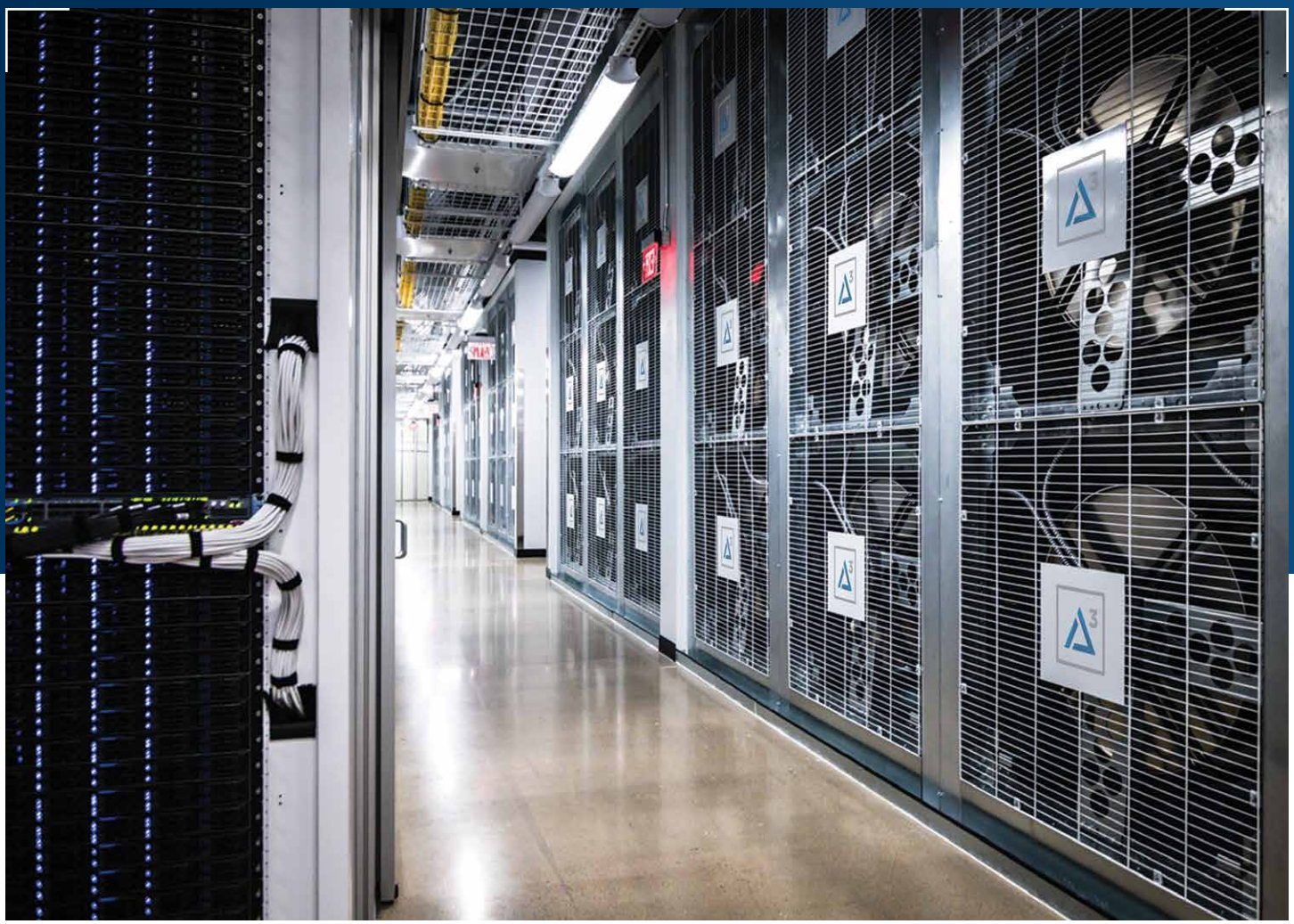
Aligned™
Adaptive Data Centers

WHITEPAPER

Go Dense, Cool Down, and Beat the Heat

Adaptive Infrastructure Solves the Data Center Density and Cooling Challenge



Executive Summary

Advanced technologies and accelerating digitization are dramatically increasing the variability of workloads as well as the density demanded within the data center. Adapting to these new, larger and more variable workloads requires not only efficient and reliable power systems, but also sustainable and reliable cooling systems. The traditional, legacy approach to cooling a data center is no longer practical where it concerns sustainability, efficiency, or total cost of operation (TCO). In order to support the density demands brought about by next-generation tech, data center infrastructure and cooling systems must become more adaptive, efficient, and environmentally responsible—and that extends to cooling systems with the flexibility to go waterless or connect to water-cooled systems, as necessary—in an increasingly water-stressed world.

A Brief History and the Current State of Data Center Density

Designed to reduce the space required for repeater and termination equipment in a telephone company central office, the 19-inch rack format with rack-units of 1.75 inches was established as a standard by AT&T in 1922, typically with 3 kilowatts (kW) of power density. While the rack format has remained a relative constant, the technology mounted within it has changed considerably.

> **"Ten years ago, standard power densities in data centers were 3 to 5 kW per rack. Today, it's common to see 8 to 12 kW per rack, with some deployments reaching 30 kW and beyond."**

Today, advancements in chipset technologies for both CPUs and GPUs continue to drive compute densities upwards, with an average density of more than 11 kW per rack. Modern IT server architectures such as 5U, hyper-converged infrastructure, rack scale designs, and multiple other forms of high-performance computing (HPC) are rapidly becoming mainstream. Artificial Intelligence (AI) and other dense architecture and applications can draw as much as 30 kW per rack or more. HPC deployments inside hyperscale data centers can reach 50 kW and beyond.

Data center density also may be measured by the number of watts consumed per square foot of white space, or watts per square meter outside the United States. By this standard, over 300W per square foot is now considered high density.

Given the increasing adoption of next-generation technologies, such as AI, machine learning, the IoT, blockchain, and virtual/augmented reality (VR/AR), densification in the data center will undoubtedly continue to climb. All these technologies call for considerably more compute, thus generating more heat. This in turn prompts customers to seek higher-density cooling solutions while maintaining, or better yet, lowering, overall cooling costs. All good in theory—or as a customer wish list—but how?

> **"We've seen two years' worth of digital transformation in two months."**
>
> **—Satya Nadella, CEO, Microsoft**

Meanwhile, accommodating unpredictable usage and growth models among hyperscalers and cloud and platform providers has become table stakes due to dynamic and increasing business demands. Compute loads are becoming more dynamic and unpredictable as demand varies from month-to-month, day-to-day, hour-to-hour, and project-to-project. Take e-Commerce traffic spikes during the holidays, for example.

These realities foreshadowed a digital economy thrust suddenly into overdrive as we all adapted to working, studying and playing from home in the wake of the pandemic. As Microsoft CEO, Satya Nadella, stated at the time, "We've seen two years' worth of digital transformation in two months."

But even before companies accelerated their digital transformation initiatives practically overnight, customer-driven demands and new technologies had been dramatically increasing the variability of workloads and the density requirements of data centers. Let's remember that as recently as ten years ago, standard power densities in data centers were 3 to 5 kW per rack. Today, however, it's common to see 8 to 12 kW per rack, with some deployments reaching 30 kW and beyond.

And for legacy data centers, therein lies the crux of the dilemma.

Overprovisioned and Underutilized

Legacy data centers are configured at a static density, whereby the space layout, power, and cooling systems are designed to support a certain density per square foot. To alter the density the footprint can support requires reconfiguring the layout, including the setup of power and cooling systems. Very often, a legacy data center may have available floor space and racks but no remaining power or cooling. Alternately, it may have the power and cooling capacity available but no remaining space.

To allow for future growth in space, power, and cooling, legacy data center operators have to overprovision. While that allows for future vertical and/or horizontal scalability, it also means the data center is underutilized, often for many years, which leads to significant capital cost inefficiencies.

Most data centers can support high-density servers, but the only way to ensure they don't overheat is to either half fill the racks or spread them apart. Both approaches create stranded capacity, a significant inefficiency in data centers, and a key driver of low infrastructure utilization rates.

> Has your organization's average rack power density increased in the past year, or is it shrinking? The Uptime Institute recently posed that question to global data center owners and operators. More than one out of five respondents affirmed, "Yes, and rapidly."

Supporting higher densities and increasingly dynamic compute loads without stranding capacity and enabling scalability without overprovisioning requires the provider and its infrastructure to be adaptive. One of the most critical challenges to address with increasing power density within the data center is cooling.

Traditional approaches to power and cooling have evolved around relatively stable loads of similar density. That is not the compute of today, when cooling systems need to be efficient and stable under dramatically varying loads and delta Ts.

Because the traditional data center can't support workloads that are dynamic from minute-to-minute, data center operators have to provision and run data center infrastructure as if IT loads were at their peak all the time. That allows the data center to support workload peaks, but it also means that the data center is grossly underutilized some, if not most, of the time.

One McKinsey & Company study found that the average data center uses only six to 12 percent of its power to do computation work. The remainder is lost idling while waiting for the next traffic surge, likely due to over-provisioning of resources out of fear of downtime. This leads to energy as well as water inefficiencies, with resulting cost implications, because traditional data center infrastructure is not built to run efficiently at low loads.

Data Center Sites Dying of Thirst

In their quest for energy efficiency and low Power Usage Effectiveness (PUE), many if not most legacy data center providers are expending tremendous amounts of water on cooling, a trend that will only continue as data center power density increases with the proliferation of compute-intensive workloads.

While some data centers have made great strides in reducing their carbon footprint, the crisis of water scarcity has reached a tipping point. The increase in water consumption and cost may not offset the savings in electricity for a particular site. This is especially the case in data center locations that are water-stressed.

According to Venkatesh Uddameri, the Director of the Water Resources Center at Texas Tech University, the typical data center uses about three to five million gallons of water per day, the same amount of water as a city of 30,000-50,000 people.

Collectively, legacy data centers are among the top-ten water consuming industrial or commercial industries in the U.S. One-fifth of data center servers' direct water footprint comes from moderately to highly water-stressed watersheds, while nearly half of servers are fully or partially powered by power plants located within water-stressed regions.

According to Gartner, public cloud adoption has accelerated, driving growth of the large data center category, which will reach nearly 1,900 sites by 2025. It will account for over 40% of the server installed base this year. This growth comes at a time of record temperatures and drought in the U.S., particularly in the West. However, these environmental challenges are by no means limited to North America. Globally, the United Nations estimates that one in four people may live in a country affected by chronic shortages of fresh water by 2050.

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Aligned's Delta³ Cooling System

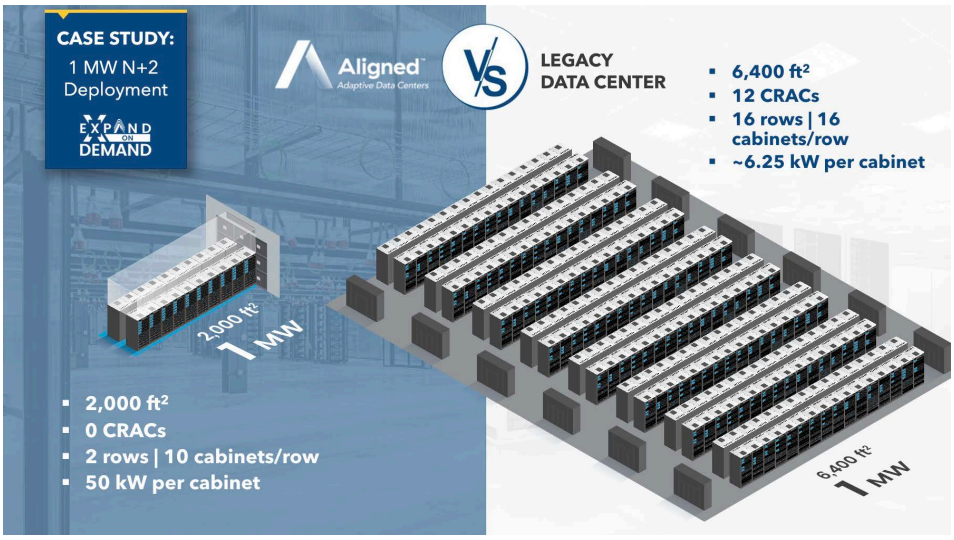
- Flexibility, adaptability and reliability at any load
- Efficiency in any climate with an industry-leading PUE as low as 1.3 in some cases
- High, mixed and variable rack densities of 1-50kW in the same row
- Increase density without reconfiguring infrastructure or stranding capacity
- Consume less space, electricity and water for significant cost savings

A Better Way to Densify

Aligned is laser-focused on solving customers' capacity management challenges through continuous improvement and innovation in adaptive data center design, including Delta³, the company's patented and award-winning cooling technology.

The Delta³ cooling system responds to the shifting data tide, supporting high, mixed, and variable densities within the same row. The system can handle much higher delta Ts than is typical because instead of forcing cold air into the data hall, it removes the heat at its source, with heat sinks close-coupled with the server racks. The Delta³ design accommodates both new data centers and retrofit facilities, improving the efficiency of existing infrastructure. Along with reducing customers' environmental footprint, this lowers the Total Cost of Ownership (TCO) for customers, delivering efficiency at any load, in any climate, and regardless of location.

Delta³ solves the challenges associated with sustainability and efficiency, specifically high, variable, and mixed density without specialized cooling infrastructure that is both costly and risky (i.e., water in proximity to equipment). The system is dynamic, ramping up and down based on server load. Variable speed fans and Variable Frequency Drive (VFD) pumps allow flow rate to respond to changing loads. The system matches the airflow of servers as they ramp, helping server fans spin down to their lowest levels. That lowers critical load, and at scale saves a significant amount of power and reduces airflow requirements.



Sustainable Future-Proofing:

ExpandOnDemand™

Future-proofing the data center doesn't require overprovisioning and stranding resources, capacity, and capital. To the contrary, both sustainability and lower cost of infrastructure are within reach.

Aligned's Mechanical, Electrical and Plumbing (MEP) design decouples space from power and can support density increases vertically within the rack or horizontally with additional rack positions by supplementing the data hall with additional Delta³ units without impacting live load. For example, if a customer purchases 8 MW in 25,000 square feet, and three years into a seven-year term wants an additional MW within the same space (i.e., densification), Aligned's systems can accommodate this vertical scale without requiring the customer to purchase adjacent space or exotic cooling solutions.

One Aligned Delta³ array cools up to 438 kW of heat in a four-foot section, which enables the Aligned system to support much higher watts per square foot (WPSF) of capacity without requiring supplemental cooling. Additionally, Aligned's system utilizes tight airflow controls to maintain enough of a negative pressure in the hot aisles that both high density and mixed density racks can be cooled efficiently.

Modular cooling systems allow for the easy addition of more cooling arrays as density grows, increasing cooling capacity on demand. With most data center operators, customers would need to build or buy more data hall space if more power capacity were needed. But in deploying a more adaptive and modular cooling technology, customers have the ability to densify the same footprint over time without stranding unused space or capacity.

Competitive Analysis

Aligned commissioned a third-party provider to conduct tests comparing the Delta³ cooling system with the main competitive cooling systems in the industry. These tests prove that Aligned's Delta³ technology is more efficient, cools more per square foot while using less power, and takes up less data center space than its competitors.

Model	Testing Factors						
	Capacity (kW)	**Pressure Drop** (ft HD)	**Fan Power** (kW)	**Size** (LxWxH)	**Fan Ratio** (W/kW Cool)	**Linear Density** (kW/ft)	**Area Density** (kW/ft)
Delta³	**282**	**21.9**	**11.3**	**58x62x181**	**40**	**58.3**	**11.3**
Tech 2	750	26	31	204x80x201	41.3	44.1	6.6
Tech 3	750	26	27	204x60x156	36	44.1	8.8
Tech 4	450	27	21.3	120x60x164	47.3	45	9
Tech 5	454	18.6	22.2	120x60x144	48.9	45.4	9.1

Cooling with the Flexibility to Go Waterless

The ultra-efficient Delta³ cooling system can also be paired with an air-cooled chiller to create an extremely efficient, waterless system within the data center.

The target design PUE for an Aligned data center is 1.3; this is achieved working hand-in-hand with customers to ensure a tight correlation between their committed IT load, utilization, and proper containment. Aligned's Delta³ cooling system relies on being able to capture the heat, before it can blend with the cold air, and extracting it from the IT environment. The higher the return temperatures, the better efficiencies, and the lower the PUE will be.

The Delta³ cooling system also has the flexibility to connect to water-cooled systems. Instead of it being the coil on Delta³, it's the coil on the chip.

50kW per rack can be air-cooled if air can blow across the chip, but for densities above 50kW, air is no longer sufficient to cool the chip. Typically, 50 kW will require some water-cooled addition. The breaking point will be dependent on the OEM of the chip (HP, Dell, etc.).

Aligned also has experience with both refrigerant and deploying a loop. A traditional, water-cooled loop can easily connect to the Delta³ cooling system. The cooling system design allows 4-inch connections for Delta³ to be added, taking that 4-inch loop connection and adding a secondary loop to a heat exchanger or a cooling distribution unit (CDU).

A common issue with water-cooled systems is leak detection. This is particularly a problem with rear-door heat exchangers. To detect and prevent leaks, Aligned installs leak detection systems and ensures our customers install them as well. If necessary, we can also bathtub servers. Our heat exchanger is the line of demarcation, so that keeps the water at bay as well.

Offering even greater flexibility, Aligned can deploy both air and water-cooled systems in the same space, next to Delta³ cooling arrays. Along with CDUs, our engineers have also worked with computer room air handler (CRAH) units and pumped refrigerant CDUs.

CASE STUDY

Cooling the Supercomputers of Our Environmental Stewards

A government agency with thousands of engineers and scientists who use high-density supercomputing to predict and respond to climate change and other environmental challenges selected Aligned as its data center provider.

Challenge:

The customer was looking for a provider with an ability to understand their needs and work with different technology partners to provide an optimal solution that addressed its cooling and scalability challenges. The agency previously used rear-door heat exchangers to cool their environment.

Solution:

Aligned integrated our patented and award-winning Delta^3 cooling technology with the agency's water-cooled infrastructure to accommodate the high temperatures associated with supercomputing. Aligned's cooling systems are designed to be easily, efficiently and cost-effectively configured for supercomputing.

Results:

Aligned ultimately saved the government agency millions of dollars in upfront capital expenditures and provided it with the ability to scale their solution quickly, seamlessly and cost-effectively, as needed. In fact, Aligned gave the agency the scalability and flexibility to double their operations in the same space, along with the ability to grow into the solution over time, which will provide additional significant savings.

Conclusion

Coming to an end are the days when data centers opened with huge tracts of unused floor space earmarked for years of anticipated growth, but with little to no anticipation of changing computing environments. High-performance workloads will continue to require higher power density per rack. There are tremendous benefits to increasing density, and it's not a complex, exotic, or expensive proposition. With the right cooling technology, companies can save data center space and reduce energy costs through increased efficiencies. Future-proofing the data center doesn't require overprovisioning and stranding resources, capacity, and capital. To the contrary, both sustainability and lower cost of infrastructure are within our reach.

Contact

For more information about Aligned Data Centers and its Delta Cube cooling technology, please email sales@aligneddc.com and visit www.aligneddc.com/technologies/.

About Aligned

Aligned Data Centers is a leading technology infrastructure company offering innovative, sustainable, and adaptive Scale Data Centers and Build-to-Scale solutions for global hyperscale and enterprise customers. Our intelligent infrastructure allows densification and vertical growth within the same footprint, enabling customers to scale up without disruption, all while maintaining industry-leading Power Usage Effectiveness (PUE). By reducing the energy, water and space needed to operate, our data center solutions, combined with our patented cooling technology, offer businesses a competitive advantage by improving sustainability, reliability, and their bottom line. For more information, visit www.aligneddc.com and connect with us on Twitter, LinkedIn and Facebook.