep pace. Historically, organizations have had to worry about when to invest in new technology, concerned they may miss the window to access new advancements that may be imminently released. The introduction of Qumulo Dynamic Scale enables administrators to leverage newly qualified platforms with the latest processors, memory and storage devices without the need for forklift upgrades, data migrations, or complex storage pool management. Qumulo users now can add new qualified platforms into existing environments with no need to manage different storage pools or perform a data migration. The new platforms are simply added to the existing environment, data is automatically redistributed, and the increased performance and capacity are automatically made available to users and applications.

"Everyone from the marketing group to our dot-com and interactive groups is relying on it. We needed the storage equivalent of a reliable Swiss army knife, and unfortunately, our old system wasn't cutting it anymore," said Raoul Edwards, Director, Network Systems Engineering and Field Ops at MSG Networks.

Qumulo Secure: Automated data encryption, for free

To help make data encryption easy and cost effective, today Qumulo is introducing AES 256-bit software encryption at-rest as part of the Qumulo Secure set of data services. For new deployments, Qumulo now encrypts all data, automatically. No additional third-party applications or key managers are needed, and there is no

added cost. Encryption now comes standard, as do all Qumulo features as part of the standard software subscription.

Qumulo Secure provides a wide range of security features, including role-based authentication (RBAC), audit, and encryption in-flight. And with today's announcement, the Qumulo software will now encrypt all data automatically, on any deployment type, at no additional cost. "With Qumulo making industry-standard AES-256 encryption a standard in their solution, I never need to worry about if my data is at risk," said Hanoz Elavia, Storage Administrator at Atomic Cartoons.

Instant Upgrade to Qumulo Core: No downtime to users or applications, no maintenance windows

Software upgrades to IT infrastructure historically required time-consuming planning, maintenance windows, and scheduled downtime. When using Instant Upgrade, the system starts the new version in a container, changes the system to point to the new version, and stops the old version in under 20 seconds, making upgrades fast and consistent across cluster sizes and different underlying hardware. And when OS updates are needed, Instant Upgrade automates those as well, applying updates and rebooting nodes as needed to achieve a fully upgraded environment with ease.

"Managing data with Qumulo is so simple that it's hard to describe the impact. It has given us tremendous ROI in terms of time saved and problems eliminated. Having such reliable storage makes us eager to use it more broadly throughout the company," said John Beck, IT Manager at Hyundai Mobis.

Qumulo Shift: Simplify transformation of data from file to object now with a visual interface

Data is typically created in a file format, but applications and developers often want to leverage capabilities and services connected to cloud object stores such as AWS S3. Qumulo Shift makes it simple to copy data from a file solution into Amazon S3. The new visual interface makes it even easier to leverage data in the location and format that makes innovation fastest. When data needs to be transformed from file to object, customers can simply select their choice Amazon S3 target buckets and initiate a data copy with the click of a button.

With Qumulo Shift, customers can:
- Leverage legacy and cloud-native applications without having to re-build their architecture
- Retain S3-native and file-native properties to maintain full data control and ownership
- Avoid having to refactor applications or use third-party data movement packages

Quobyte Enables Storage for Generation Scale-Out with Latest Version of its Data Center File System (Company PR, 10/13/20)

Quobyte announced details of its latest version of the Data Center File System, a deploy-anywhere, scale-out storage solution with new security features, a powerful

new policy engine and simplicity of self-service to better enable low-latency and high-throughput workloads within a single system.

Quobyte is a software-based distributed file system that offers unlimited performance, unconditional simplicity and seamless integration into any technology stack. Quobyte helps enterprises build a reliable, scalable and flexible software storage infrastructure to help keep up with the exploding amount of corporate data to provide a competitive edge. Version 3.0 of the Quobyte Data Center File System builds on its previous successes to offer organizations additional features of multi-tenancy, 360 security and self-service.

Among the highlights of Quobyte 3.0 are:

360 Security -

- Provides holistic data protection
- End-to-end AES encryption (In transit / at rest / untrusted storage system)
- Selective TLS support, e.g. between data centers
- Access Keys for the file system
- X.509 certificates
- Event stream (metadata, file access)

Powerful Policy Engine -

- Control all aspects of a Quobyte cluster through flexible policies, from data redundancy, automatic recoding to immutability
- The policies can be reconfigured at runtime without interruption of service
- Automation ensures the optimal selection of redundancy and placement, including the new automatic policy that switches between replication and erasure coding as well as flash and HDD inside a file

Self Service -

- Storage-as-a-Service / Cloud-like experience
- Self-service for users from the webconsole
- Automatic resource provisioning from kubernetes

Additional new features of Quobyte 3.0 includes a multi-cluster data mover with bi-directional sync, policy-based data tiering between clusters and recoding; and more native drivers, including HDFS and MPI-IO, which provide the benefits of lower latency and less memory bandwidth by bypassing the kernel.

Quobyte 3.0 is available now through the company's channel of value-added resellers. These VARs, who are committed to providing their customers with a superior storage experience, help find the perfect infrastructure fit for their clients' needs in order to maximize resources with minimal effort. Pricing is based on

volume with unlimited capacity and unlimited clusters available. Discounts are available for academic institutions.

Silicon Motion Launches PCIe 4.0 NVMe 1.4 Controller Solutions for Client SSDs (Company PR, 10/20/20)
Silicon Motion Technology Corporation (NasdaqGS: SIMO) ("Silicon Motion"), a global leader in designing and marketing NAND flash controllers for solid-state storage devices, today announced a new portfolio of PCIe 4.0 NVMe 1.4 controller solutions to address performance, mainstream and value SSD applications. The portfolio consists of SM2264 for performance, SM2267 for mainstream and SM2267XT for value DRAM-less client SSDs.

Silicon Motion's latest controller family has been designed from the ground up with PCIe Gen4 technology and innovative hardware features especially optimized for true Gen4 performance at low power consumption, advanced error correction as well as data path and EMI protections. To date, ten of the leading global NAND makers and SSD OEMs have selected Silicon Motion's Gen 4 controllers with 3D TLC and QLC NAND technologies.

For Performance and Automotive PCIe Gen 4 Solutions: SM2264 Gen4 x 4 Lanes, 8 NAND Channel SSD Controllers
Targeted at performance and automotive SSDs, SM2264 features a quad-core ARM R8 CPU with four lanes of 16Gb/s PCIe data flow and supports eight NAND channels with up to 1,600 MT/s per channel. Its advanced architecture, based on 12nm process technology, enables high throughput, lower power consumption, and rigorous data protection while delivering ultra-high speed of sequential read/write performance of up to 7,400/6,800 MBs and random read/write speeds of up to 1,000K IOPs.

The quad core ARM R8 CPU offers high multithreaded performance to handle mixed workload operations required by emerging storage applications. SM2264 is designed with Silicon Motion's state-of-the-art 7th generation NANDXtend™ ECC technology with a performance-optimized 4KB LDPC engine and RAID to maximized error correction capability for the latest and next generation 3D TLC and QLC NAND. SM2264 is also ideal for automotive storage, offering built-in SR-IOV capability that provides direct, high-speed PCIe interface for supporting to up to eight Virtual Machines. SM2264 is currently sampling to leading customers.

For Mainstream and Value PCIe Gen 4 SSD Solutions: SM2267 Gen 4x4 Lanes, 4 NAND Channel and SM2267XT Gen4x4 Lanes, 4 NAND Channels, DRAM-less

Silicon Motion's SM2267 and SM2267XT meet the requirements of mainstream and value client SSDs and feature four 16Gb/s lanes of PCIe and four NAND channels with up to 1,200 MT/s per channel, delivering an impressive 3,900/3,500 MB/s sequential read/write performance. SM2267 includes a DRAM interface

while the SM2267XT DRAM-less controller enables small form factor SSDs without compromising performance. Both also include NANDXtend™ ECC technology and support the latest TLC and QLC NAND. SM2267 and SM2267XT have entered volume production.

More information about Silicon Motion SSD controllers can be found at www.siliconmotion.com.

	SM2267XT	SM2267	SM2264
Host Interface	PCIe Gen4 x4	PCIe Gen4 x4	PCIe Gen4 x4
PCIe Protocol	NVMe 1.4	NVMe 1.4	NVMe 1.4
NAND Flash Channel	4	4	8
CE/Channel	4	8	8
DRAM	No DRAM	Yes	Yes
Max. Performance			
Seq. Read	3,900 MB/s	3,900 MB/s	7,400 MB/s
Seq. Write	3,500 MB/s	3,500 MB/s	6,800 MB/s
Random Read	500K IOPS (HMB) 200K IOPS (no HMB)	500K IOPS	1,000K IOPS
Random Write	500K IOPS	500K IOPS	1,000K IOPS

Supermicro 2U Ultra-E Short-Depth Server -- Now with NEBS Level 3-Certification -- Delivers Data Center Computational Power to the Telecom Edge (Company PR, 10/22/20)
The 2U Ultra-E short-depth is the latest update to Supermicro's growing NEBS (Network Equipment Building System) Level 3-certified server lineup. Its deployment and operation in telecom and other edge applications confirm that industry-standard and open server computational power can be found outside of traditional data centers.

(PRNewsfoto/Super Micro Computer, Inc.)

The 2U Ultra-E server, available today, targets edge micro data centers and is fueled by dual 2nd Gen Intel Xeon Scalable processors with up to 205-watt TDP. The 2U Ultra-E has front hot-swap drives and fan modules in a compact 22.6-inch depth. Also, the server supports up to 6TB of DDR4 memory in 24 DIMM slots and features eight PCI-E 3.0 expansion slots for flexible networking, GPU, and FPGA selections. This system flexibility and multiple configuration options give customers additional choices for modernizing their data centers and edge infrastructure. Ultra-E NEBS Level 3 versions will support either AC or DC power supplies.

With short-depth systems, NEBS compliance, and DC power options, Supermicro is proving its ongoing commitment to the telecom segment. In parallel, Supermicro continues to collaborate with industry-leading 5G and telco software providers to offer complete solutions. Supermicro is working with open standards such as O-RAN based solutions, as operators are looking for commercial off the shelf (COTS) servers for their new infrastructure rollouts.

Symetrix to continue the development of new semiconductor memory technologies in collaboration with Cerfe Labs (Company PR, 10/1/20)
Symetrix Corporation announced it will continue its development of CeRAM nonvolatile memories and other technologies in collaboration with Cerfe Labs, the recently formed ARM spin-out also announced today. CeRAM harnesses the quantum phase transition known to exist in carbon-doped transition metal oxide (TMO) materials, a transition that produces a huge change in resistance due to a voltage and current induced shift in the occupancy of electron orbitals surrounding each metal ion. Other TMO-based resistive memories being developed elsewhere rely upon the formation and rupture of conductive filaments in the memory element, a mechanism that has proven difficult to reliably control at advanced geometries. CeRAM exhibits robust storage from high temperatures (400^0C) to lower temperatures (< 2^0K) due to robust nonvolatile storage derived from its quantum mechanism and is the first memory to operate in this wide temperature range without degradation. Power consumption is very small with programming voltages at 0.6v and 1.2v and a read voltage below 0.2v (with even lower voltages being

demonstrated using a different TMO).   Read endurance cycling exceeds 10^{12} cycles. CeRAM technology is being prepared through a contract development with IMEC in Belgium for advanced manufacturing on 300mm tooling with process integration compatible with sub-14nm CMOS process nodes.

Taiwan's TSMC reveals details about 3nm process technology (Taiwan News, 10/22/20)
Taiwan Semiconductor Manufacturing Company (TSMC) plans to continue expanding its use of extreme ultraviolet (EUV) lithography tools for its next-generation 3 nm (N3) node process.

TSMC was the first company to use ASML's EUV lithography machines for high-volume production and now has at least three processes that use EUV for select layers, according to Tom's Hardware. The Taiwanese company employs EUV lithography for its N7+, N6, and N5 nodes.

TSMC's 2nd generation 7 nm technology (N7+) uses EUV for up to four layers in order to reduce its use of multi-patterning techniques when building highly complex circuits, while the 6 nm process (N6) is for clients who looking to re-use IP designed for 1st generation 7 nm, per the report. TSMC's 5 nm process (N5) can use EUV for up to 14 layers and is for clients who need a significant increase in transistor density in addition to performance enhancements.

Moving forward, the Taiwanese chipmaker says it plans to offer customers 2nd generation 5 nm (N5P) and 4 nm (N4) fabrication processes, which are primarily based on 5 nm technology and will have performance and power benefits. N5P is slated to become available in 2021, while N4 chips are scheduled for volume production in 2022.

When it comes to their next-generation 3 nm process (N3), it will be a full node improvement over N5. TSMC says there will be a logic density gain of up to 70 percent, an up to 15-percent performance gain, and an up to 30-percent power reduction compared to its 5-nm process. According to ASML, N3 will use EUV over 20 layers.

TSMC will use the FinFET transistor structure for their 3-nanometer chips designed for both mobile and high-performance computing applications. Risk production for their N3 node is scheduled for 2021, with volume production slated for the second half of 2022.

WD_BLACK Expands Portfolio with New Storage Solutions (Company PR, 10/9/20)
Western Digital is helping gamers enhance their setups and adapt to the evolving gaming landscape heralded by the next generation of games with today's introduction of three new and upcoming products for its WD_BLACK portfolio of

storage solutions. These include its first NVMe solid-state drive (SSD) with next-gen PCIe® Gen4 technology, a fully bootable Gen3 x8 add-in-card and a Thunderbolt 3-powered NVMe SSD gaming dock, each offering eye-catching RGB lighting options.

The latest and upcoming WD_BLACK gaming portfolio includes:

WD_BLACK SN850 NVMe SSD – Designed to feature the unprecedented performance of PCIe Gen4 technology, this future-ready product will deliver fast read/write speeds up to 7000/5300MB/s[1] (1TB model). Built with the WD_BLACK G2 controller and optimized for top-tier and high-intensive gaming (not intended for NAS or server environments), the WD_BLACK SN850 NVMe SSD will help gamers achieve supreme PC performance. It reduces game load times and transfers files faster than its predecessor while using brand new cache technology[3]. In addition to high performance, the WD_BLACK SN850 NVMe SSD also delivers improved low queue-depth performance over its predecessor, allowing both gaming and everyday users to experience smoother loading of applications. And, for the ultimate in aesthetics and customization, there will be an optional RGB-enabled heatsink model that cuts down on thermal throttling. The WD_BLACK SN850 NVMe SSD non-heatsink version will be available in 500GB, 1TB and 2TB capacities[2] starting at $149.99 (MSRP USD).

WD_BLACK AN1500 NVMe SSD Add-in-Card – For gamers looking to achieve next-gen performance in a current-gen setup, this fully bootable plug and play add-in card is one of the fastest PCIe Gen3 x8 solutions on the market. Powered by two internal SSDs in RAID 0 and PCIe Gen3 x8 technology, gamers can experience read speeds up to 6500 MB/s[1] and write speeds up to 4100MB/s[1] (2TB and 4TB models), giving them lightning fast gameplay so they can spend less time waiting and more time playing. Customizable RGB lighting (Windows® only) complements your current rig while an integrated heatsink combats thermal throttling to help maintain peak performance. The WD_BLACK AN1500 NVMe SSD Add-in-Card is available in 1TB, 2TB and 4TB capacities[2] starting at $299.99 (MSRP USD).

WD_BLACK D50 Game Dock NVMe SSD – This compact, high-performance gaming dock SSD, with heatsink design, transforms a Thunderbolt 3-compatible laptop into an integrated and immersive gaming station. An optimal solution for gamers looking to streamline their setup, the dock offers superfast speeds with NVMe technology, more capacity for games, and multiple ports for accessories – all powered by a single Thunderbolt 3 cord. The WD_BLACK D50 Game Dock NVMe SSD is complete with customizable RGB lighting controlled through the WD_BLACK Dashboard (Windows® only). The WD_BLACK D50 Game Dock NVMe SSD is available in a 1TB capacity[2] starting at $499.99 (MSRP USD). A non-SSD option, the WD_BLACK D50 Game Dock, is also available for purchase for $319.99 (MSRP USD).

Availability

- The WD_BLACK SN850 NVMe SSD standard non-heatsink model is expected to be available for purchase before the end of October 2020. The WD_BLACK SN850 NVMe SSD heatsink model is expected to be available for purchase in the first calendar quarter of 2021.
- The WD_BLACK AN1500 NVMe SSD Add-in-Card is now available for purchase at select Western Digital retailers, e-tailers, resellers, system integrators and the Western Digital store.
- The WD_BLACK D50 Game Dock and WD_BLACK D50 Game Dock NVMe SSD is now available for pre-order at select Western Digital retailers, e-tailers, resellers, system integrators and the Western Digital store.

Western Digital and Dropbox Team to Accelerate Deployment of Leading-Edge Cloud Infrastructure for Today's Online World (Company PR, 10/28/20)
Empowering the world's most essential data infrastructures, Western Digital Corp. announced that Dropbox Inc. (NASDAQ: DBX), a leading global collaboration platform, is one of the first to qualify the Ultrastar® DC HC650 20TB, host-managed, shingled magnetic recording (SMR) hard disk drives (HDD). With Western Digital SMR HDDs serving as the storage foundation for its custom-built, multi-exabyte storage platforms, Dropbox continues its strategic path, taking advantage of the highest storage densities with the lowest TCO without sacrificing data durability and availability for its 600 million+ online customers.

Zerto Launches New Data Protection Solution; Marks Significant Change to the Backup Industry (Company PR, 10/15/20)
Zerto Data Protection (ZDP) delivers 50% TCO savings by reducing hardware needs, enabling recovery of data without downtime or data loss, and is priced for backup use cases.

ZDP delivers:

- **Local Continuous Backup for Day-to-Day Backup Restores -** local journaling technology allows you to recover without the data loss, downtime, or production impact that are inherent to traditional backup solutions ensuring business continuity and availability.
- **Long-Term Retention On-premises or in the Public Cloud -** required for compliance and regulatory demands where data needs to be stored for months and years, data is incrementally copied from the journal into cost-effective storage on-premises or in the public cloud with Microsoft Azure and AWS, driving cost optimization and the elimination of problematic backup windows. Long-term retention is about adhering to compliance requirements while optimizing costs.

QUARTERLY HDD NUMBERS UPDATE

Total HDD shipments in C3Q 2020 were up 8.3% compared with C2Q 2020 (63.5M versus 58.7M), down 13.5% in C2Q from C1Q 2020, down 12.8% in C1Q 2020 from C4Q 2019, down 5.5% in C4Q from C3Q3 2019 and up 5.8% in C3Q from C2Q 2019.

Seagate and Western Digital have both changed their release of HDD shipment information during their quarterly announcements making it more difficult to figure out their actual unit shipments. WD started with their CQ3 2018 announcements while Seagate starting doing this in CQ1 2017. The latest quarterly numbers from Seagate only give quantitative information for mass capacity (mostly nearline and surveillance HDDs) and legacy HDDs. Western Digital's latest number give similar information. Also, Toshiba has changed their data presentation, starting in 2020, although there is still more detail available than for Seagate and Western Digital. This has made it more difficult to report actual shipments of various categories of HDDs. Thus, the numbers reported here are our best guess estimates.

Notebook HDD shipments are estimated to be up 29.6% from the prior quarter while desktop HDD shipments are up by 17.2% Q2Q. CE HDD shipments were up 1.8% while branded shipments were up 23.5% Q2Q. High performance enterprise HDDs were up 12.9% while near line enterprise HDDs were down 15.8% Q2Q.

3.5-inch HDDs are estimated to have declined by 1.7% Q/Q. 2.5-inch HDDs increased by 23.4% Q2Q.

Total 2020 HDD shipments through C3Q 2020 total 190M. We project C4Q 2020 shipments will be between 60 and 65M units, resulting in 250-255M total HDD shipments for the calendar year, down 19-21% from 316.3M shipped in 2019. Total decline in HDD shipments between 2018 and 2019 was 15.7%.

In **Table 1** we see an 7.6% ASP decrease from C3Q to C2Q 2020 compared to an 2.1% ASP increase from C2Q to C1Q 2020, an 8.9% ASP increase from C4Q 2019 to C1Q 2020, an 2.4% ASP increase from C3Q to C4Q 2019 and an 6.0% ASP increase from C2Q to C3Q 2019. The ASP decline in C3Q 2020 was due to declining nearline HDD shipments.

TABLE 1. AVERAGE DISK DRIVE SALES PRICES (ASP) AND UNIT VOLUMES (MILLIONS/$ PER UNIT)

	Q3 19 Units/$	Q4 19 Units/$	Q1 20 Units/$	Q2 20 Units/$	Q3 20 Units/$
Seagate	33.8/$73.1	32.4/$76.6	29.3/$86.2	26.4/$87.9	25.9/$82.5
WD	29.3/$81.0	29.0/$81.0	24.4/$85.0	23.1/$87.0	23.0/$79.0

The multiyear trends in ASPs as shown in **Figure 1**.

Table 2 gives CQ3 2020 drive numbers by company and application.

Table 3 shows CQ3 2020 drive numbers by company and form factor.

Table 4 shows CQ3 2020 Estimated Exabytes Shipped by company and general application. Note that per Seagate's reports, Legacy includes PC, CE, Branded and enterprise applications.

Figure 2 shows the unit shipment market share of the three HDD producers for 2020 through C3Q 2020. In C2Q Seagate, WDC and Toshba had 44.3%, 39.4% and 16.3% market share. In C3Q these companies had 40.9%, 36.2% and 22.9% market share. Toshiba gained market share from both Seagate and WDC QoQ. Toshiba gained 7% market share in nearline HDDs in C3Q and also gained market share in legacy drives QoQ.

FIGURE 1. AVERAGE DRIVE PRICE TREND FOR SEAGATE, WESTERN DIGITAL AND HGST (Q4 '98 TO Q3 '20)

Figure 3 shows high, median and low estimate of total drive unit volume estimates out to 2025. We have reduced our estimates for 2020 and future years based upon continuing softening in Q3 2020.

TABLE 2. CALENDAR Q3 2020 ESTIMATED DISK DRIVE SHIPMENTS BY APPLICATION (UNITS IN MILLIONS)

Company	Mobile	CE	Branded	Desktop	Near Line	Enterprise	Total Q1
Seagate	5.7	6.9	2.4	4.0	5.5	1.4	25.9
WD	7.1	4.2	2.8	3.4	5.4	0.1	23.0
Toshiba	3.6	3.1	2.4	2.6	1.7	1.2	14.6
Total	**16.4**	**14.2**	**7.6**	**10.0**	**12.6**	**2.7**	**63.5**

TABLE 3. CALENDAR Q3 2020 ESTIMATED DISK DRIVE FORM FACTOR SHIPMENTS (UNITS IN MILLIONS, ESTIMATED)

Company	2.5 inch	3.5 inch	Total Q4
Seagate	11.2	14.8	25.9
WD	10.7	12.3	23.0
Toshiba	9.9	4.6	14.6
Total	**31.8**	**31.7**	**63.5**

TABLE 4. CALENDAR Q3 2020 ESTIMATED DISK DRIVE EXABYTES OF CAPACITY SHIPMENTS

Company	Nearline	Other Mass	Legacy	Total Q3
Seagate	64.30	22.30	27.80	114.40
WD	63.26	13.00	38.24	114.50
Toshiba	16.71	1.40	13.90	32.01
Total	**144.27**	**36.7**	**79.94**	**260.91**

FIGURE 2. 2020 MARKET SHARE THROUGH C3Q
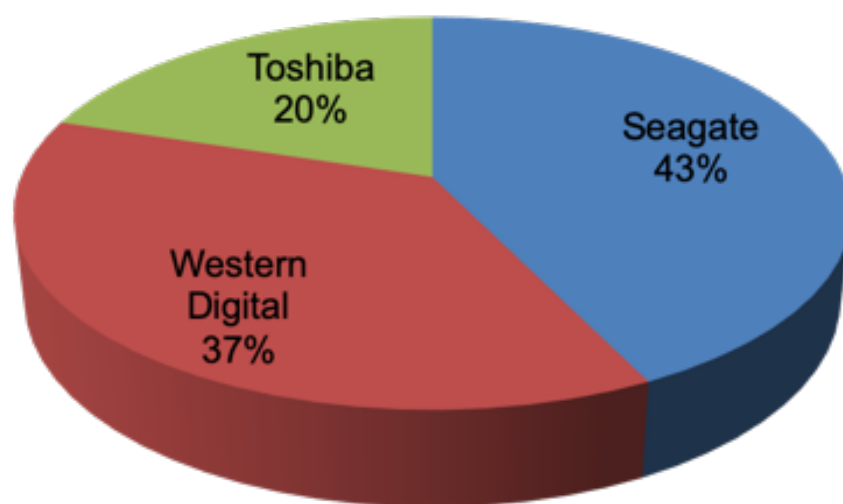
FIGURE 3. BANDED HARD DRIVE VOLUME PROJECTIONS
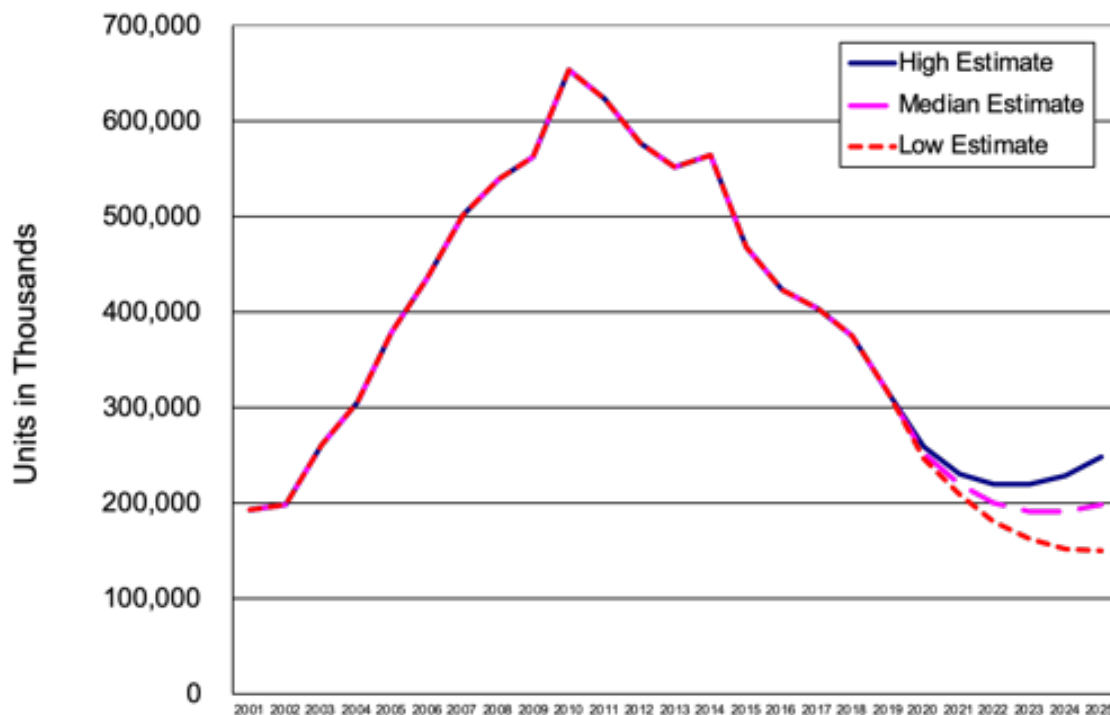
Figure 4 gives our estimates for HDDs, magnetic media (disks) and heads production out to 2025 based upon the median estimate for HDDs in Figure 3.

FIGURE 4. PROJECTED DEMAND FOR HDD HEADS AND DISKS
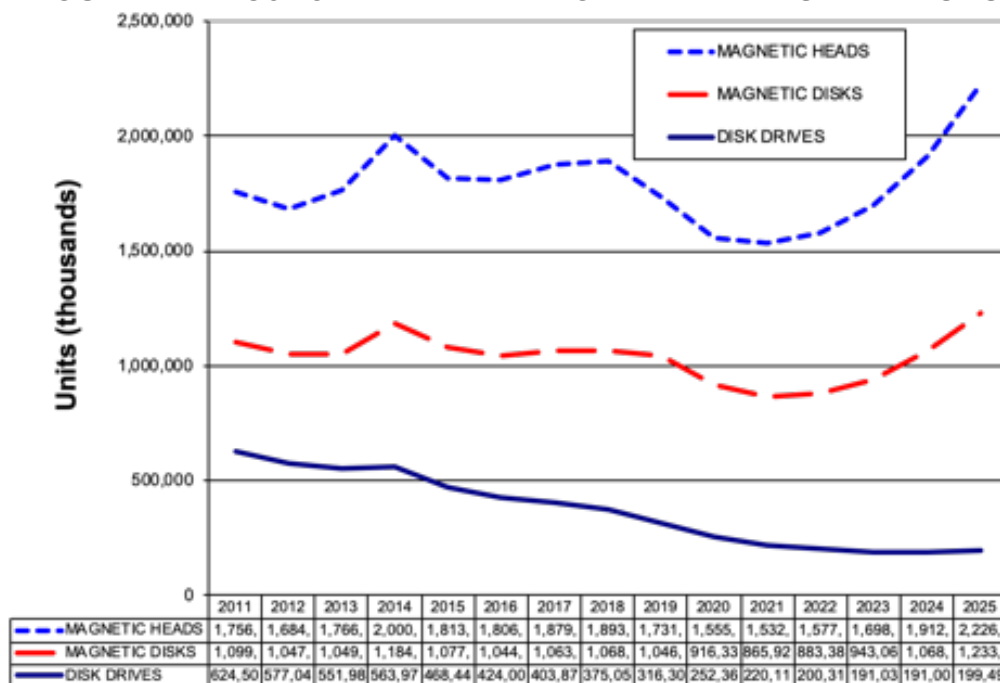
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
MAGNETIC HEADS	1,756,	1,684,	1,766,	2,000,	1,813,	1,806,	1,879,	1,893,	1,731,	1,555,	1,532,	1,577,	1,696,	1,912,	2,226,
MAGNETIC DISKS	1,099,	1,047,	1,049,	1,184,	1,077,	1,044,	1,063,	1,068,	1,046,	916,33	865,92	883,38	943,06	1,068,	1,233,
DISK DRIVES	624,50	577,04	551,98	563,97	468,44	424,00	403,87	375,05	316,30	252,36	220,11	200,31	191,03	191,00	199,49

The growth of capacity-oriented Nearline drives for enterprise and hyperscale applications will result in more components per drive out to 2025. We project that total shipments of heads and media will exceed the peak in 2014 by 2024-2025, largely due to the growth of high capacity (many heads and media) hard disk drives.

Figure 5 shows laboratory demonstrations and product announcement maximum areal densities history.

Figure 6 shows the product announcement maximum areal density per quarter compared to lines representing areal density growth. Note that we are now in a period of extended product and laboratory areal density stagnation, longer than any period since the turn of the century.

Figure 7 gives our projections for drives by market niche out to 2025. **Figure 8** does the same for drive form factor.

Figure 9 projects total shipments of HDD storage capacity on an annual basis to 2025. **Figure 10** shows the average $/GB for HDDs. **Figure 11** shows total projected shipments for Tape (LTO), SSDs and HDDs. **Figure 12** shows Seagate's Q3 2020 Near-Line storage capacity shipment trend chart. COVID-19 data center spending boosted the near-line buying trend in C1Q and C2Q and it has dropped in C3Q 2020.

FIGURE 5. AREAL DENSITY ANNOUNCEMENT DEVELOPMENTS
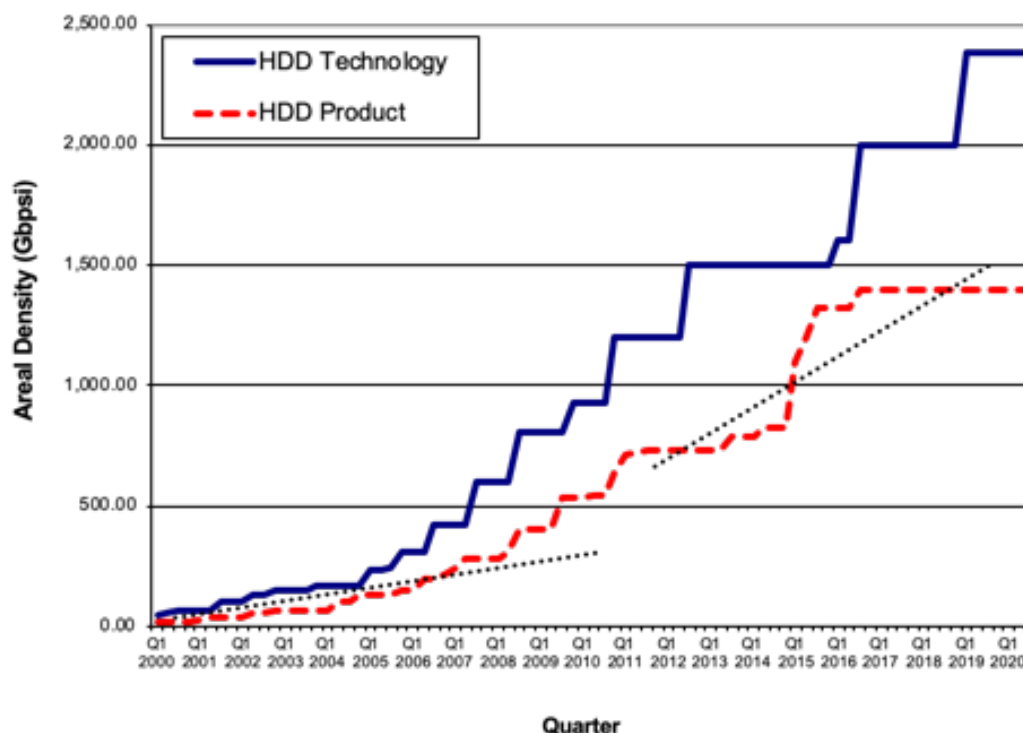
FIGURE 6. AREAL DENSITY PRODUCT ANNOUNCEMENTS VS. CAGR
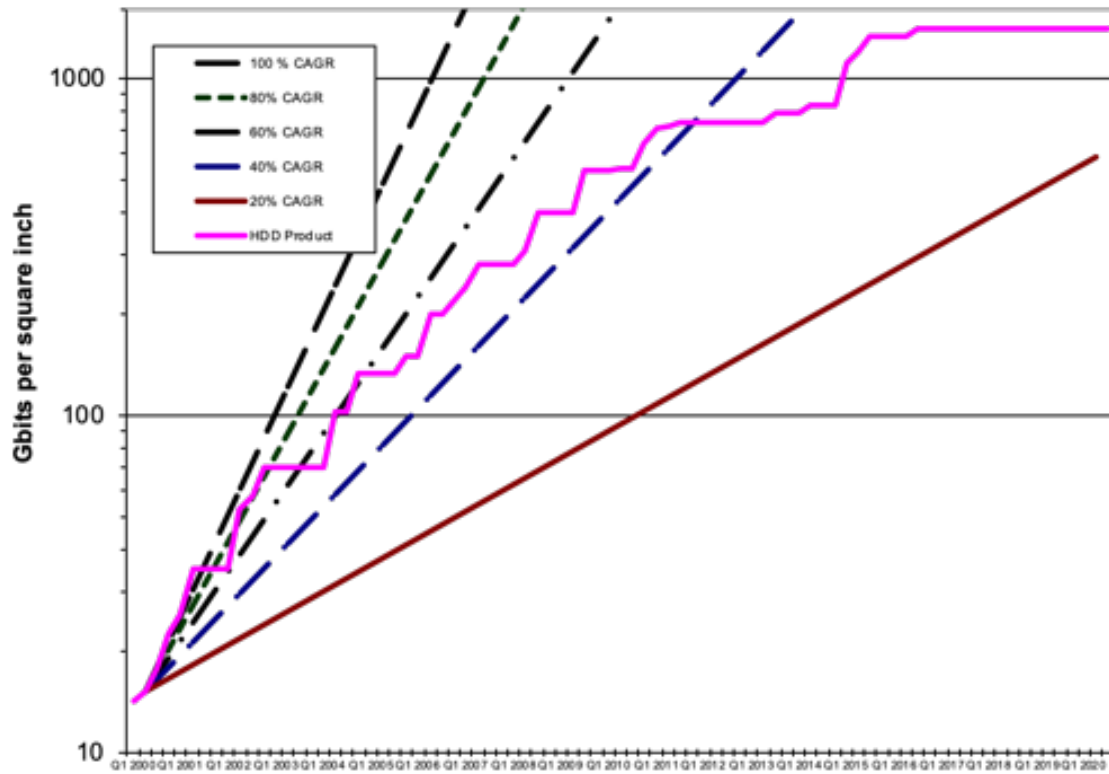
FIGURE 7. PROJECTION OF DRIVES BY MARKET NICHES (1,000'S UNITS)
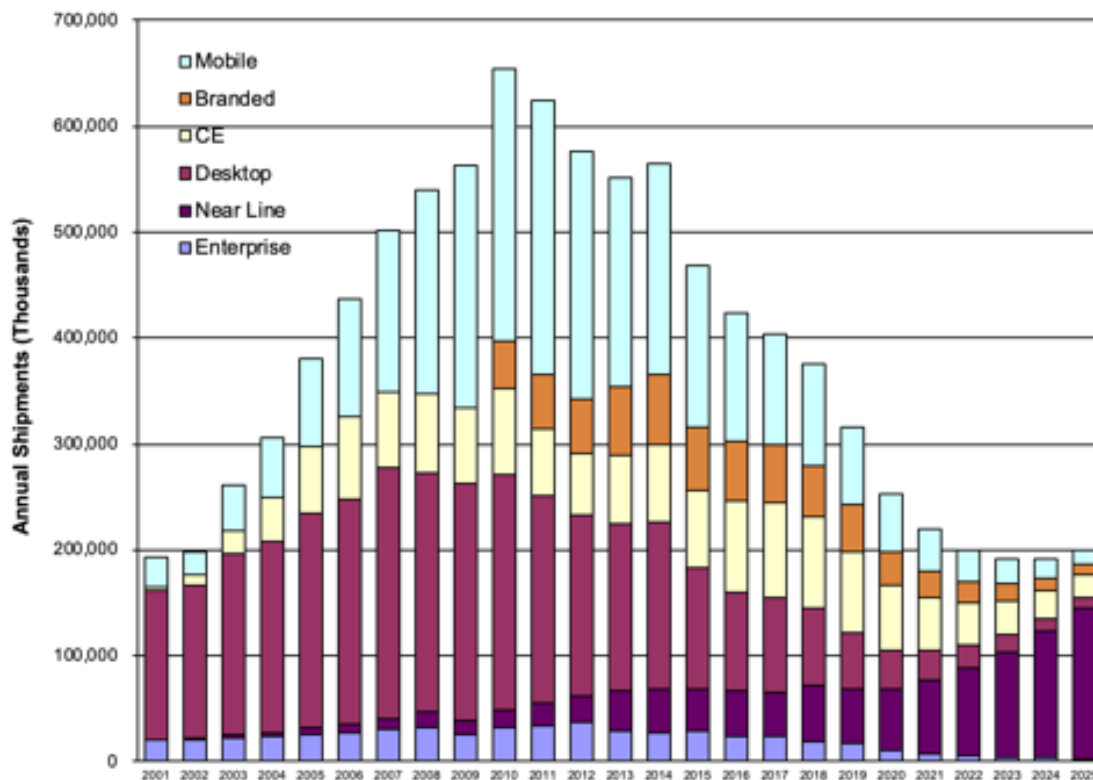
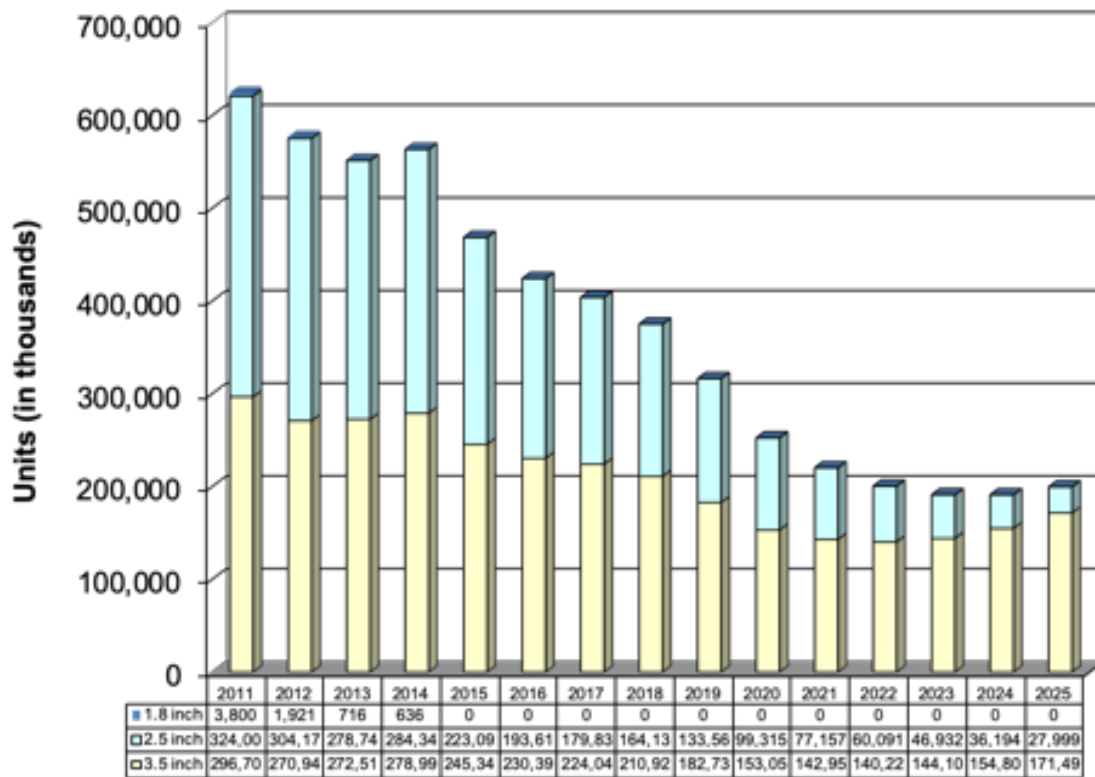**FIGURE 8. PROJECTION OF DISK DRIVES BY FORM FACTOR (K-UNITS)**

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1.8 inch	3,800	1,921	716	636	0	0	0	0	0	0	0	0	0	0	0
2.5 inch	324,00	304,17	278,74	284,34	223,09	193,61	179,83	164,13	133,56	99,315	77,157	60,091	46,932	36,194	27,999
3.5 inch	296,70	270,94	272,51	278,99	245,34	230,39	224,04	210,92	182,73	153,05	142,95	140,22	144,10	154,80	171,49

FIGURE 9. PROJECTION OF DISK DRIVE ANNUAL CAPACITY SHIPMENT
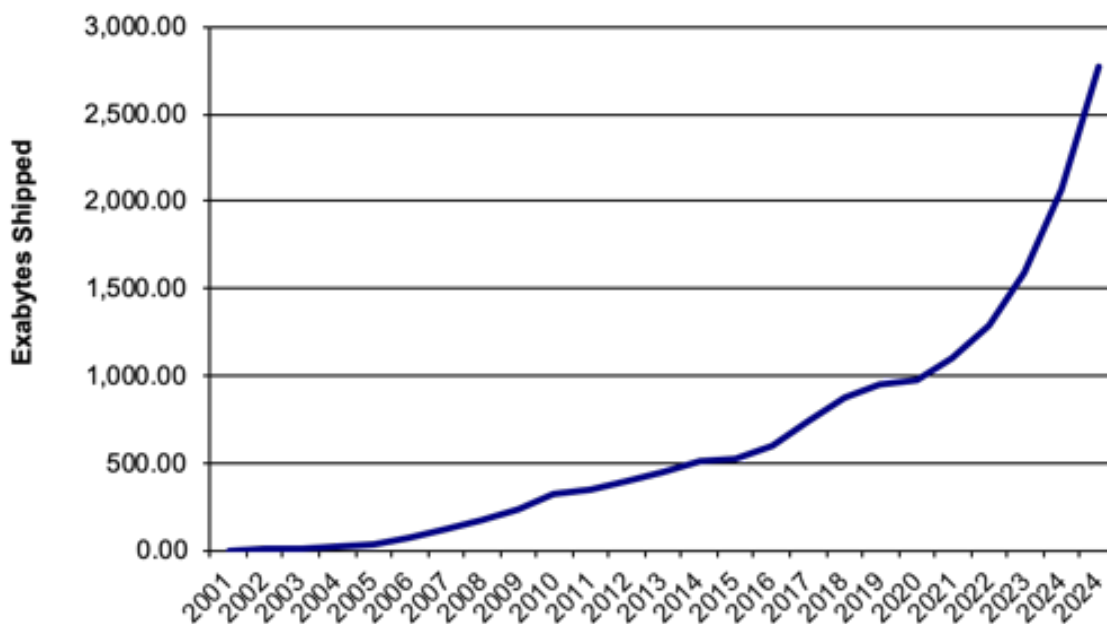
FIGURE 10. AVERAGE $/GB FOR HDDS
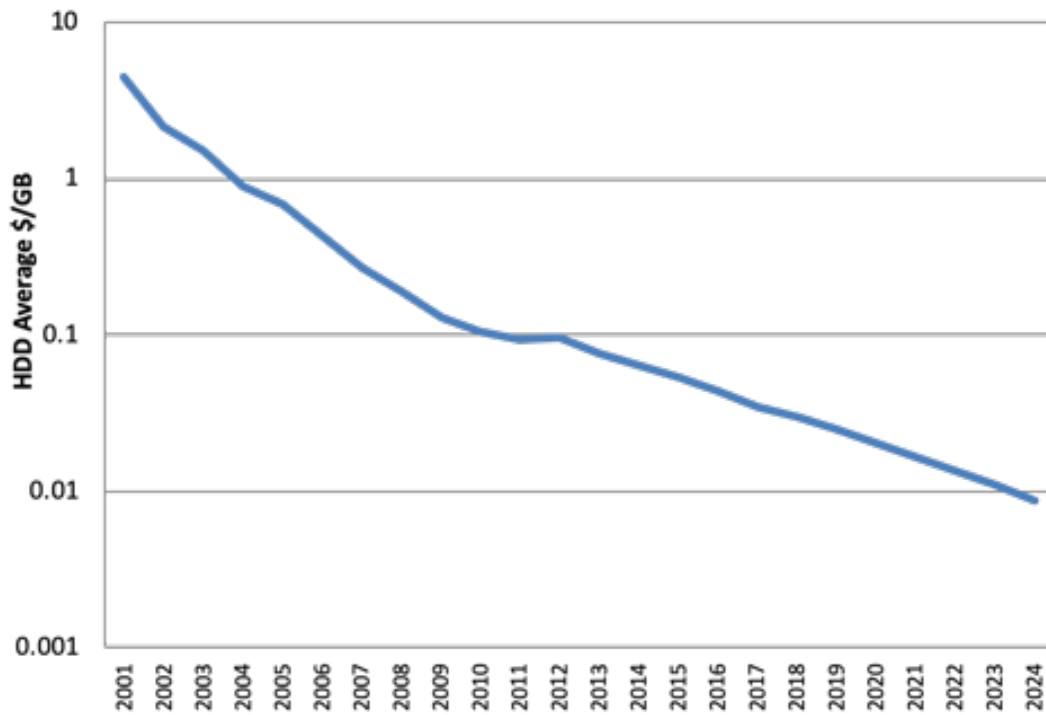
FIGURE 11. CAPACITY SHIPMENTS FOR LTO TAPE, SSDS AND HDDS
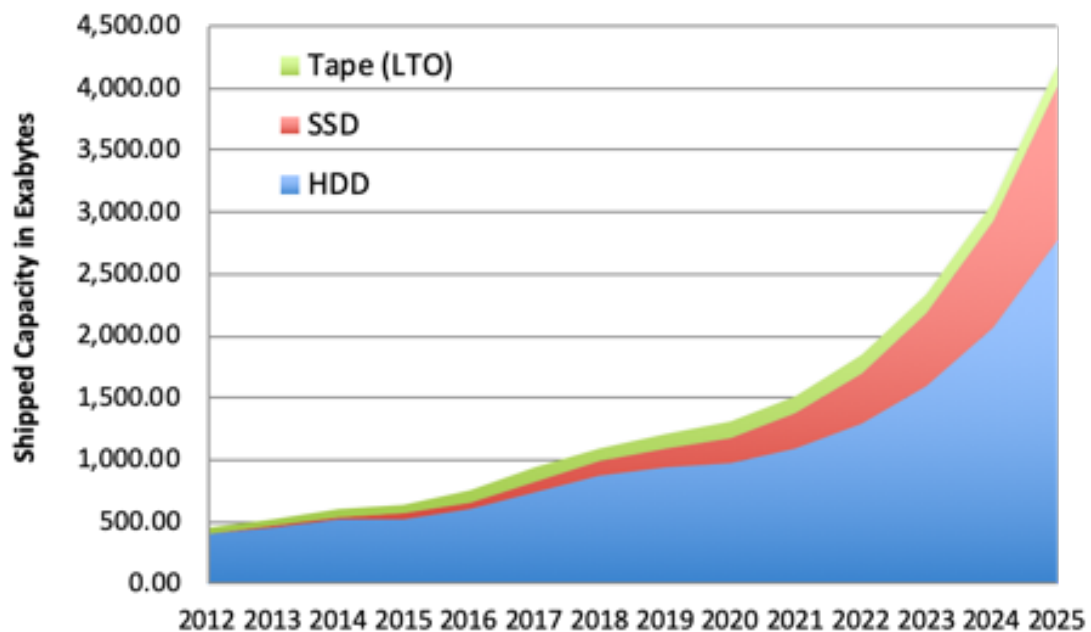
FIGURE 12. SEAGATE CQ2 2020 NEAR-LINE CAPACITY SHIPMENT TREND
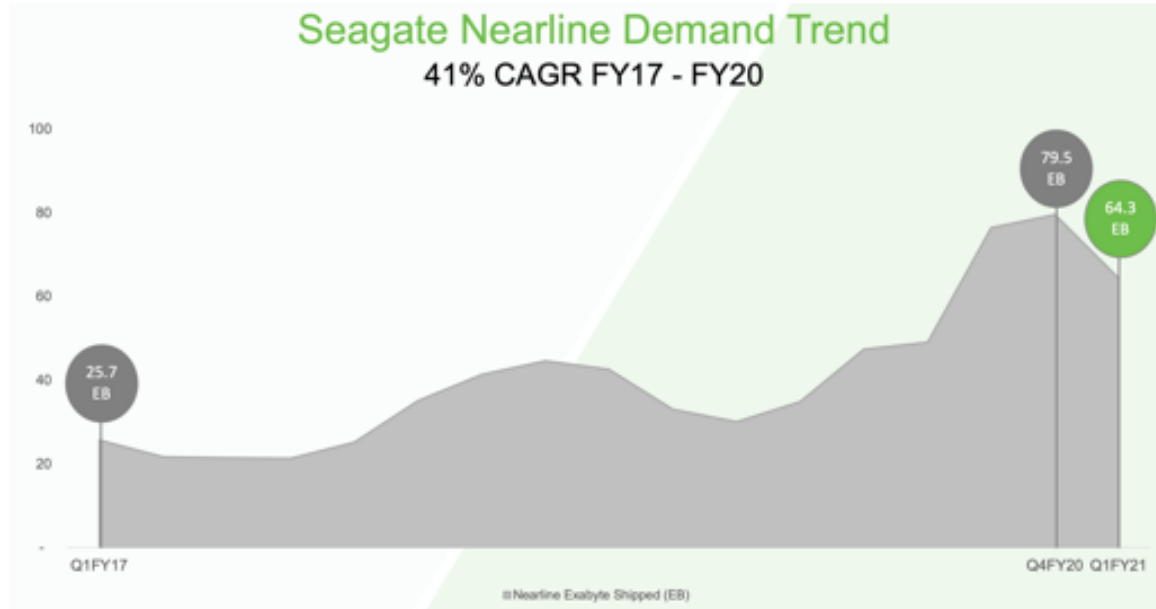
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Emerging Memories Ramp UP

This report, jointly produced by Objective Analysis and Coughlin Associates, provides an exhaustive look at emerging memory technologies and their interaction with standard memories, both as discrete devices and in embedded applications (the memories within logic chips like ASICs and MCUs). The report provides a well of technical information, market dynamics, forecasts, and competitive analyses of the leading companies. Forecasts show how the markets will grow not only for the technologies themselves, but also for the capital equipment used to produce them. Read this to understand the competitive landscape and market drivers for these new memories, and to learn how to profit from tomorrow's market.

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2020 Digital Storage in Professional Media and Entertainment Report

This updated and expanded report is the fourteenth annual comprehensive reference document on this topic. The report analyzes requirements and trends in worldwide data storage for entertainment content acquisition; editing; archiving and digital preservation; as well as digital cinema; broadcast; satellite; cable; network; internet and OTT and VOD distribution. Capacity and performance trends as well as media projections are made for each of the various market segments. Industry storage capacity and revenue projections include direct attached storage, cloud (including object storage), real-time as well as near-line network storage.

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About Tom Coughlin

Tom Coughlin, President, Coughlin Associates is a widely respected storage analyst and consultant. He has over 39 years in the data storage industry with multiple engineering and management positions at high profile companies.

Tom has many publications and six patents to his credit. Tom is also the author of Digital Storage in Consumer Electronics: The Essential Guide, which was published by Newnes Press in March 2008. Tom has also written Blogs on digital storage topics for GLG, POST Magazine and Forbes.com. Coughlin Associates provides market and technology analysis (including reports on several digital storage technologies and applications and a newsletter) as well as Data Storage Technical Consulting services.

Tom is active with SMPTE, SNIA, the IEEE Magnetics Society, IEEE Consumer Electronics Society, and other professional organizations. He is an IEEE Fellow and IEEE-USA President in 2019. Tom is the founder and organizer of the Storage Visions Conference (www.storagevisions.com as well as the Creative Storage Conference (for more information go to www.creativestorage.org). Tom was chairman of the annual Flash Memory Summit for 10 years. He is a Leader in the Gerson Lehrman Group Councils of Advisors and a member of the Consultants Network of Silicon Valley (CNSV). For more information go to www.tomcoughlin.com.

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