Case Study

Advanced Cooling Advances Science

One University's Immersion-Cooled, Supercomputing Journey

GRC
THE IMMERSION COOLING AUTHORITY®

POWERED BY
DELL Technologies

The Texas Advanced Computing Center (TACC) was busier than ever. Designer and operator of some of the world's most powerful computing resources, they had several thousand projects in the queue, and needed to upgrade their already powerful Lonestar5 supercomputer to keep up.

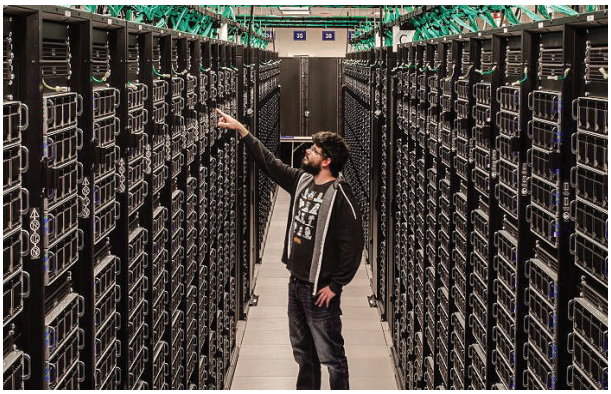
But in order to make the massive scientific leaps for which they were famous — in fields like quantum mechanics, astrophysics, photovoltaics, and biological research — major obstacles stood in the way:

- Available **space**
- Available **power**
- Available **budget**

With the launch of their new Lonestar6 supercomputer, TACC overcame each of those obstacles, reduced their backlog, and accomplished their goals with the help of GRC, along with partners Dell Technologies OEM Solutions and AMD.

About TACC

TACC's unassuming name belies the groundbreaking work for which they are widely known. Located at The University of Texas at Austin, their mission is to enable discoveries that benefit science and society through the application of advanced computing technologies. For this they receive funding from the National Science Foundation (NSF), along with other important research and education institutions.



Since their inception in 2001, TACC has evolved their capabilities while making the best use of their existing hardware investment whenever possible. As a result, they have employed a variety of cooling strategies that include CRAC[1] and chiller, in-row, liquid-to-chip, as well as single-phase liquid immersion cooling.

Immersion cooling in particular has allowed TACC to continue achieving key scientific advancements by pushing the limits of computing power. Thus, it comes as no surprise that they are now the home of the world's longest running immersion cooling system. This system was designed by GRC, who pioneered single-phase liquid immersion cooling for data centers.

TACC is the home of the world's longest running immersion cooling system.

[1]Computer room air conditioning.

TACC's Long, Productive Partnership with GRC

Faced with increasing power demands, the advent of advanced server and processor technologies, and higher operating temperatures, TACC foresaw the limits of air-cooling early on. Largely out of necessity, they soon discovered liquid immersion cooling's potential to address these challenges.

Starting with a single-rack installation in 2009, TACC has continued stretching the boundaries of supercomputing using Austin-based GRC's innovative liquid immersion cooling solutions. And they have since quadrupled the deployments of ICEraQ®-cooled supercomputing systems leading up to Lonestar6.

Progression of TACC's Single-Phase Immersion Cooling Systems

2009

ICEraQ Prototype

- Proof-of-concept for immersion cooling ability and reliability
- Installed on a loading dock Demonstrated location flexibility of single-phase cooling
- No chilled water; used evaporative cooling tower

2012

Maverick2

- Supports GPU-accelerated machine learning and deep learning research
- Proof-of-concept for the future Frontera supercomputer
- 30 kW/rack density
- 23 nodes each with 4 NVidia GTX 1080 Ti GPUs running in a Broadwell-based compute node
- 4 nodes each with two of NVidia V100s GPUs running in a Skylake-based, Dell PowerEdge R740-based node
- 3 nodes each with two NVidia P100s GPUs running in a Skylake-based Dell PowerEdge R740 node

Progression of TACC's Single-Phase Immersion Cooling Systems

2019

Frontera

- Single-precision compute cluster to run AI, machine learning and molecular dynamics applications accelerating new scientific discoveries
- Hybrid liquid immersion-cooled GPU subsystem and liquid-to-chip
- 60 kW/rack density
- Intel® Xeon® CPU E5-2620 v4 @ 2.10GHz
- 16 cores per socket, 32 per node
- 360 NVIDIA Quadro RTX 5000 GPUs; 4 GPUs per node
- Became the most powerful Peta scale supercomputer at any U.S. university

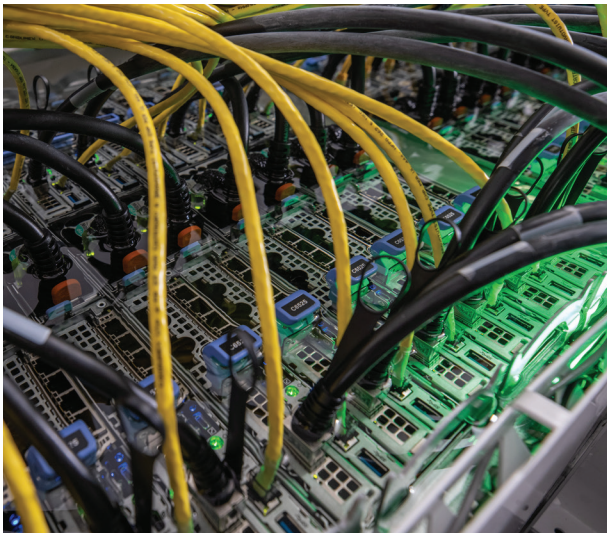
2021

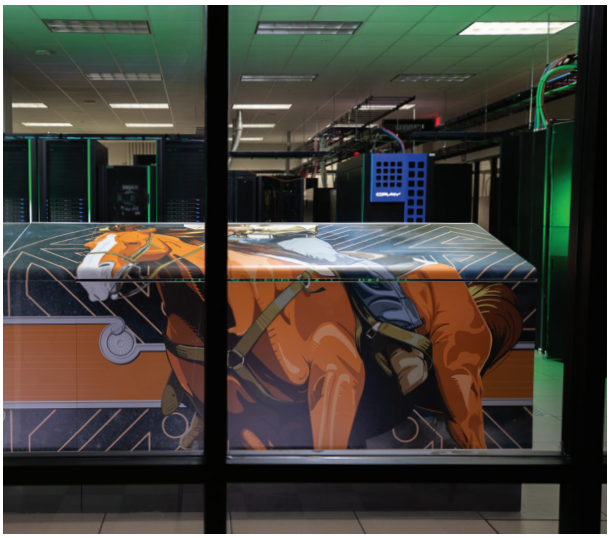
Lonestar6

- Can perform ~3 quadrillion mathematical ops/second
- Operates within a discrete high-density zone
- 70 kW/rack
- Hybrid immersion and air-cooled system
  - 336 immersion-cooled, compute nodes
  - 80 air-cooled GPU nodes
  - 200 air-cooled 1U servers in 10 racks
- 84 Dell PowerEdge C6525 servers
- 2x AMD EPYC 7763 64-Core CPUs ("Milan"), 2.45 GHz (boost up to 3.5 GHz)
- 128 cores on two sockets (64 cores/socket)

Learn more about TACC at TACC.UTexas.edu

Lonestar6: TACC's 'Brightest' Supercomputer Yet





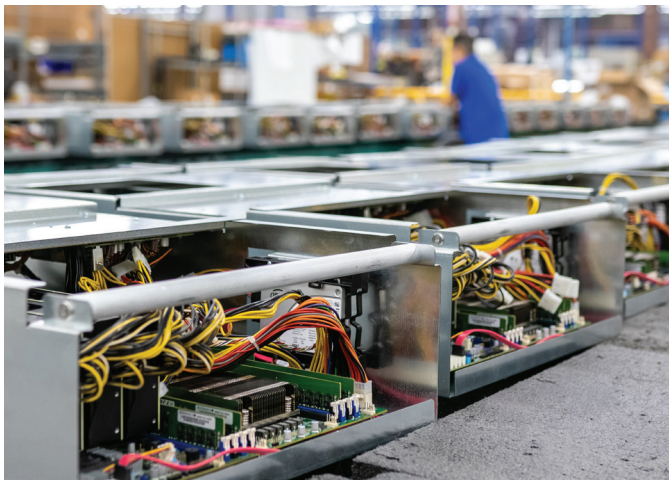
The newest in TACC's Lonestar series of high-performance computing systems, Lonestar6 was deployed specifically to support Texas researchers. Clocking in at an amazing three petaflops, it is three times as powerful as its predecessor, and one of the fastest supercomputers at a U.S. university.

Of course, where data centers are concerned, with increased performance comes greater heat production. Working closely with TACC, along with partners Dell Technologies OEM Solutions and AMD, GRC has evolved their single-phase immersion cooling systems to overcome the heat dilemma.

Because of GRC's proven performance, TACC chose to cool Lonestar6 with the latest evolution in GRC's ICEraQ line of single-phase immersion cooling solutions: the ICEraQ Series 10 Quad.

Persistent TACC Challenges

While housing a succession of acclaimed supercomputing systems, the Texas Advanced Computing Center has never been immune from the many challenges less celebrated centers face every day. Perhaps the biggest is discovering that air cooling is simply incapable of handling the kind of GPU-heavy compute loads that are in growing demand today — notably HPC, AI, and AR/VR applications.



Immersion cooling was chosen to extract the heat from the massive GPU subsystem for the demanding projects the Frontera compute cluster was about to face.

Nor, despite its notoriety, is TACC exempt from dealing with issues like finite space or limited funding. In the latter case, the ICEraQ Series 10 Quad helped them optimize GPU processing with the allotted grant monies.

TACC has faced other distinctive challenges as well, starting with triple-digit weather that is common to their region. Complicating matters even more, *"TACC is very unique in that they have a number of different cooling technologies, and a number of different computing evolutions, all in one facility,"* explains Brandon Moore, GRC's Senior Solutions Architect.

GRC's liquid immersion cooling solution addressed all these concerns. Thus, for TACC, immersion cooling soon emerged as the only practical way forward.

> Air cooling is simply incapable of handling the kind of GPU-heavy compute loads that are in growing demand today.

Why TACC Chose GRC

GRC's ICEraQ Series 10 Quad enabled TACC to triple their raw computing power within the same space and power envelope. That alone stood as an overriding reason to choose GRC. But other factors influenced their decision as well.

ICEraQ installation is straightforward and systems are operational in just days.

Decision Factors:

- Sheer cooling performance
- Reduced CapEx and OpEx
- Sustainability
- Minimal changes to infrastructure
- Location flexibility
- Reliability and safety
- Partnerships with technology providers
- Results of previous GRC system deployments

A single ICEraQ Quad with 336 high-performance nodes now carries the bulk of the Lonestar6 compute load. More compute, less space, and no infrastructure upgrades made immersion cooling the ideal solution for Lonestar6.

"We had the budget to install 600 nodes," says Tommy Minyard, Ph.D., TACC's Director of Advanced Computing Systems. *"But we didn't have the corresponding cooling capacity for it. We evaluated several different vendors and cooling technologies, and cost was a huge consideration."*

For both environmental and cost considerations TACC also wanted to minimize the extent of modifications to the data center, which was another reason they opted for the GRC solution. That and GRC's historical willingness to partner with TACC and Dell Technologies to problem solve and create ideal solutions.

"GRC's immersion cooling solution has given us the ability to use the densest servers from Dell Technologies and hottest chips from AMD."

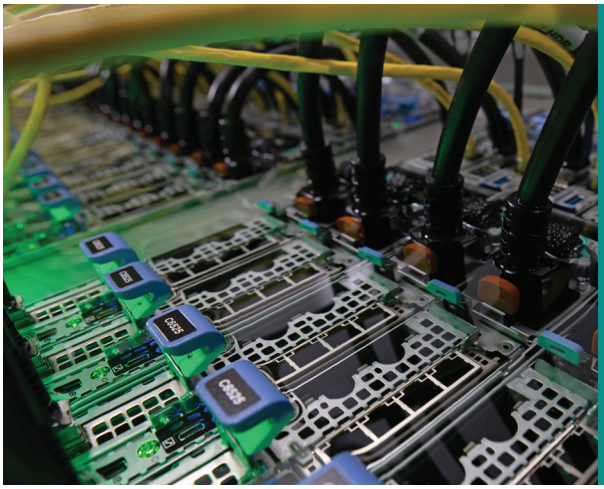
—Tommy Minyard, TACC's Director of Advanced Computing Systems

Immersion Cooling Delivers Impressive Results

Thanks in no small part to single-phase immersion cooling, TACC's Lonestar6 supercomputer delivers **three times the performance than its predecessor — with less space, power, and expense.** That level of productivity has proven itself critical to TACC's ability to continue extending the boundaries of scientific discoveries.

"When running parallel simulations, you need to squeeze every bit of performance out of these computers," explains Dan Stanzione, Associate Vice President for Research at The University of Texas at Austin, and TACC's Executive Director. *"The only other option would be to run air cooling at hurricane speed, or else slow the chips down."* The latter was not really feasible, considering that doing so would add to project lead times, reduce the number of projects that can be completed, increase costs due to longer run times, and be a very inefficient use of Lonestar6's processors.

GRC's ICEraQ Series 10 Quad has helped provide a host of benefits to TACC's operation.



Immersion Cooling Benefits Critical for Lonestar6

- A huge jump in performance
- Running high-power chips at a very high density
- Cooling 70 kW/rack (with more to spare)
- Doubling the number of servers in same power envelope
- Accommodating more nodes per rack
- Maximizing a hybrid cooling environment

"GRC's immersion cooling solution has given us the ability to use the densest servers from Dell Technologies[2] and hottest chips from AMD[3]," Tommy Minyard declares. *"These chassis have 280 W CPUs that run so hot they cannot be cooled by air."*

> *"When running parallel simulations, you need to squeeze every bit of performance out of these computers."*
>
> — Dan Stanzione, Associate Vice President for Research at The University of Texas at Austin

[2] Dell PowerEdge C6525 rack servers.
[3] AMD EPYC Milan processors.

Other Key Benefits:

Sustainability

For all its raw power TACC's new Lonestar6 supercomputer scores highly when it comes to sustainability, too, and is playing a huge role in helping The University of Texas at Austin meet its ESG[4] goals.

From the outset, the fact that TACC was able to easily deploy Lonestar6 using their existing infrastructure versus a new build contributed to a much more environmentally friendly approach. After putting GRC's ICEraQ to work, the system began delivering a PUE nearing ~1.1 like Frontera before it (versus 1.4 or higher for a typical air-cooled system), while reducing the facility's carbon footprint up to 40%.

What's more, the new system conserves a significant amount of water; and the heated water can be reused for other purposes.

Cost-Efficiency

"The fact that we didn't have to worry about additional infrastructure improvements saved us a significant amount of upfront costs."

— Tommy Minyard, TACC's Director of Advanced Computing Systems

When it comes to cost-efficiency, TACC banked on their favorable experiences with earlier GRC immersion cooling systems — like Maverick2 and Frontera — and could not have chosen a better way to cool Lonestar6's servers (core processing). They knew that GRC's ICEraQ systems have been proven to cut data center cooling energy consumption by up to 95%, increasing compute without increasing power.

As Tommy Minyard remarks, *"The fact that we didn't have to worry about additional infrastructure improvements saved us a significant amount of upfront costs."*

Down the road, TACC can look forward an overall TCO[5] reduction of up to 44% based on data gleaned from GRC's immersion cooling installations worldwide.

[4] Environmental, Social and Governance.
[5] Total Cost of Ownership.

Reliability and Saftey

Starting with their immersion cooling prototype back in 2009, TACC has found that single-phase cooling reduces the failure rate of immersed equipment, due largely to the fact that the system runs at a relatively constant temperature. As Dan Stanzione explains, *"We routinely send samples of immersed boards back to Intel once a year for analysis, and they've found no degradation."*

What's more, the ICEraQ system itself is highly reliable because it has fewer moving parts than other cooling technologies.

GRC's ElectroSafe® fluids serve as an excellent insulator and protectant. They are safe, reliable, and non-toxic, have a high flash point, and can easily be handled without special protective measures. Plus, they are effective for the life of the data center. As a testament to this, TACC's Maverick2 system has been using the same ElectroSafe coolant that was originally installed in it back in 2012.

GRC partners with top-tier fluid manufacturers — such as SK Enmove, ENEOS, Shell, and Castrol — to continually develop, test, and validate high-performance ElectroSafe fluids, enabling them to deliver the best formulation for each installation.

Last but far from least, TACC has experienced no leaks in the Lonestar6 system or any previous single-phase immersion deployment. Unfortunately, the same cannot be said for Frontera's liquid-to-chip cooled component, which developed leaks and has destroyed several motherboards over the years.

Flexibility

The innovative, flexible design of the ICEraQ Series 10 Quad makes it ideal for data center refreshes because it helps make the best use of existing infrastructure. In fact, the Lonestar6 installation required no retrofitting whatsoever. Although raised floors are not a requirement, the Series 10 easily rests atop TACC's existing raised-floor with no reinforcement required beneath it. The system is also very compact.

In addition, the Series 10 can work with either warm or chilled water systems as well as any dry or evaporative cooling system. For Lonestar6, it leveraged TACC's current piping to tap right into their existing chilled water system.

Finally, the ICEraQ Series 10 Quad system can utilize any Dell Technologies or other OEM's servers which have been properly optimized for immersion cooling.

Servicing and Convenience

GRC's ICEraQ Series 10 Quad has made maintenance easy for TACC. Servers are simply pulled from the rack, coolant is allowed to drip back into the rack, and they are then serviced just like any other type of IT equipment. The system also includes new and improved switch mounting, along with more integrated cabling and power distribution. Plus, as Tommy Minyard remarks, *"The containment is located inside the racks, so it all fits very nicely and looks very neat."*

Helping Texas Researchers Eclipse the Competition

"The users have been happy, and the performance has been fantastic."

— Tommy Minyard, TACC's Director of Advanced Computing Systems

For reasons of reliability, sustainability, servicing, flexibility and sheer cooling power, TACC has been very pleased with GRC's ICEraQ Series 10 Quad system for Lonestar6. *"The users have been happy,"* remarks Tommy Minyard, *"and the performance has been fantastic."*

TACC continues working closely with GRC, developing new strategies to reliably cool ever-increasing power density needs.

Not surprisingly, TACC's continued track record of performance has translated into more funding. *"Support from The University of Texas Research Cyberinfrastructure Initiative has made a difference,"* says TACC's Dan Stanzione. *"It has allowed Texas researchers to leapfrog the competition, providing a competitive advantage to scholars in the UT System, at Texas A&M, Texas Tech, and now The University of North Texas."*

What the Future Holds

Data center hardware typically has a five-year lifespan due to changing technology and advancements in energy efficiency. While it is always difficult to predict the future, the recent past can be very instructive: performance and sustainability demands on data centers are unlikely to decrease, which means power density per server must keep climbing. TACC's Tommy Minyard adds, *"Dollar and environmental costs of power will continue to grow."*

One thing is for certain: GRC will rise to the challenge by relentlessly innovating while working closely with Dell Technologies and other Tier I and Tier II technology providers. *"70 kW/rack is not approaching the limits of what our systems are capable of,"* says Brandon Moore. *"There are still many dials we can turn. Plus, we can deploy new systems at a larger scale."* In fact, while TACC's Lonestar6 rack density is impressive, GRC's single-phase immersion solutions can actually deliver cooling performance up to an amazing 184 kW / rack[6].

Equally important, GRC will continue being a dedicated partner to support TACC as they continue pushing the limits of supercomputing.

[6] Using a chilled water system.

GRC
THE IMMERSION COOLING AUTHORITY®

POWERED BY
DELL Technologies

Two Great Names. One Smart Source for Future-Proof, Sustainable Computing.

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