



**White Paper:**  
**Overcoming HPC**  
**Challenges to**  
**Optimize Workloads**



# Introduction

The High Performance Computing (HPC) landscape has changed dramatically over the past two decades. As HPC has become a more mainstream technology, it's changed the world of design and engineering forever.

HPC offers plenty of benefits for users, including the speed of processing, flexible deployment model, fault tolerance, and total cost of ownership. However, designing the right HPC platform for unique workloads is a complex task.

Making sure that the compute, storage, and network infrastructure are well designed to work seamlessly is crucial. This can be especially challenging in organizations that have grown organically over time. Disparate data sources, legacy systems, and complex networks need to be brought together in a way that users can harness the power of HPC. Poor design choices at any point can hurt performance, reliability, and availability.

The whitepaper will take an in-depth look at the current HPC landscape and the challenges users face while working to harness its power and optimize it for various workloads. Whether you are a veteran of HPC or deploying your first application, we'll examine the six main challenges organizations face today when adopting powerful technology. We'll also offer solutions for overcoming these challenges.



The technology that powers HPC continues to evolve at an increasingly rapid pace. If you can adapt, you can significantly enhance your capabilities and improve your competitiveness.

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# The Current HPC Landscape



HPC is playing an ever-increasing role in life sciences, scientific research, financial services, energy exploration, manufacturing, government, and more.

Analysts estimate the market is already valued at

**\$34.9 billion**

and is projected to grow to

**\$50.3 billion**

by 2028.<sup>1</sup>

That represents a compound annual growth rate (CAGR) of 6.3%.

HPC is now being used across a wide segment of industries. Here are just a few of the use cases:



## Life Sciences

Much of the demand is being fueled by life sciences organizations and researchers that are focusing on genomic research. HPC systems have the speed, accuracy, and reliability required to analyze complex genetic variations across the entire human genome.

HPC is also pivotal in drug design for running intricate simulations which often include terabytes of data that must be included in the compute cluster in parallel. For example, the COVID-19 High Performance Computing Consortium, a public-private partnership, has been instrumental in COVID mitigation and response.<sup>2</sup>



## Scientific Research

HPC is also front and center in scientific research. Climate change research uses the power of HPC to run a massive amount of data, stored both hot and cold, in long-running applications.



## Financial Services

HPC is prominent in FinTech and automated trading, where response times are measured in milliseconds and microseconds. HPC solutions are powering risk management, fraud detection, and consumer financial services with exceptionally low latency.



## Energy Exploration

Energy exploration takes mass computing power. For example, researchers use HPC to help locate new energy deposits deep into the earth by analyzing signatures created by seismic waves. As these waves are generated, they produce a huge amount of data which can help researchers determine the amounts and locations of oil deposits.



## Manufacturing

Manufacturing IT systems analyze huge datasets for modeling and simulations that are redefining design, production, and operations.



## Government

Some of the world's largest users of HPC are governments. Real-time data analytics, deep learning, modeling, and simulations are being used to detect cyber threats, predict crimes, and study weather patterns among other things.<sup>3</sup>

# The ROI and Benefits of HPC

There's a reason HPC continues to expand. Hyperion Research has tracked HPC projects since 2013 as part of a research project funded by the U.S. Department of Energy Office of Science, Office of Advanced Scientific Computing Research, and the National Nuclear Security Administration.

Hyperion reports that for every dollar invested in HPC in finance, manufacturing, life sciences, and transportation companies generate

**\$504**

in additional revenue.

Industrial firms see an additional

**\$452**

in revenue for every dollar spent.<sup>4</sup>

On average, companies record an additional

**\$38**

in additional profits or cost savings for each dollar spent on HPC solutions.<sup>4</sup>



Organizations deploying HPC are solving large and complex problems in less time and at lower costs than traditional computing. Benefits include:



## Faster calculations

Using the most advanced technology in CPUs and GPUs, along with low-latency networking fabrics, and fast recall storage, HPC systems can perform mass amounts of calculations in minutes rather than weeks or even months. For example, it took 13 years to complete the first human genome sequencing. Today, it can be done in less than a day.



## Reduced costs

Because of their speed, HPC workloads are completed more quickly. Since you only pay for what you use, this can reduce costs while allowing you to scale as needed.



## Reduced physical testing

Using HPC, an organization can create complex simulations to replace the need for many physical tests. For example, it's much easier to generate simulations for therapeutics than to test on real patients, or test scenarios for autonomous vehicles rather than doing actual crash tests.



## Innovation

HPC is driving innovation at scale across multiple industries, including major breakthroughs. Researchers used HPC to sift through mass amounts of data, resulting in the elimination of 200 pounds from the weight of a commercial aircraft, saving Boeing more than \$200 million.



## Challenges of Leveraging HPC

While the ROI and benefits of HPC are significant, there are also real challenges that impact deployment, usage, and costs.

When asked by Futurum Research to rank which applications are creating the most significant adoption challenges for networks and users, industry leaders pointed to High-Performance Computing as the biggest challenge — ranking higher than virtualization, AI/ML and advanced analytics, 5G/IOT adoption, simulation and modeling, container management and hyper-converged infrastructure (HCI).<sup>5</sup>

### White Paper

Overcoming HPC Challenges to Optimize Workloads

There is no shortage of challenges when it comes to HPC deployment, including:



**Platform complexity**



**Risk mitigation**



**Hardware abstraction**



**Cluster Management, Control, and Customization**



**Exponential Data Growth**



**Data Center Infrastructure**

# Platform Complexity

HPC platforms can be notably complex. Organizations are often working with legacy resources. This leads to a lot of different accelerators, networking technologies, and compute technologies — each optimized to serve a specific workload. The challenge is in the pace of change in accelerators, compute resources, and interconnects as you begin to integrate different components.

In the early days of HPC, you would build a static cluster. Maintenance focuses on keeping it functioning properly through its lifecycle. This allowed you to function with custom scripts that could integrate different open-source tools for cluster management. It was possible to manage this in-house and handle things like server provisioning, monitoring, and alerts. However, it was labor-intensive and burdensome. Today, clusters are no longer static, raising the overall complexity of platforms. Integrating processors and accelerators, hardware from different manufacturers, and cloud compute resources add to the challenge as do mixing VMs, containers, and bare metal servers.



Penguin Computing aims to define HPC architecture to manage and deploy components together. Then, you can test and develop your architecture against workloads for optimization.

# Risk Mitigation

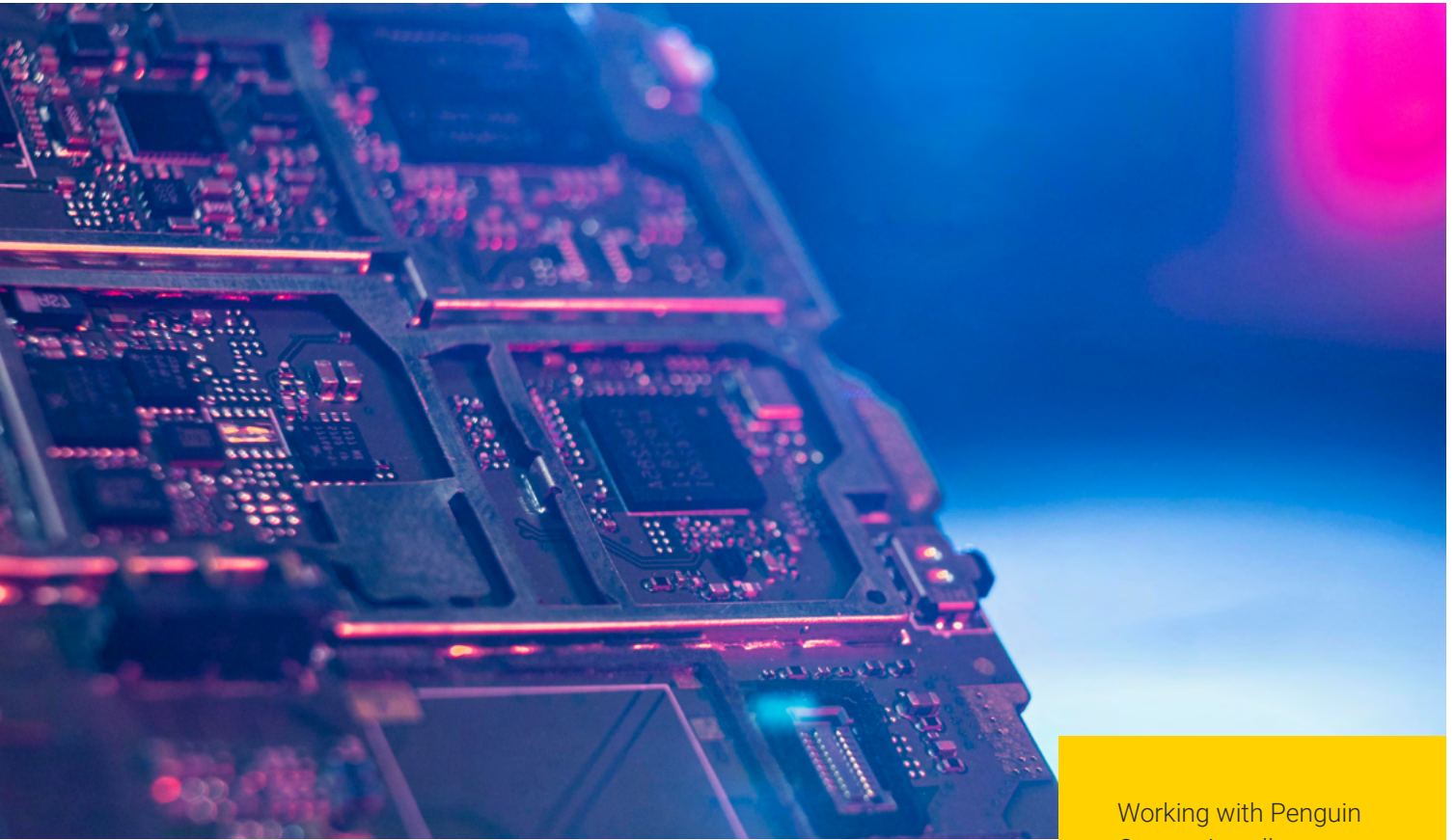
These complex, high-performance environments require a robust cluster management tool to manage HPC hardware, software, and consumption. For example, in AI training, you might test various solutions from both a performance and cost perspective. The market moves quickly, so you must be agile to continually optimize. That's why it's so important for organizations to work with a partner that understands the current state of the market and how it's developing. This can help better align your deployment with future tech that may allow for even greater performance gains and evolving cost structures. Any technology solution must take into account risk in various forms, especially financial risks. HPC computing can be an expensive venture. Organizations need to tightly manage upfront investments without limiting the capability and power of HPC.

This requires an expert hand to avoid making costly mistakes.

**At Penguin Computing™, we invest heavily in our R&D to test and validate emerging technology.**

As tech comes on the market or becomes available, we make it safe. Technology is put through a formal process and integrated into a test environment to demonstrate its impact. This allows us to take individual pieces of cutting-edge technology and build them into a reference architecture and solution. This dramatically reduces the risk by proving the tech.

During this process, we analyze potential conflicts or roadblocks to integration as well as identify performance gains or cost-saving measures. This helps guide design and production, thereby mitigating more risk.



## Hardware Abstraction

With hardware, there is a matrix of options. Organizations and end-user typically want to focus on the science, application, or workflow. As more organizations have migrated resources to the cloud, they've gotten used to focusing on use cases and applications and often forget about what is happening in the tech layer underneath that makes cloud computing possible.

When it comes to actually designing more purpose-built solutions for HPC, the end-user wants to consume them as an infrastructure that allows them to do the job. It takes quite a bit of detective work to reverse engineer the process from the use case back to the required hardware and architecture.

Few organizations have the in-house skills or resources to handle the level of hardware abstraction needed to build out robust, future-proof solutions. You want to build the resources to handle today's needs but evolve quickly to leverage different workloads in the future. At the same time, you want to focus on best-fit products

Working with Penguin Computing allows organizations to focus on business and workflow and not infrastructure. We are a hardware-agnostic company. We work with every major manufacturer, so we can design the hardware, software, and abstraction layers necessary to fit your exact use case.

We're experts at analyzing and understanding context and identifying which set of technologies work together in the most efficient way.

### White Paper

Overcoming HPC Challenges to Optimize Workloads

# Cluster Management, Control, and Customization

Effective cluster management and control are essential to leveraging the power of HPC, especially when it comes to big data and clustering at scale for enterprise IT. As production environments require consistent application performance, the value proposition for cluster management grows ever more important. This includes the ability to customize clusters and cluster management for each unique environment.

At the same time, HPC clusters demand secure management to protect against misuse. In the past, HPC clusters were generally built for private use by a few workers. Today, many enterprises are deploying large-scale clusters that are shared among departments or divisions with controlled, but public access. As such, HPC environments can be powerful targets for cybercriminals, who can use the same HPC resources and mass computational power for nefarious reasons, such as launching massive DDoS (Denial of Service) attacks or brute force password methods.

HPC architecture must put in place secure communication, encryption, and controlled access. Only nodes and users that are meant to access specific resources should be allowed access. Tight security controls need to be deployed to prevent unauthorized access with role-based authentication for users and prevention of lateral movement.



Penguin Computing has HPC experts who understand security and cluster management challenges. We build custom solutions that provide the robust cluster management and control you need to operate efficiently and securely.



# Data Center Infrastructure

HPC excels at processing mass data sets, which is crucial in today's data intensive environments. Worldwide, more than

**97 zettabytes**

are forecast to be created, captured, copied, and consumed.

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The amount of data continues to grow, forecast to nearly double in size again by 2025.<sup>6</sup>

Already, the majority of data being gathered is unstructured. The evolution of 5G technology and the growing use of IoT and IIoT devices will only accelerate this trend. Most HPC environments are structured to work with regular data and algorithms such as matrix computation. Despite the advanced performance, it can be challenging to implement applications to handle unstructured or irregular data in HPC frameworks.

Penguin Computing can bring together the resources you need to combine Big Data with HPC for better and deeper insights.

This may require the deployment of task-based abstraction that is easy for HPC programmers to use. An example might be COMPSs, a framework for management development and execution of parallel applications for clusters, cloud, and containerized platforms, and adding support for the Hadoop Distributed File System (HDFS). Other deployments may rely more on Spark due to its diverse available libraries of integration tools. We develop custom solutions to manage your data in a scalable environment that can grow with your needs. HPC and AI can be deployed in the same architecture. Researchers can work together to leverage a unified data infrastructure to accelerate speed to insight.

## Exponential Data Growth

HPC combines hardware, software, systems management, and data center facilities to support large arrays of interconnected computers that work together to perform shared tasks.

Organizations have choices to make about how they want to structure their data centers to leverage HPC. For example, some companies want to build out an HPC infrastructure within their own on-prem data centers while others opt to build resources in the cloud or lease HPC computing power.

Many companies find that their facility requirements are a limiting factor. You need the physical floor space and support to handle the weight of server racks, plus the energy and cooling power to mitigate heat. Organizations often find they lack the necessary infrastructure to handle HPC infrastructure on-site. But, there are other options.

At Penguin Computing, we will do an analysis of your current infrastructure to develop a roadmap for HPC deployment.

We can provide a detailed cost analysis based on your current infrastructure and available space as well as options for colocation facilities and cloud deployments. You need a secure HPC infrastructure that is optimized for your workloads and cloud computing needs, and is engineered by a partner like Penguin Computing that knows HPC, AI, and the cloud.

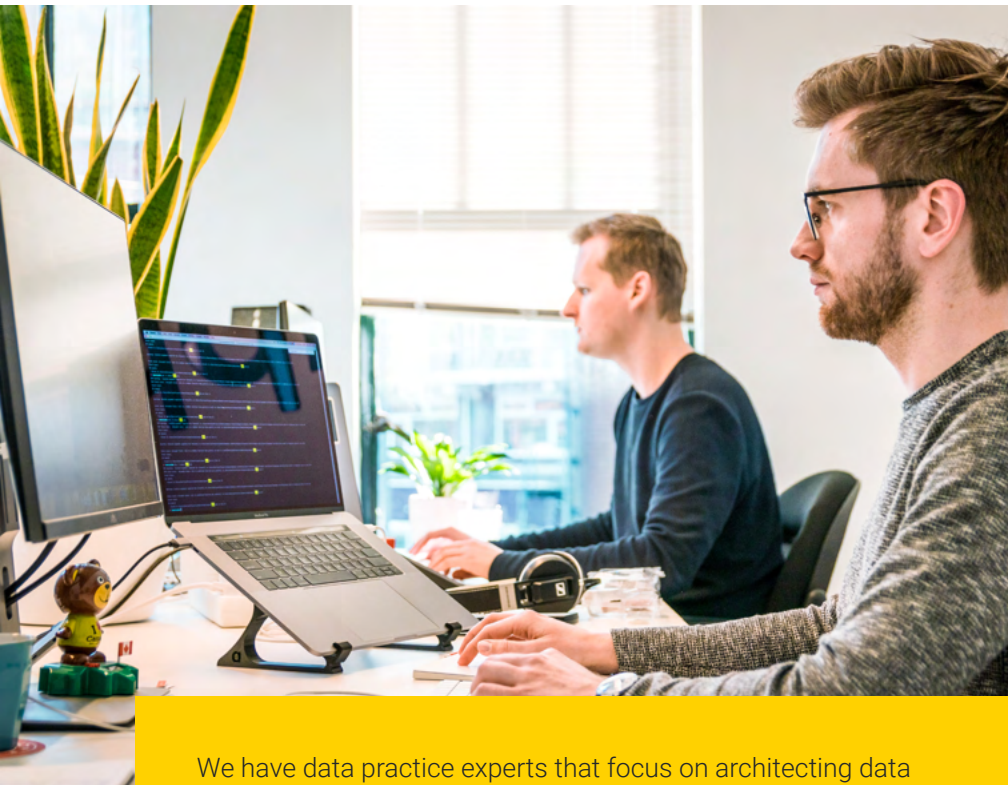
# Overcoming the Challenges of HPC for Better Outcomes

While each of these challenges is different, they have one common theme that runs through each of them. Before you begin to architect and leverage the power of HPC, you must have a deep understanding of an organization's high-level business problems and objectives and how they are currently using technology. Only then can you work backward from the goal to architect an efficient workflow.

So, goals and objectives are where the conversation starts to develop the necessary infrastructure to optimize performance.



At Penguin Computing, we go through a robust discovery process to understand hardware and software, workload requirements, and core competencies. While we have years of experience with predefined solutions, we create custom solutions within the hardware and software stack that meet the organization's unique goals.



We have data practice experts that focus on architecting data workflow and solutions.

When we design a solution inside a data practice, it's aimed at solving these high-level challenges all the way down to the fine points that make systems more user-friendly and accessible.

Often, this requires a new workflow and re-examination of current practices. For example, many of the algorithms still in use today are now more than a decade old — especially in the public sector. These have been used to develop sophisticated models, but may no longer be able to leverage the power of HPC in today's environment (let alone future use cases).

Testifying before a House subcommittee, Dr. Roscoe Giles, then chairman of the Department of Energy's Advanced Scientific Computing Advisory Committee, testified that government algorithms, operating systems, runtime systems, and tools for data management were woefully out of date.<sup>7</sup> Yet, years later, many of these same systems remain in place.

Overcoming HPC challenges also requires commitment and funding. A study by EY revealed that

**53%**

senior executives identify data and analytics as their top investment priorities between now and 2024.<sup>8</sup>

At the same time, however, there's a continuing shortage of skilled IT professionals, data scientists, and data architects to leverage HPC.

In fact, the Bureau of Labor Statistics projects the shortage of skilled engineers will top

**1.2 million**

by 2026.<sup>9</sup>

The lack of qualified, skilled engineers has become so ubiquitous that

**75%**

of IT executives say it is now their biggest risk factor in deploying technology.<sup>10</sup>

It is crucial for companies looking to mitigate that risk and build HPC workflows that are future-proofed by working with experts like Penguin Computing.

# Penguin Computing's Deep Expertise in HPC

Mitigating these risks and building optimal infrastructure takes careful planning.

You need to work with a technology partner that knows HPC and a cluster orchestration tool that was created specifically for HPC administrators by engineers who manage HPC environments.



# Penguin Computing TrueHPC™

[Penguin Computing TrueHPC™](#) is the result of decades of HPC design experience to provide proven, streamlined architectures that have the power you need to deploy HPC at scale.

TrueHPC is a complete software, hardware, and management platform, including optimized hardware and cluster orchestration software. This is an out-of-the-box, enterprise-supported HPC solution that lets organizations leverage the highperformance and low-latency networking and storage technologies needed to deliver on the promise and potential of high performance computing.

cloud, and AI/ML. Combining the benefits of these technologies, you can build complex, high-performance environments across your IT infrastructure for optimal results.

Penguin Computing accelerates digital transformation with the power of emerging technologies in HPC, AI, and IoT with solutions and services that span the continuum of edge, core, and cloud. Penguin Computing specializes in innovative and emerging technologies for the world's most demanding workloads to tackle the most complex business challenges.

# Penguin Computing InsightHPC™

[The Penguin Computing InsightHPC™](#) solution is built on HPC- and AI-optimized server building blocks and cloud orchestration technologies. This creates an onprem and cloud-native HPC solution to leverage an AI pipeline with reduced timeto- insight for HPC workloads.

# Penguin Computing AccessHPC™

[Penguin Computing AccessHPC™](#) provides a complete software, hardware, and management platform built on optimized hardware and Penguin Computing Scyld cloud and cluster software for HPC orchestration.

You can also combine Penguin HPC solutions for data,



[Click Here to Contact Penguin Computing](#)

to see how you can drive innovation with ready-to-run HPC today.



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