rescale

Transforming Computational Engineering in Manufacturing and CPG

Through HPC and AI in the Cloud

Microsoft Azure

NVIDIA

The State of Manufacturing and CPG

Abstract

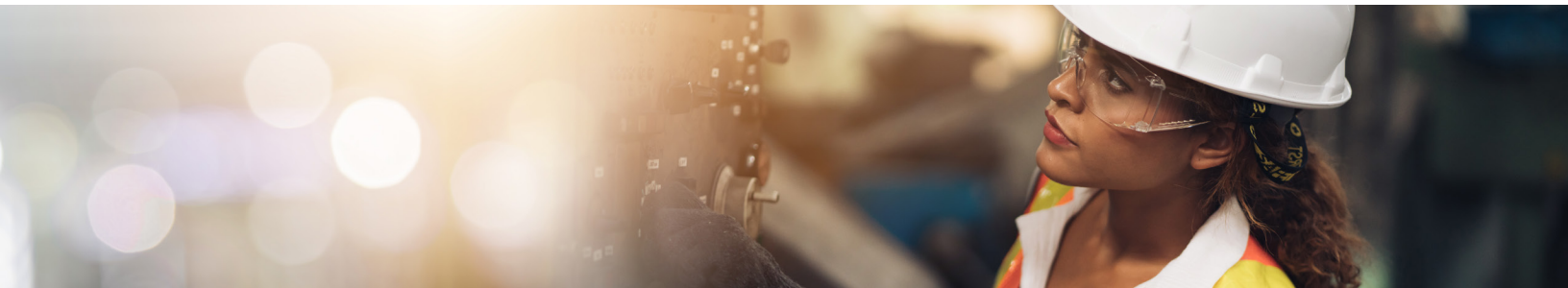
Computational science and engineering, through the development and application of simulations run in cloud based high-performance computing (HPC) environments, is providing new growth opportunities for Manufacturing and Consumer Packaged Goods (CPG) organizations. Adopting the latest AI/ML practices can drive tangible product benefits such as improved quality and durability while also driving business results such as improved cost efficiency and reduced materials waste. A surge in data growth, with no clear path to leverage it in the design and manufacturing process, plus emerging competitors who already leverage cloud HPC and AI/ML solutions, make the need for established organizations to adopt cloud HPC and AI/ML a priority. By not doing so, CPG and Manufacturing organizations risk becoming secondary players in the industries that demand continual innovation to stay relevant.

Manufacturing and CPG organizations are in a race to distinguish themselves in the global marketplace. Stacked against them are pressures on productivity compounded by fragmented product networks and disruptive supply chains. They are also facing new market verticals and sub-categories as well as market-disruptive competitors who move quickly. To remain competitive, they need to consistently analyze their markets and channels and adopt manufacturing models that drive agility, productivity, and efficiency.

In short, they must digitally transform themselves to realize new user and customer-centric processes and insights that help push the boundaries of innovation. Doing so helps create products that not only resonate with the market and drive growth, but also demonstrate market leadership and reinforce their brands as leading innovators. Achieving this may seem daunting. Yet, by positioning themselves with the right tools and processes- and new ways of thinking, Manufacturers and CPG organizations can produce more innovative and efficient products and processes that center around the customer.

Organizations have unprecedented access to product data that can help inform design decisions and accelerate new product development. For example, product performance data such as material flexibility, strength, durability, and the chemical characteristics that determine flavor and texture, can help determine the correct materials and designs that make up a product's features and characteristics. In turn, these attributes help improve a product's overall quality and safety. These are invaluable insights. Still, they can be challenging to discover, assess, understand, and compare to thousands of other potential inputs. Manufacturing and CPG organizations can spend years—and millions of dollars—just to make incremental advancements in production and design.

> HPC, which has been a boon for engineers, scientists, and researchers for decades, has helped by shifting the mathematical burden off workers and solving large computations faster. The downside: leveraging HPC, traditionally kept on-premises, is CAPEX intensive. On-premises HPC requires significant upfront capital outlays, and lengthy planning and implementation cycles. These slow the decision-making process for designers and engineers who need greater compute power quickly.



The Role of AI and ML in Computational Engineering

Computational engineering refers to a field of computer science that applies advanced computational methods and analysis to engineering problems. New computational engineering techniques combine the capabilities of AI and ML with big data, cloud computing, IoT, and computer-aided engineering (CAE), to create the foundation for next-level research & development (R&D).

Development teams use AI for things such as the acceleration of design exploration, optimizing architectural configurations based on software needs (e.g., predicting workload performance and optimizing for cost and speed), digital twins to predict how products (e.g., factory equipment or the products themselves) will perform, and anticipating product failures and maintenance requirements.

> As with any new approach, switching to cloud HPC and leveraging AI require a well thought out plan to gain a sense of shorter- and longer-term needs, and identify the right set of tools and services to help you get there. There also may be a lack of institutional knowledge around AI and the core skills it requires. Budget may be an initial concern, but one that can be overcome, again, with an understanding of your upfront and longer-term goals and by mapping out the cost analysis of cloud HPC compared with on-premises HPC.

A unified AI/ML environment can manage data and compute requirements, improve resource efficiency, and increase user productivity. Another key aspect of successfully leveraging computational engineering through cloud HPC and AI is ensuring your technology stack—and engineering teams—are properly equipped to manage the transformation.

Challenges Facing the Industry and why Existing Solutions Fail

Manufacturing and CPG companies face complexity on many levels

An explosion in consumer and operational data through social media, omni-channel marketing, IoT, and low-cost storage have spurred major transformation for how organizations consume, view, and interpret massive quantities of data every day. This data explosion creates new possibilities. On the marketing side it can be easier to acquire and retain customers through tactics like targeted and focused promotions. On the manufacturing side, big data can help optimize complex manufacturing processes by analyzing risks and potential threats. It can also help create just-in-time or lean manufacturing processes by having a constant stream of data to provide direction on consumers preferences.

However, all this data can be difficult to coalesce and package into something tangible that can help create, design, and test new products and services. On-premises HPC solutions are often siloed and without access to real-time or just-in-time data. Since they lack the ability to leverage data in a timely manner, they rely on less relevant, outdated consumer feedback and manufacturing process data.

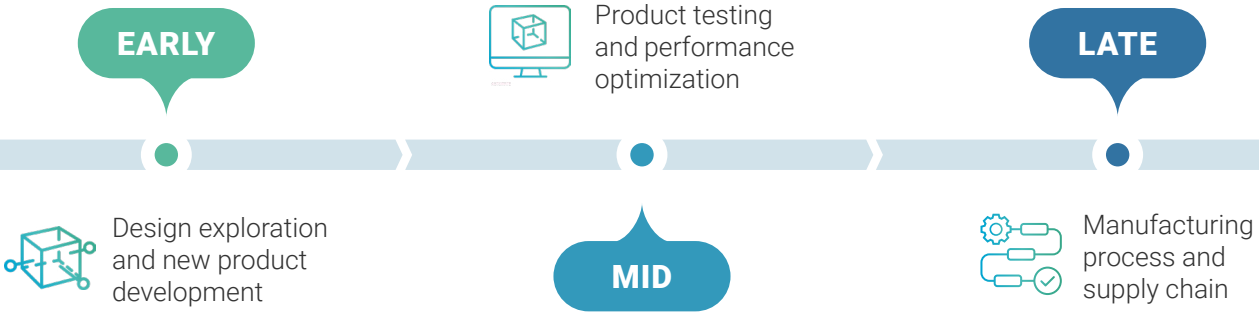
As they continue to increase in complexity, supply chains can be another challenge, as they can become outdated. While they may not change daily, they are subject to volatility in markets, economic uncertainty, regulatory changes, and supplier risks, among other factors. Combined, this can be a massive undertaking to manage when the smallest of factors can create disruptions in the production of products and services. Transforming the supply chain with cloud native solutions and AI/ML can have profound, positive effects across every aspect of the supply chain and help organizations optimize processes like lean manufacturing, just-in-time manufacturing, and just-in-time consumption.

The sheer level of competition creates other complexity. Startups who adopt native cloud and AI/ML solutions to perform computational engineering tasks at the outset are at an advantage over organizations who are stuck with solutions that do not scale, are not able to process and analyze just-in-time data, and generally work against intelligent automation. Consumers will continue to demand new products from companies that are aligned with their preferences for cost-efficiency, reliability, and eco-friendliness.

The inability to leverage unprecedented amounts of data, market volatility impacting supply chains, and increased competition from cloud-native startups are some of the challenges Manufacturing and CPG companies are facing.

HPC and AI/ML Opportunities in Manufacturing and CPG

Computational engineering practices can have far-reaching impacts within the Manufacturing and CPG industries. Here are a few examples of how these industries may benefit.

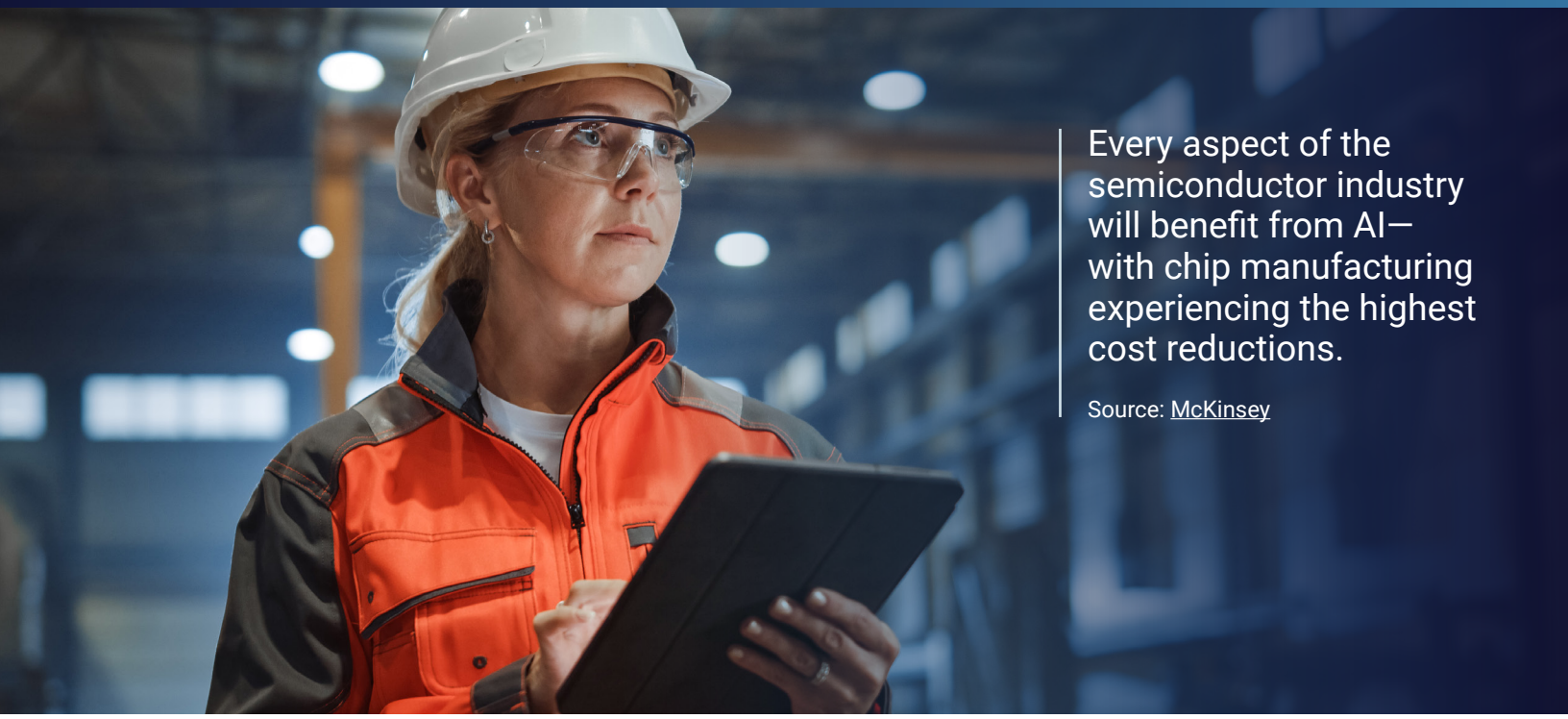


Early stage: design exploration and new product development

Cloud HPC and AI/ML allow organizations to run models and analyze and process data that shapes how products are designed and created. Simulation Process and Data Management (SPDM) for example, creates a digital thread that enables the flow of data between digital and physical worlds to optimize products, people, processes, and places. Digital threads create a persistent path that follows a product's entire lifecycle—from design and production to the end customer. With greater information about the entire lifecycle, digital threads can increase production output by reducing bottlenecks, reducing waste, improve products, and spur faster innovation. Additionally, exploring more design spaces that drive greater insights and reduces time-to-answer can become a frequent aspect of the workflow process because you're able to run jobs much faster, cheaper, and with fewer resources. Cloud HPC and AI also combine to offer advances in multi-disciplinary design optimization (MDO) that allow designers to study multiple design problems simultaneously rather than sequentially when product interactions are overly complex.

Mid-stage: product testing and performance optimization

Before a new product can go into mass production, it must be evaluated for safety and quality. The same goes for revamped packaging. For example, packages should be tightly sealed and delicate items should withstand some level of stress. While these and other considerations are part of the core development process, additional testing must be done to ensure the manufacturing process will not introduce issues, and products are created to the exact specifications they were designed. In food processing and packaging, for example, HPC and AI simulation testing is used in areas such as object detection in warehouse optimization and for classic structural and fluid mechanics work that goes into things like testing non-Newtonian fluids during drop testing and fluids-solids interaction, to the simulation of vending machines that deliver products to consumers.



> Every aspect of the semiconductor industry will benefit from AI—with chip manufacturing experiencing the highest cost reductions.
>
> Source: McKinsey

In Manufacturing and CPG assembly lines, computer vision and sensors combined with machine learning enable real-time product improvements and can create digital twins of factory operations to enhance production efficiency and prevent equipment failures. This powerful combination can be used to identify and assess materials through temperature patterns to ensure products are created to exact specifications and are safe. Many other use cases and simulation scenarios abound and are now possible because of the combination of Cloud HPC and AI including Discrete Element Modeling (DEM) to help predict bulk solids behavior, multiphysics simulation to predict real-world outcomes, and fluid dynamics and particle fluidics simulations to study the motion of fluids.

Manufacturers often have multiple factories worldwide using different equipment and specifications. Therefore, a test conducted in one location may yield significantly different results than one in another locale. Testing for all locations is expensive and time-consuming. In some cases, ensuring every location is properly tested can take months, or even years. AI simulations run in the cloud enable more scenarios than ever before and can complete tests faster, while scaling to meet the needs of multiple locations and data sets. Applied AI is already in use at factories around the world. For example, image processing plays a key role in optimizing CPG warehouse workloads to detect where objects are in real time.

Late stage: manufacturing process and supply chain

Factory equipment and connected devices (e.g., field worker tablets) are a wealth of valuable historical data. Sensors on the production line can monitor environmental information that might impact product quality. Predictive maintenance uses AI/ML to predict asset breakdowns, enabling teams to schedule maintenance before a breakdown can occur. Taking proactive measures can also help prolong the remaining useful life (RUL) of manufacturing machinery by avoiding significant issues.

Fragmented production networks, where there are multiple production facilities that do not have a collective view of the same data and are not set up for seamless collaboration during the manufacturing process, can, especially benefit. Production line agility and the ability to shift production schemas based on real-time data and then to permeate that information throughout the production process is key to improving assembly line efficiency and becoming customer centric. Efficiencies created throughout the production process increase the combined value of each line, driving up ROI and helping companies become more eco-friendly by decreasing material usage and waste.

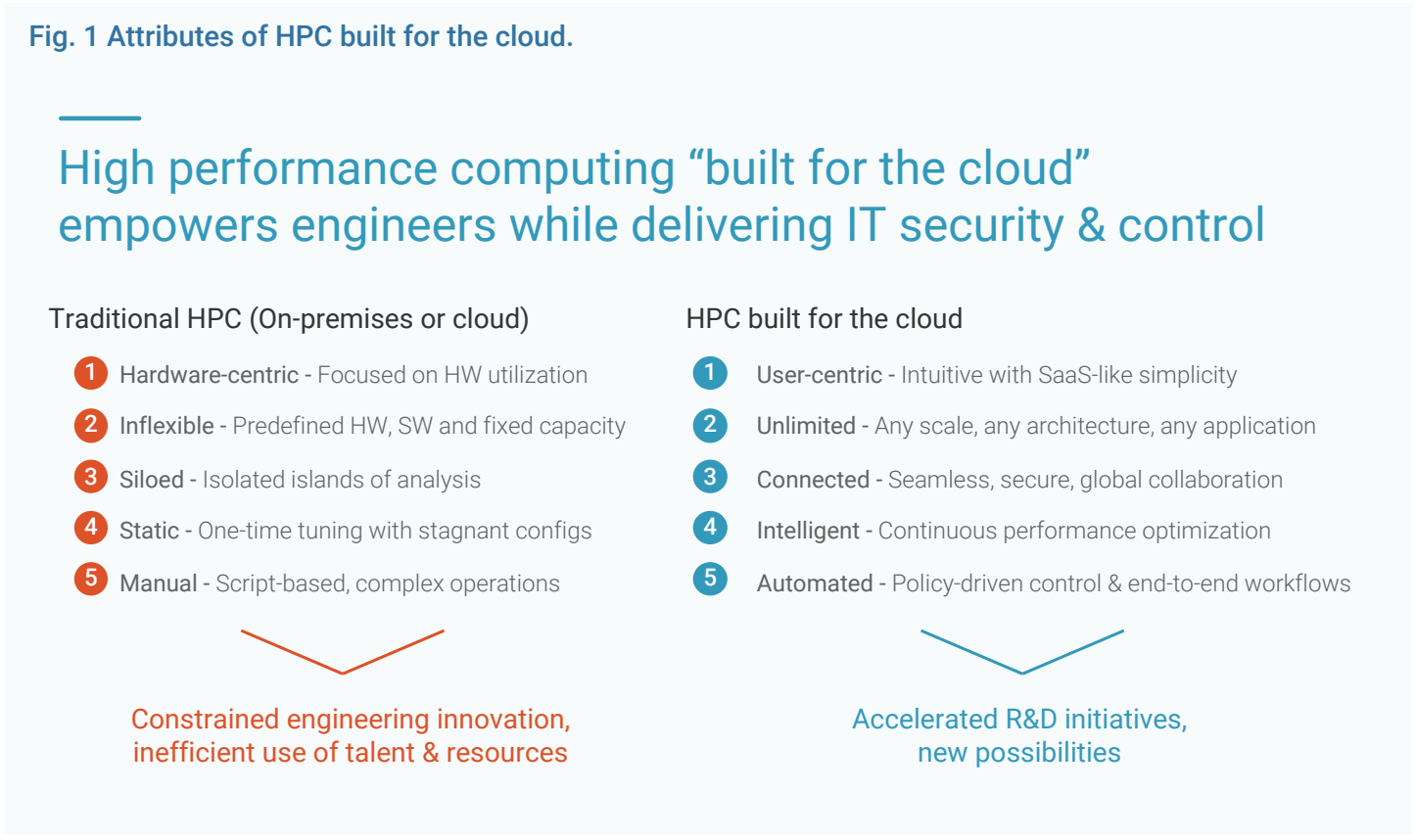
HPC Built for the Cloud

Organizations that undertake HPC for the cloud and cloud AI/ML understand they need a strategy and solutions that are not simply fast and intelligent, but also cloud native, accessible, and automated. HPC built for the cloud-which enables democratizing access to computational tools-means users have access to every step of the workflow. This goes from overseeing simulations that run based on real-time data coming from a molding machine, then automatically creates numerous simulations based on that data and then outputting results into a dashboard that gives users-residing anywhere-access to real-time insights. Some of this may be possible with on-premises HPC but it's often constrained, limited to an individual location, and far more costly.

HPC built for the cloud overcomes the limitations of on-premises solutions and puts the user in control to innovate, as necessary. Unlike on-premises supercomputers, HPC clusters, and workstations, cloud HPC is user centric: a fully on-demand solution with compute resources, models, templates, and workflows that can be procured and deployed in a moment's notice and with unlimited scale, all from anywhere, and with consideration of project prioritization, budget, and administration delegation. Because it's unlimited, cloud HPC also removes the under-utilization of fixed hardware capacity and gives engineers, scientists, and researchers the freedom to pursue ideas they may otherwise not be able to investigate. Instead of organizations being locked into large, fixed on-premises contracts, with cloud they are free to upgrade or change hardware as needed and only pay for what they use.

HPC built for the cloud offers flexibility, security, and ease of management. Teams can use their preferred hardware and software, including proprietary and open-source solutions, on any architecture. A secure and compliant cloud platform offers unprecedented levels of automation across workflow management, end-end visibility on usage and spend, and full administrative management with software-defined security policy implementation and encryption, protecting sensitive IP and data throughout the process.

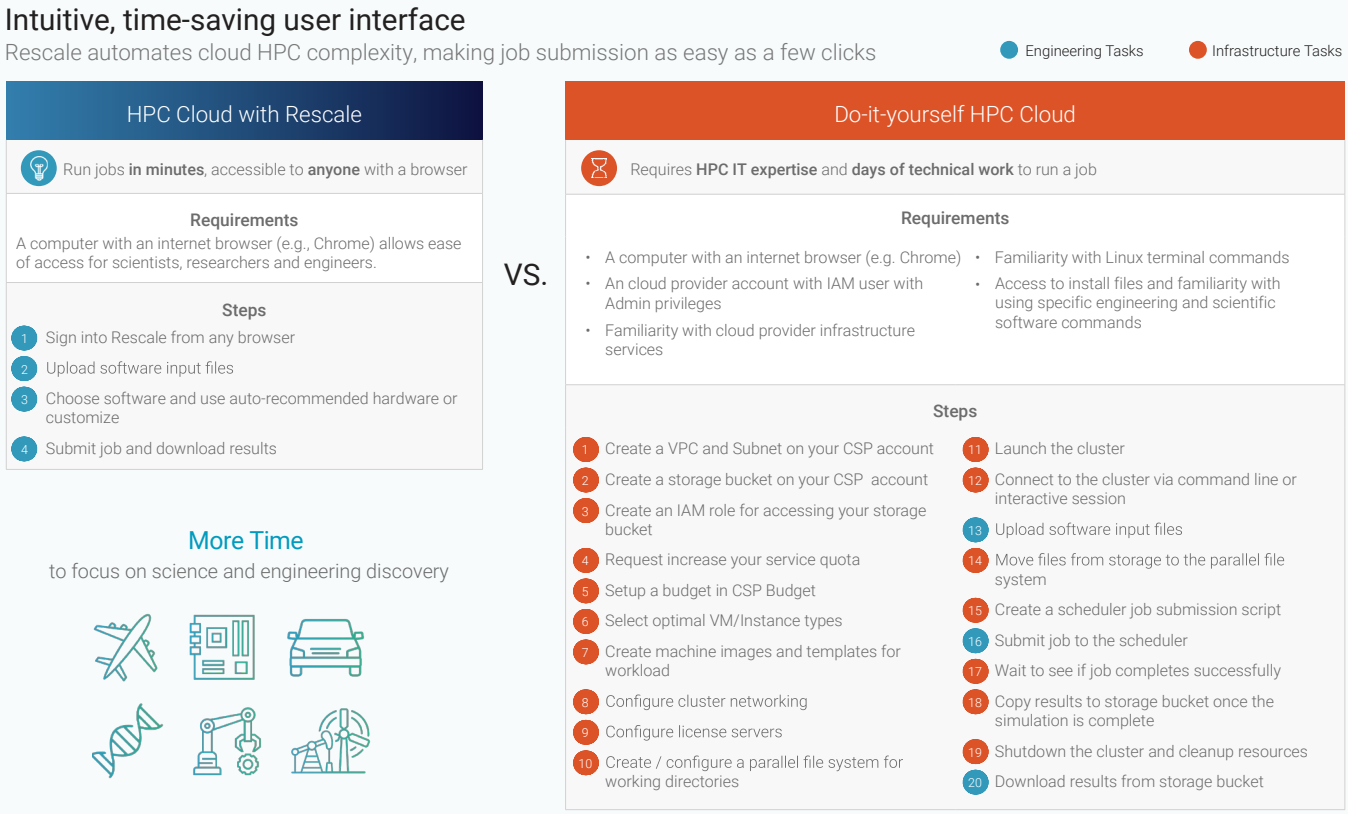
Fig. 1 Attributes of HPC built for the cloud.



Cloud HPC also offers greater agility to deploy these technologies quickly and efficiently, while providing the flexibility to adapt as the business needs and the available technology changes. An on-premises solution may take weeks to order and deploy new hardware. This can be done within minutes in the cloud, without the involvement of anyone except the user, assuming the cloud infrastructure policies allow it.

By adopting new computational engineering techniques that combine artificial intelligence (AI), machine learning (ML), and cloud computing together, organizations can make even faster, highly accurate, and lower-risk decisions. A global manufacturer, with plants located in different countries that make the same products can benefit immensely from the democratization of Cloud HPC and AI. Training a single high-fidelity model and inferencing it multiple times to test different scenarios can reduce simulation time by weeks or months by not being forced to run multiple simulations in each location. On top of this, the data generated from it is automatically available and accessible to anyone, increasing collaboration and workflow efficiency.

Fig. 2 Steps of deploying HPC and running a job with and without HPC built for the cloud



Running a job requires expertise in computer science concepts, IT, and cloud infrastructure, as well as familiarity with a broad tech stack. As a result, engineers and scientists can get stuck doing many tasks that are not in their wheelhouse.

Having access to a single dashboard for example (from anywhere you have a good Internet connection), provides access to dozens of SaaS solutions right at your fingertips. As a new engineer who needs to quickly and easily run simulations based on new data received that shows potential problems with your product, you have a distinct advantage with cloud HPC. With a proliferation of specialized hardware available, you have guidance on which ones to use for which workloads and ensuring you have the right capacity (e.g., getting your hands on highly in-demand GPUs). With the combination of Rescale and NVIDIA on Azure, you have access to 1000+ pre-installed HPC applications plus the latest AI/ML frameworks and pre-trained models to unlock new use cases without spending critical time installing and configuring them. This is all with the scale, security, and policy guardrails in place to help ensure you stay within budget.

Cloud HPC and AI impact business outcomes in many ways:

- Decreased the cost per unit
- Increased production output with reduced bottlenecks
- Decreased material usage and waste
- Reduced product failure rate
- Reduced machinery failure rate
- Increased machinery utilization

Similarly, engineers and scientists with deep expertise in AI and ML have instant access to the full-stack environment of what cloud HPC offers with the world's fastest processors to create and run physics informed neural networks (PINNs) that use the laws of physics to train the model, rather than the data. Many industries, including manufacturing and CPG leverage PINNs in areas such as fluid dynamics and acoustic and structural engineering.

> The performance intelligence capabilities of Rescale cloud HPC also enable more efficient models and workloads that benefit organizations. By analyzing thousands of data points per second, machine learning models can provide real-time or near-real-time insights into a systems performance. These models will continue to improve as new data emerges, making even more accurate predictions that are invaluable to the process of performance monitoring and testing.

As opposed to on-premises HPC, where you work with tightly coupled and bespoke technology stacks that offer little in the way of data sharing and collaboration, Cloud HPC is connected by its very nature. Being highly connected fosters best practices including templates, saved workflows, and policy controls that can be applied across the organization, and across multiple business units and new software and architectures can be put into effect in a moment's notice.

A highly connected environment can also drive significant engineering velocity improvements by immediately invoking any resource required by an engineer's tasks. For example, an engineer looking to perform simulation or rendering work can instantly access all the compute, storage, or virtual desktop infrastructure they need, along with application, data, and workflow templates. With all data sitting on a unified storage fabric, the results can be instantly shared with other users, also in the same connected HPC environment.

> Again, with Cloud HPC and AI/ML all these scenarios available to the engineers and scientists are significantly faster and easier to use than what's possible with on-premises HPC and AI/ML. Cloud HPC provides the two key elements organizations need to complete a digital transformation: giving engineers access to infinite compute but also making it easy to access, use, share, collaborate, and, in the process, **wildly increasing new opportunities to do more and go farther than any on-premises solution will allow.**

Technology Partners Aligned for Your Success

Together Rescale, Microsoft and NVIDIA deliver a turnkey, full-stack, software-to-hardware HPC and AI platform solution that accelerates innovation.

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Learn more

With Rescale's intelligent built-for-the-cloud HPC platform, engineering and R&D users can run workloads of any system type, including bare metal, virtualized, or container-based, on the cloud infrastructure of their choice, whether it's private cloud, hybrid, or multi-cloud on public cloud service providers. For workloads on bare metal, Rescale can provide delegation to the scheduler that manages the systems. By default, the Rescale platform runs fully virtualized in the cloud and supports all major cloud service providers. Additionally, Rescale allows users to run any container-based workloads, which can be automatically deployed to Microsoft Azure on the Rescale platform.

NVIDIA

Learn more

NVIDIA is a leader in the advancement of ML modeling across industries. Since NVIDIA's creation of the first accelerated computing processor—the graphics processing unit (GPU) in 1999, which revolutionized PC gaming and redefined modern computer graphics—NVIDIA's portfolio has expanded to an ecosystem of software including application frameworks, libraries, and toolkits for developers, data scientists, and others to accelerate machine learning operations. NVIDIA accelerated computing powers a broad range of AI applications in production today, such as personalized shopping experiences, contact center automation, voice assistants, chatbots, visual search, and even assisted medical diagnostics. NVIDIA offers a full-stack AI platform that combines hardware and software optimized for high-performance machine learning that empowers businesses to accelerate time-to-insight and develop AI-enabled products and services at scale. This full-stack approach simplifies and accelerates the entire ML workflow—start to finish—from importing and preparing data sets for training to deploying a trained network as an AI-powered service using inference.

Microsoft Azure

Learn more

Azure HPC + AI is a complete set of computing, networking, and storage resources integrated with workload orchestration services for HPC applications. With purpose-built HPC infrastructure, solutions, and optimized application services, Azure offers competitive price/performance compared to on-premises options. with additional high-performance computing benefits. Additionally, Azure includes next-generation machine-learning tools to drive smarter simulations and empower intelligent decision making.

Customer case study: Kinetic Vision

kinetic vision

Kinetic Vision integrates advanced technologies to accelerate product innovation within a broad array of industries including consumer electronics, transportation, aerospace, and consumer packaged goods, such as pre-packaged food and drinks. Their services include conducting classical structural and fluid mechanic tests that include drop testing packaged products. In layperson's terms, they test bottles to see if they leak after being dropped by a user.

Constantly dropping physical containers to see if the bottle material and design can withstand impact is costly, time-consuming, and not necessarily accurate. Instead, Kinetic Vision uses AI to simulate likely scenarios and determine a product's resiliency. It sounds simple, but from a physics perspective, it's quite complicated. There are structural dynamics that play a vital role in predicting things like stresses in the bottle. Even the liquid contained within has calculated forces and movements that can impact the packaging.

With AI, Kinetic Vision can maintain tight control over the "test," creating an exact digital model of the bottle, liquid, and test surface based on provided models. In the event a model "fails," the AI can identify what factors contributed to the issue. Testers can then adjust and try again without waiting weeks or months for a new model to be designed and built. Kinetic Vision estimates shifting from physical models to an AI simulation can reduce overall engineering work time by 75-90%.

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High Performance Computing Built for the Cloud

Digital Engineering

Workload Optimization

Intelligent Automation

Security & Compliance

Conclusion

Manufacturers and CPG organizations must continue to evolve to remain competitive in the marketplace. Computational engineering practices, used in conjunction with AI/ML and HPC built for the cloud, can help organizations better predict customer demands, reduce R&D cycles, produce higher quality products, and get to market faster. Rescale, Microsoft, and NVIDIA provide a comprehensive, cloud-based solution to help manufacturers and CPG organizations-under constant pressure to stay competitive-by increasing their pace of innovation through better making.

About Rescale

Rescale is high performance computing built for the cloud to empower engineers while giving IT security and control. From supersonic jets to personalized medicine, industry leaders are bringing new product innovations to market with unprecedented speed and efficiency with Rescale, a cloud platform delivering intelligent full-stack automation and performance optimization. IT leaders use Rescale to deliver HPC-as-a-Service with a secure control plane to deliver any application, on any architecture, at any scale on their cloud of choice.

Learn more about high performance computing built for the cloud:

Get in touch with our team of experts

Start your free trial today

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