Hewlett Packard Enterprise

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MARKET-LEADING HPC SOLUTIONS FOR MANUFACTURING

Improving quality, productivity, and time to market

TABLE OF CONTENTS

EXECUTIVE SUMMARY

A profound digital transformation is underway in the manufacturing industry due to information technology (IT) and operational technology (OT) convergence and integration. Digital manufacturing, also known as Industry 4.0 or Smart Manufacturing, is the convergence of data and information throughout the product lifecycle to improve the overall quality and effectiveness of a company's products, manufacturing processes, supply chain, and customer engagement. Big Data analytics, automation, and the Internet of Things (IoT) all play a large role in digital manufacturing.

Manufacturing companies and their suppliers can leverage this convergence of information, operations, and physical production systems to quickly respond to quality issues or design changes. Furthermore, a digital manufacturing environment supports collaboration in a way that was previously not possible, both internally between engineering and production, and externally with suppliers to effectively overcome competitive pressures to deliver higher-quality products faster and at lower costs. To address these challenges, computer-aided engineering (CAE) is being integrated with several emerging technologies—IoT, Machine Learning (ML), Connected Products and Vehicles, Robotics, Digital Twins, and others—to optimize all manufacturing operations across the entire value chain and product lifecycle.

The Hewlett Packard Enterprise computer-aided Engineering (CAE) solutions—anchored in HPE Apollo high performance servers and storage—brings scalability to the world of CAE and analytics packages. HPE's CAE offering maximizes value for manufacturers. It integrates processors, system software, networks, storage, and visualization tools. It leads to quicker deployments and faster time to value.

DIGITAL TRANSFORMATION IN MANUFACTURING AND PRODUCT DESIGN

The manufacturing economy is expanding across many industries. According to the influential Institute for Supply Management, new orders, production, prices, and employment are all rising while inventories are tightening.[1] In this growing and highly competitive market, manufacturers across the entire supply chain are challenged to deliver the highest quality products at the lowest costs, while improving productivity and time to market.

To overcome these challenges, manufacturers are accelerating their digital transformation by complementing existing computer-aided design (CAD), CAE, and computer-aided manufacturing (CAM) tools with a portfolio of new digital technologies (Figure 1). These novel technologies include

- Advances in production equipment (3D printing, Robotics, and adaptive control machining)
- Smart finished products (connected vehicles using the IoT)
- Advanced analytics on the ever-growing volume, variety, and velocity of digital data across the value chain
- New forms of human-machine interaction such as touch, speech, or visual processing; ML; and artificial intelligence (AI)

These technologies together with fast ubiquitous internet connectivity, high-performance computing (HPC) and large scalable storage and data management systems provide manufacturer's unprecedented capabilities to gather, aggregate, and analyze data throughout a product's lifecycle. Data from concept design, virtual and physical product development, to manufacturing and after-market operations and service can be integrated and analyzed. This helps manufacturers further improve their plant floor and production machinery efficiency, optimize product maintenance schedules, provide deeper insights into the product consumer's use patterns, address regulatory obligations, and mitigate risks.

As a market-leading CAE platform vendor, Hewlett Packard Enterprise is at the forefront of this digital transformation by helping manufacturers maximize value and further improve quality, productivity, and time to market.

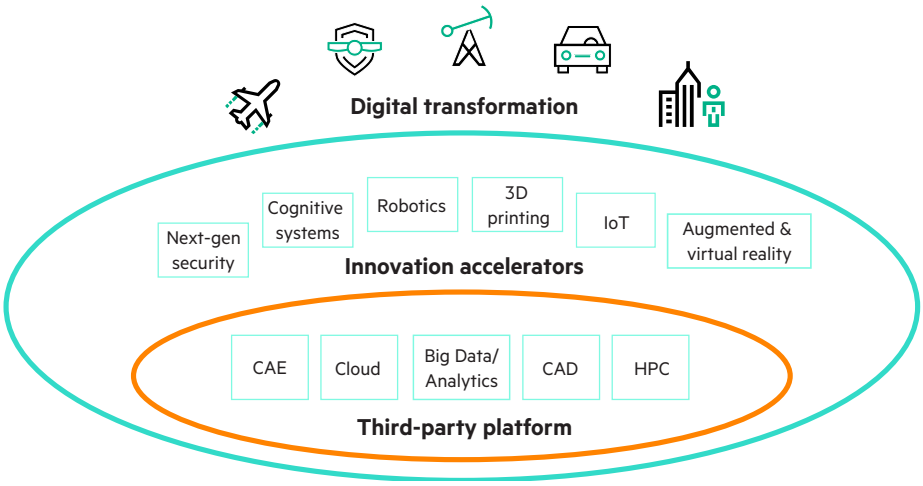

FIGURE 1. Key digital technologies transforming manufacturing

[1] "PMI® at 50.9%," Institute of Supply Management (ISM), January 2020

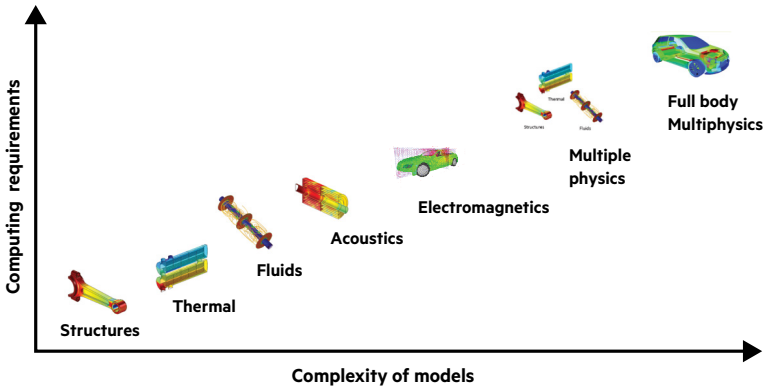

FIGURE 2. Evolution of complex multidisciplinary CAE

CAE NEXT: VIRTUAL PRODUCT DEVELOPMENT WITH A DIGITAL TWIN

Extensively used in product design and development for decades, CAE can slash production time, optimize designs, and prevent expensive rework. Consequently, the CAE software market is expected to grow over 11% annually and cross $9.7B in 2026.[2]

CAD, CAM, or CAE enable virtual product design (VPD) and development. These virtual products are rich and highly accurate models of their physical counterparts. These models describe the physical product's detailed 3D geometry, material properties, tolerances, applied forces, boundary conditions, and so on. With these virtual products, engineers can design and test ideas for new products without having to physically build many expensive prototypes. This can quickly eliminate large number of bad ideas, allowing companies to focus on only the designs that have the best potential for market success. VPD reduces corporate risk by finding issues early in the design cycle before they go to manufacturing. Other benefits include lower warranty costs and less potential litigation if product failure causes injury.

Over the last decade, multidisciplinary CAE (Figure 2—combining fluid mechanics, structural analysis, mechanical dynamics, electromagnetics, and so on) and iterative design and exploration studies have become very popular to simulate, design, and optimize complex systems.

Multidisciplinary CAE requires simulating how multiple types of coupled physics interact at the system and component levels over a wide range of operating conditions. These comprehensive, high-fidelity multiphysics simulations use very detailed geometric models (and large meshes) to accurately predict how complex products behave in real-world environments. Design exploration and optimization studies require integrated and parametric analyses over thousands of operating scenarios on very large meshes with sometimes a billion or more cells.

These multidisciplinary design workloads significantly strain a manufacturer's HPC and storage infrastructure. Also, CAE is itself evolving to handle smart connected products. Products once solely composed of electrical and mechanical parts have become complex systems of systems, nested and networked in numerous ways with edge servers, sensors, software, and data. Designing, developing, manufacturing, servicing, and operating these smart connected products is further stressing today's HPC environments.

Until very recently, CAE was primarily used before actual production of the physical product commenced. Also, CAM tools enabled engineers to simulate an entire factory and predict how it will function in the real world. However, today, a wealth of digital data is continuously collected throughout the physical product's entire lifecycle. Data collection starts from manufacturing execution systems (MESs), including gauges, lasers, vision systems, and scanners on the plant floor. Then, this extends to service or warranty defect data from the field and even includes real-time sensor or telemetry data from operating vehicles or systems.

[2] "Computer Aided Engineering Market (Finite Element Analysis and Computational Fluid Dynamics) for Aerospace, Automobile, Electronic and Electricals Defense, Industrial Machineries and Other Applications: Global Industry Perspective, Comprehensive Analysis and Forecast, 2016-2026," Zion Market Research, 2019.

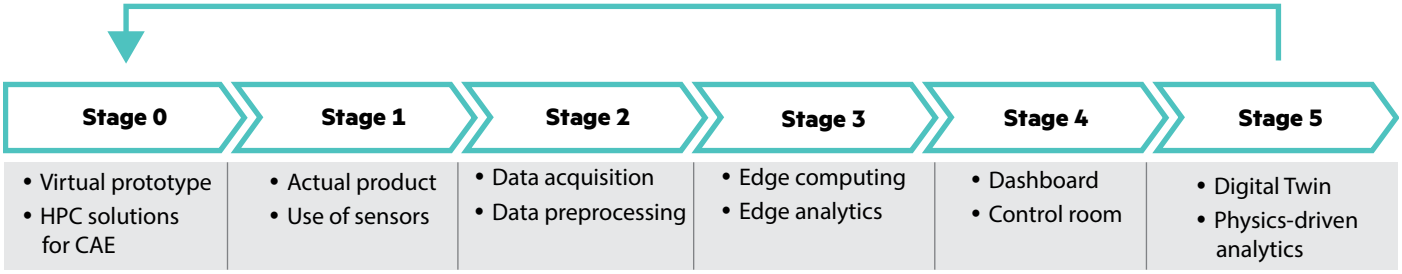

FIGURE 3. Typical "Digital Twin" workflow

This digital representation, or "Digital Twin," of any real equipment, plant, or product provides very detailed and granular data on the actual production form and operation of physical products in real-life situations.[3] Engineers can use this data from the Digital Twin to enhance their virtual products and CAE processes with better predictive models to further improve design, development, and production cycles. This reduces costs, improves product quality, and provides a path toward robust predictive maintenance. In fact, a 2019 Gartner Survey revealed that Digital Twins are entering mainstream use. 75% of organizations implementing IoT already use Digital Twins or plan to within year.

For instance, design engineers can visualize their existing 3-dimensional virtual model and overlay the actual dimensions from the Digital Twin of the physical product. This visual comparison can instantly highlight differences between the virtual and physical product. Manufacturing engineers—collaborating across the entire supply chain—can then take precise corrective actions at the appropriate steps in the production phase. This can be a very valuable tool to take manufacturing to higher levels of productivity, accuracy, and quality.

Likewise, engineers can feed data from real-time sensors and the Digital Twin into the virtual model (Figure 3) to better predict product anomalies or failures. This helps plant floor and service professionals improve production equipment performance, minimize unplanned downtime, and increase reliability and quality while lowering maintenance costs.

Most importantly, manufacturing and engineering executives can optimize all operations across multiple plants, many product lifecycles, and the supply chain for better utilization of all resources—equipment, inventories, and human. This improves enterprise performance and profits.

However, as the volume, variety, and velocity of data continue to grow exponentially throughout the value chain, generating timely, actionable insights from this data can be very challenging. This requires highly reliable HPC solutions that scale and perform. As a market-leading CAE platform vendor, HPE HPC solutions scale to deliver the performance needed to overcome next-generation CAE challenges.

OVERCOMING SCALE AND COMPLEXITY CHALLENGES OF CAE WITH HPE

The data deluge in manufacturing causes numerous IT challenges for CAE environments that increase costs and complexity, and reduce productivity, innovation, and time to market:

1. It is harder to intelligently organize and seamlessly deliver critical data as manufacturing teams expand in size and diversify in geographic locations.
2. Distributed engineering workstations cannot easily interact with compute resources and data in the corporate data centers. These workstations must be replaced with low cost, remote clients connected through high-speed WANs.
3. The HPC infrastructure must deliver high levels of performance, reliability, security, and scalability to support faster response times, larger and more complex simulation models, and foster collaboration across the organization.
4. The CAE environment must be streamlined with management capabilities to reduce capital and operational costs (including expensive simulation software licensing) and complexity.

[3] Digital Twin (from Wikipedia, the free encyclopedia)

As a global market leader in HPC with over 37.8% market share[4] (after including the acquisition of CRAY). HPE solutions for CAE address all these challenges and more. HPE solutions center around three high-level areas: platforms, services, and partnerships with the following features and benefits.

TABLE 1. Solution platforms: features and benefits

Feature	Benefits
High performance	Reduces time to results, can solve larger and more complex problems with greater accuracy
Efficiency	Provides more performance in a smaller footprint, reduces data center floor space requirements, and lowers energy costs
Reliability	Minimizes downtime and unplanned outages, and improves system availability for engineers and time to market
Scalability	Update or upgrade systems incrementally without replacing large quantities of hardware, dynamically adapts to changing business requirements, streamlines budget planning, and improves predictability of expenses
Remote Visualization	Enhances security by keeping critical data within the data center; boosts productivity and collaboration with anytime, anywhere access to graphic-intensive models; lowers costs by centralization, improving system manageability and optimizing resource (GPUs, software licenses, hardware, and so on) utilization; and promotes retention of highly skilled staff with better work-life balance and location flexibility

TABLE 2. Solution services: features and benefits

Feature	Benefits
Purpose-built solutions	Specific solution architecture reduces time to value
Advisory services	Customized solutions tailored to client requirements, end-to-end system integration, and faster implementation of CAE solutions
HPE Centers of Excellence (CoE)	Identify performance bottlenecks, increase efficiency, and reduce costs by performance testing key CAE applications on a globally accessible platform for sharing best practices and resources
HPE GreenLake	An infrastructure service that offers on-demand HPC capacity, combining the agility and economics of public cloud with the security and performance of on-premises IT

TABLE 3. Solution partnerships: features and benefits

Feature	Benefits
Strong partnerships with CAE application providers	Reliable implementation, optimized systems to deliver best performance, and deep expertise in key CAE applications
Intel® Alliance	End-to-end system integration, and access to deep CAE expertise reduces delays in solution implementation
Support for many job schedulers and resource managers	Improves resource utilization of clusters, increases throughput and scalability of CAE workloads, and reduces costs and complexity of managing the HPC infrastructure

[4] Hyperion Research HPC Qview Q3 2019

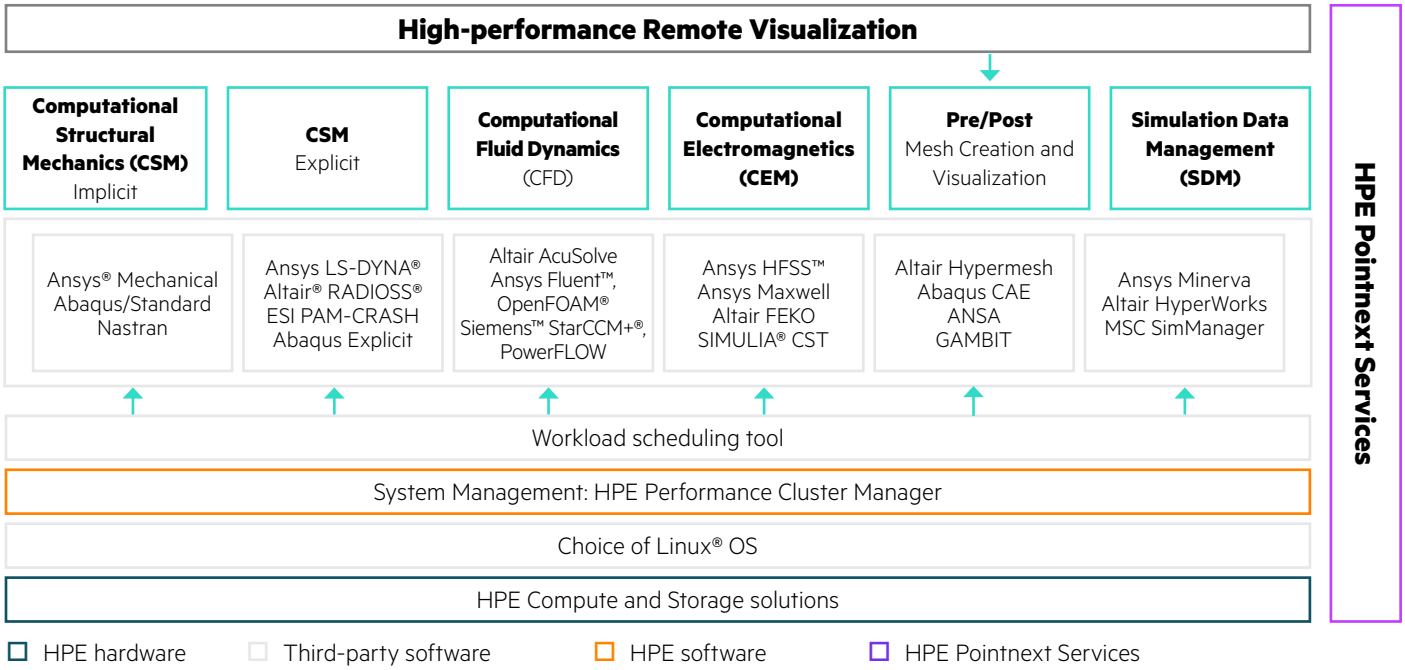

FIGURE 4. Key components of the HPE CAE solution stack

COMPONENTS OF THE COMPLETE CAE SOLUTION

Hewlett Packard Enterprise provides a complete end-to-end solution stack (Figure 4) that is flexible and customizable for a manufacturing client's business requirements. This stack has the largest portfolio of supported and optimized CAE application software, a broad range of software and hardware platforms, all delivered with high-value services.

CAE applications: As a trusted advisor, HPE has excellent relationships with independent software vendors (ISVs). Major CAE applications supported and optimized include Altair RADIOSS and Altair FEKO; Ansys Fluent, Ansys Mechanical, Ansys LS-DYNA and Ansys HFSS; MSC Nastran; Siemens StarCCM+; OpenFOAM and SIMULIA Abaqus FEA®; and ESI PAM-CRASH to name just a few.

In addition, HPE has computer scientists who help ISVs test and optimize their applications on HPE platforms. Clients benefit from the earliest releases of new versions of application software, as well as optimized versions developed by HPE specialists.

Hardware platforms: HPE Cluster Platforms (Figure 5) provide a choice of servers, processors, operating systems, and interconnects—including the HPE Apollo family of servers, the choice of 2U and 5U rackmount servers, or modular HPE water-cooled compute nodes. These clusters combine the flexibility of a custom solution with the simplicity, reliability, and value of a preconfigured, factory-built product. A wide range of qualified options ensures flexible choices, simple implementation, and successful results.

- **HPE Apollo systems:** This high-density server family delivers breakthrough performance with efficient rack-scale compute, storage, networking, power, and cooling for the most demanding HPC, massive data analytics, and object storage workloads. HPE Apollo combines a modular design with innovative power distribution, and air and liquid cooling techniques to provide up to four times more performance per square foot than standard rack servers.[5]
- **Interconnects:** Hewlett Packard Enterprise supports all major commercial interconnect technologies giving customers a flexible choice to optimize price and performance. These technologies include Ethernet, InfiniBand®, and the Intel Omni-Path Architecture.

[5] hpe.com/us/en/servers/density-optimized.html

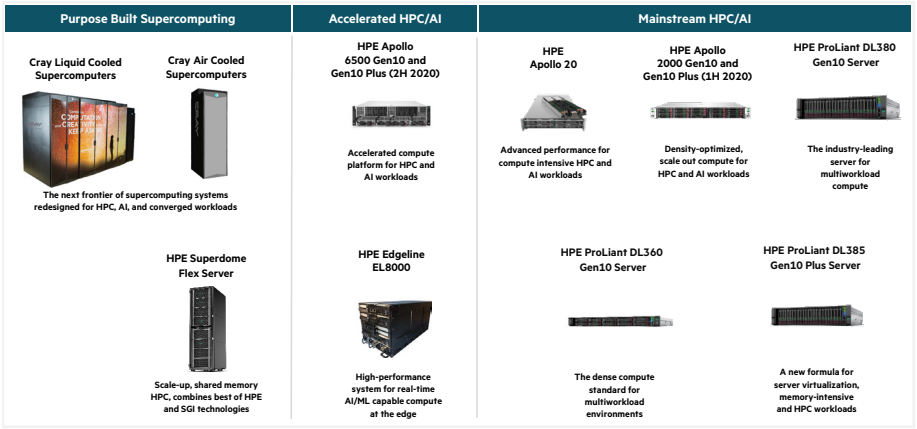

FIGURE 5. HPE systems

Software platform: HPE offers HPC customers complete and modular software portfolio which consists of software solutions we created, combined with best-of-breed solutions from our commercial partners and open source providers—all validated, integrated, and performance-optimized by us so you can select the right software mix for their CAE efforts—all from one source, including:

Server operating system: HPE systems run standard Windows as well as Linux server options. HPE offers specially priced and packaged HPC subscriptions for Red Hat® Enterprise Linux Server and SUSE® Linux Enterprise Software and our customers can also run CentOS.

Cluster management software: To manage their HPC clusters, HPE offers customers HPE Performance Cluster Manager—a fully integrated system management solution offering customers all the functionalities they need to manage their Linux-based systems. The software provides system setup, hardware monitoring and management, health management, image management, and software updates as well as power management for systems of any scale. The HPE Performance Cluster Manager reduces the time and resources spent administering the systems—lowering total cost of ownership, increasing productivity, and providing a better return on your hardware investments.

- **Job schedulers and resource managers:** Job schedulers manage the allocation of submitted jobs to nodes across the cluster and can include policy controls to set resource priorities based on users or projects. Additional functions include load balancing to optimize resource utilization or optimize power or cooling efficiency. Hewlett Packard Enterprise resells some of the most popular schedulers, including Altair® PBS Professional and Adaptive Computing Moab. HPE systems also support Univa Grid Engine and IBM Spectrum LSF.
- **HPC tools and libraries:** HPE offers tools we created and improved over several decades combined with best-in-class third-party software helping CAE customers accelerate performance of their CAE applications. HPE Message Passing Interface (MPI)—an MPI development environment designed to enable the development and run of parallel applications on HPE clusters including acceleration of applications developed with other MPI implementations at runtime. We also offer leading third-party software development tools for all architectures, such as Arm® HPC tools or Intel Parallel Studio XE. As of summer 2020, we will also be offering HPE customers Cray Programming Environment—full-featured software development solution.
- **Remote Visualization:** Hewlett Packard Enterprise offers customers NICE Desktop Cloud Visualization (DCV) through a web portal (NICE EnginFrame). DCV provides users with efficient and optimized remote access to graphic-intensive 3D applications including all the major CAE pre- and post-processing software.

Services: Hewlett Packard Enterprise offers a spectrum of services to meet manufacturing CAE requirements—from services like application tuning to more integrated advisory service offerings such as project management, on-site consulting, technical account management, and solution architecture consulting.

- **HPE Strategic Advisory Services:** IT services to manage the digital transformation include assessment of performance; alignment of business and technical objectives; integration of people, process, and technology; creation of leading architectural and governance practices; recommendation of new and existing technologies; and education and training.
- **HPE custom services:** Hewlett Packard Enterprise and its CAE partners have implemented best practices associated with component choice, integration, power requirements, and maintainability. Services range from on-site systems software support, applications development and tuning, and clusters training.
- **HPE Datacenter Care:** This provides the flexibility and the economies of scale to effectively manage HPE and third-party hardware and software environments. Customers are assigned a personalized on-site account team with a quality call experience delivered globally and backed by HPE Centers of Expertise. In addition, customers can choose the right level of hardware and software support for each device in their multivendor data center.
- **HPE + Intel Center of Excellence for HPC:** This center provides the best HPC solutions for today and the future. It is staffed with a team of benchmarking, applications, and development specialists dedicated to serve CAE customers to ensure that their applications are compatible with current technologies and those in development.
- **Remote Visualization services:** The visualization nodes in the HPE system are preconfigured with the appropriate software while still in the factory. Once the system is delivered, HPE consultants provide knowledge transfer, training, and best practices. These services allow CAE customers to streamline their results data workflow and remotely access this information for post processing and analysis. Other options include a remote system administration service to help customers maximize value from their investment.
- **HPE GreenLake:** HPE provides 3- to 5-year contracts to support the breadth of infrastructure offerings from servers, storage, networks, and software and bill usage in several ways including cloud pricing and delivery models. Installation and other proactive support services are also included. There are two different HPE GreenLake offerings. Pay-as-you-grow, where once capacity is used, it becomes committed and charged for the duration. Pay-as-you-go is offered at a higher price, provides full variability, and is charged only on actual usage.

CUSTOMER EXAMPLES

By providing a range of innovative platforms and high-value services, Hewlett Packard Enterprise and its synergistic CAE partners are driving and accelerating the digital transformation of manufacturing customers worldwide. Here are some VPD examples.

ŠKODA Auto

Rapidly develop more innovative vehicles with excellent value-to-price ratios

Description or challenges	• Required high-performance and scalable computing systems to perform complex product performance and safety analysis • Applications: Fluent, ESI PAM-CRASH, OpenFOAM
Solution or results	• HPE shared memory nodes are used especially for parts of computing workflow that demand large memory • The new processing system delivered over 70 teraflops of processing power and enables ŠKODA to achieve higher resolution simulations and accelerate computational workflows
Benefits	• Reduced processing time, improved design efficiency, quality, and safety • Faster development time and increased cost-effectiveness

"This latest installation enables us to conduct complex product performance and safety analysis that will in turn help us to further our commitment to our customer's welfare and ownership experience. It helps us develop more innovative vehicles at an excellent value-to-price ratio."

– Petr Rešl, head of IT services, ŠKODA AUTO

Sauber Motorsport AG

Accelerate design processing for improved performance on Formula One circuit

Description or challenges	• Process the maximum number of CFD jobs within regulations • Need flexible and scalable HPC solution to handle future business requirements and potential regulatory changes
Solution or results	• HPE systems used for compute-intensive CFD jobs with bursting for urgent processing and Remote Visualization for pre- and post-processing tasks • Deployed 1008 nodes in just 15 minutes
Benefits	• Doubled CFD calculations • Reduced energy consumption

"It is today far more about how much data you can generate, how do you store that data, how do you retrieve that data, and what is the relevant data at the end of the day. That is where the expertise of such a strong partner like Hewlett Packard Enterprise comes in."

– Monisha Kaltenborn, CEO, Sauber F1 Team

The next Flowserve example highlights how multidisciplinary CAE is being used together with other emerging technologies—augmented virtual reality, Digital Twin, and IoT—to improve product performance and predictive maintenance.

Flowserve

Improve product operating performance and reduce unplanned downtime

Description or challenges	• Determine root cause of product anomalies or failures and take optimal corrective actions during operations • Need computational performance for multidisciplinary design optimization coupled with real-time predictive analytics from data generated from operating equipment
Solution or results	• HPE HPC systems used for compute-intensive multidisciplinary (structures, fluids, and electromagnetics) Ansys workloads with Remote Visualization for pre- and post-processing tasks • PTC Software provides augmented reality views for real-time service and control room dashboards • HPE Edgeline servers for real-time analysis of data acquired by National Instruments from optimally placed sensors on equipment (also determined up front by Ansys CAE Analysis)
Benefits	• Reduced unplanned downtime from days to hours • Improved production equipment operating performance and duration; saving millions of dollars annually

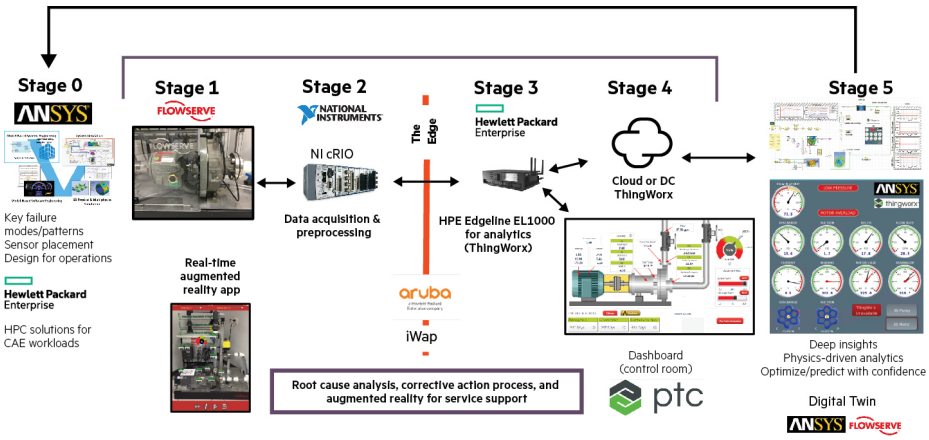

FIGURE 6. Flowserve workflow with "Digital Twin"

"A wonderful convergence of different technologies and different capabilities that don't exist in one place. Through our collaboration with HPE, these are some of the things that have become possible for us."

– Eric van Gemeren, vice president of R&D, Flowserve

WHY HPE FOR CAE

As the scale and scope of CAE continues to grow and as more manufacturers embark on their digital transformation journey, they need a reliable partner with deep HPC, IoT, and manufacturing expertise. Hewlett Packard Enterprise provides a comprehensive portfolio of high-performance systems and software, high-value services, and the best ecosystem of CAE partners to help manufacturing customers reduce costs, improve quality, productivity, and time to market.

Worldwide, many manufacturing companies are already using these CAE solutions from Hewlett Packard Enterprise. As CAE and other emerging technologies evolve to become an integral part throughout the entire value chain and product lifecycle, HPE continues to drive collaborations in manufacturing to help customers innovate and achieve new levels of profits and performance.

As a market-leading CAE platform vendor, Hewlett Packard Enterprise delivers a unified compute and storage solution designed to simplify system and data management, reduce costs and complexity, and scale to deliver the performance needed for the next-generation of HPC solutions in manufacturing.

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