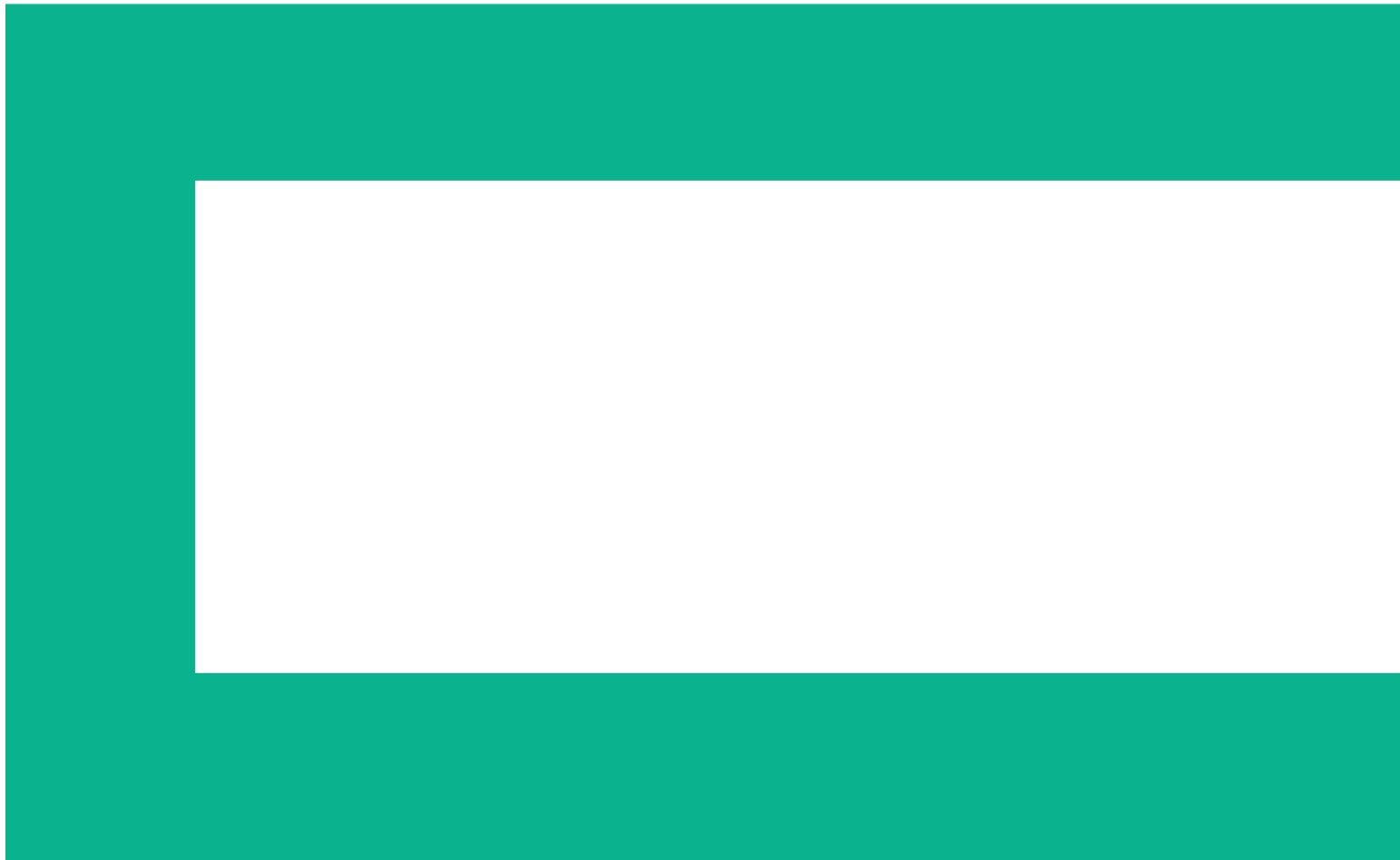


# **Galvanizing manufacturing with Artificial Intelligence and Deep Learning**

Optimizing production, operations, and product/service quality  
with the HPE Apollo 6500 Gen10 system and NVIDIA GPUs





# Table of contents

<b>3</b>	<b>Executive summary</b>
<b>3</b>	<b>Driving value in manufacturing with AI and DL</b>
<b>5</b>	<b>DL benefits from HPC</b>
<b>6</b>	<b>Extending HPE HPC manufacturing leadership to AI and DL</b>
<b>8</b>	<b>HPE Apollo 6500 Gen10 system: Optimized for AI and DL</b>
<b>9</b>	<b>Unique solutions and resources for manufacturers to ramp up AI and DL</b>
<b>10</b>	<b>How manufacturing clients can benefit from HPE Apollo 6500 Gen10 system</b>
<b>11</b>	<b>HPE advantage for AI and DL for manufacturing</b>
<b>12</b>	<b>Resources</b>



## Executive summary

Manufacturers are under severe competitive pressures to deliver and support higher quality and more custom products and services faster and at lower costs. To address these challenges, computer-aided engineering (CAE) is being integrated with several innovative data-driven computing technologies—Artificial Intelligence/**Deep Learning** (AI/DL), **Internet of Things (IoT)**, and others. Many CAE software providers are augmenting their strong physics-based capabilities with AI/DL.

The use of AI and DL is growing rapidly in manufacturing especially as data continues to grow in volume and variety and a lack of skilled data scientists or modelers persists. AI/DL, when combined with real-time production data (from IoT) and product usage or customer insight data, can automate and significantly enhance the product development, testing, and support processes.

With AI/DL, manufacturers can optimize manufacturing operations across the entire value chain and product lifecycle from design and development to production operations to service operations. The economic impact of these growing high-value manufacturing use cases is enormous.

As a market leader in CAE solutions, Hewlett Packard Enterprise is delivering a purpose-built solutions portfolio jointly with NVIDIA® and several independent software vendors (ISVs) in the manufacturing industry to help manufacturers improve their AI/DL implementation journey. This portfolio is anchored on **HPE Apollo 6500** Gen10 system with NVIDIA GPUs.

## Driving value in manufacturing with AI and DL

In a highly competitive market, manufacturers across the entire supply chain are pressured to deliver higher quality, more custom smart products at lower costs while improving productivity and time to market. To overcome these challenges, manufacturers are investing—even with severe budget constraints—in information technology (IT) to connect products, smart factories, and supply chains. Over 60% of manufacturing executives surveyed<sup>1</sup> recently agree that data analytics and IoT can reduce occurrences of equipment breakdowns, unscheduled downtime or maintenance, and supply chain issues.

**Data analytics** including AI, Machine Learning (ML), and DL are core technologies that manufacturers are investing throughout the product lifecycle. IDC predicts that global spending on cognitive and AI solutions will increase at a compound annual growth rate of 55.1% over the next few years, exceeding \$47 billion by 2020.<sup>2</sup>

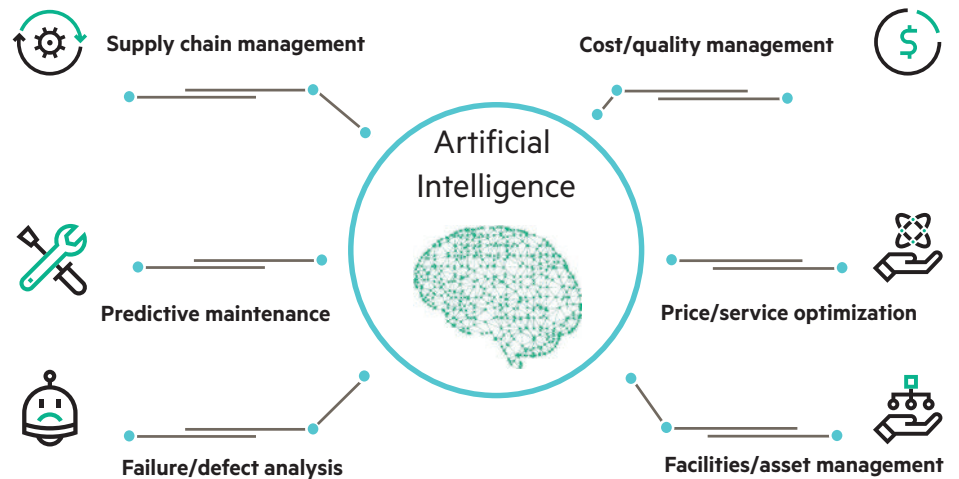
About 30% of high-tech and automotive or assembly manufacturers are adopting one or more AI technologies.<sup>3</sup> Recent interviews with HPE software business partners in manufacturing also confirm this uptick in client interest in deploying many high-value AI use cases throughout the product lifecycle—from design and development to production operations to service operations (Figure 1). In fact, both HPE and NVIDIA are already using AI/DL technologies in product development and manufacturing.

<sup>1</sup> **Manufacturers rely on Big Data analytics to navigate tough business conditions**  
PR Newswire, Honeywell, 2016

<sup>2</sup> **Worldwide Cognitive Systems and Artificial Intelligence Revenues Forecast to Surge Past \$47 Billion in 2020, According to New IDC Spending Guide**  
IDC, 2016

<sup>3</sup> **What AI can and can't do (yet) for your business**,<sup>\*</sup> Michael Chui, James Manyika, and Mehdi Miremadi, McKinsey Quarterly, January 2018





**Figure 1.** Transformative impact of AI in manufacturing

AI is a broad concept of enabling machines to perform tasks that mimic human intelligence using logic and rules. ML is a subset of AI that is typically based on statistical computational techniques that enable machines to improve their tasks by progressively building on experience. ML relies on data scientists to identify and target features. By continuously training on a growing volume of enterprise and sensor data, ML allows manufacturers to discover new rules and handle real-time information flows to further improve the accuracy of data analytics.

DL is a subset of ML with algorithms that enable software to train itself to perform tasks, like speech and voice recognition and image recognition, by processing vast volumes of data using multilayered neural networks. DL typically adds voice, vision, and video to ML data sets and is usually slower or more resource intensive but more accurate. With DL, it is possible to handle very complex models with larger number of parameters, or “degrees of freedom”, providing the capability to model very complex patterns in multidimensional data.

DL enables training a model from raw data, without spending a lot of time on feature engineering and data transformations before feeding the data to a DL algorithm. Further, with its ability to “rinse and repeat”, DL can significantly improve productivity of even very experienced data scientists.

However, implementing a data science workflow can be complex and requires a keen understanding of the computational process and how to map it to a **high-performance computing (HPC) infrastructure.**



### DL benefits from HPC

DL “trains” computers to do what is natural for humans: learn from experience. For example, if you provide a computer a coaching set of images, some of which say, “this is a gear” and some of which say, “this is not a gear,” then, when you show the computer a series of new photos, it could begin to identify which are the gears. DL then continues to add to its coaching set. Every photo that it identifies—correctly or incorrectly—gets added to the coaching set, and the program effectively gets “smarter” and better at completing this task over time.

Inference is the next step to execute this trained neural network model for real-time decision-making. For example, if you are looking at thousands of new machine parts image data, you can quickly infer which parts are gears in real time. The performance and accuracy of DL frameworks (based on neural networks) improve as the number and types of data samples available for training increases. This trained model can be used to make inferences on new data sets (Figure 2).

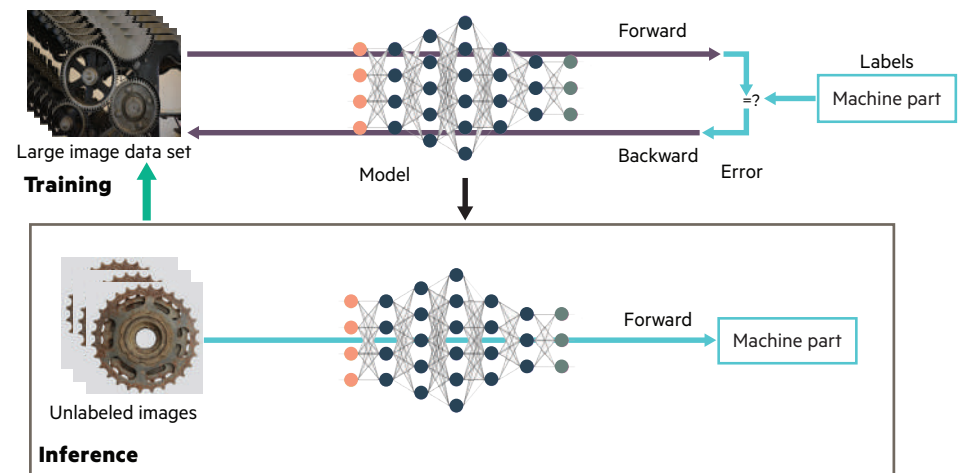


Figure 2. A typical machine parts image recognition workflow—training and inference

Prior to the use of NVIDIA graphics processing units (GPUs) for DL, training (usually computing in the data center) a model with thousands or millions of images typically took days or weeks. On the other hand, one inference (analytics at the edge) instance is less compute intensive but often repeated millions of times. Training and inference involve very compute-intensive parallel matrix operations. NVIDIA GPUs are extensively used to significantly accelerate these matrix operations to reduce training time and improve inference throughput.

Extending our HPC leadership, HPE and NVIDIA are working together with a growing ecosystem of software and solution partners to help manufacturers in their journey to effectively deploy DL.





### Extending HPE HPC manufacturing leadership to AI and DL

HPE is a market leader in CAE and in fact for all HPC with a 36.8% market share.<sup>4</sup> With a purpose-built solutions portfolio jointly developed with NVIDIA and several ISVs in the manufacturing industry, HPE is extending its leadership in CAE to help manufacturers incorporate elements of AI into their processes.

Developed in collaboration with several ISV partners, the flexible HPE HPC and AI/DL blueprint for manufacturing, depicted in Figure 3, shows the entire product lifecycle: design and development, production operations, and service operations functions.

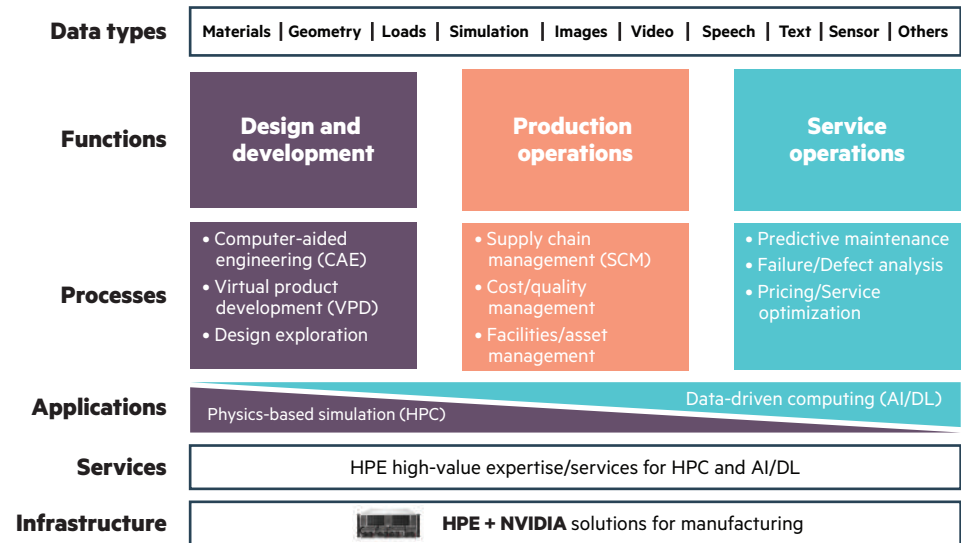


Figure 3. HPE blueprint for HPC and AI/DL

<sup>4</sup>Hyperion Market Update: 'Decent' Growth Led by HPE; AI Transparency a Risk Issue. HPCwire, 2017





Here is a brief description of the key layers of the HPE blueprint for HPC and AI/DL listed above.

- **Data types:** Manufacturers must manage an ever-growing volume and variety of data. In design and development, most of the engineering input data include CAD/CAE model data: materials, geometry, loads, and such, which are typically small. The larger output of structured and parametrized simulation data includes results and visualization data. Production operations and service operations deal with a much larger volume of unstructured data in the form of images, video, voice, text, sensors, and others.
- **Functions, processes, and applications:** To implement key business processes in each function, manufacturers use many applications—some sourced through ISVs and others are built in-house. Increasingly, data across functions are being integrated and analyzed to further improve 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.

Major CAE (traditionally physics-based) application providers such as Altair, ANSYS, Dassault Systèmes, ESI Group, and others are adding more data-driven computing capabilities including AI/DL. Likewise, many data-driven IoT software providers such as GE Digital with Predix, Siemens with MindSphere, and PTC with ThingWorx are implementing DL. In fact, HPC is meeting AI and DL. **Watch** the HPE presentation on “HPC & AI Technology Trends.”

- **Services and infrastructure:** Key HPE offerings to help manufacturers scale AI/DL include high-value expertise and services, including flexible consumption models from **HPE Pointnext**, a growing partner ecosystem, and sophisticated, tailored hardware or software infrastructure with integration services. These offerings complement the existing **HPE Apollo** portfolio and strengthen overall HPE capabilities from the **core data center** to the **Intelligent Edge**.

HPE Apollo 6500 Gen10 system is the leading system for HPC and AI/DL in the data center. With industry-leading accelerators from NVIDIA, this system delivers enterprise-grade reliability and exceptional performance.



## HPE Apollo 6500 Gen10 system: Optimized for AI and DL

HPE Apollo 6500 Gen10 system (Figure 4) best addresses the most important step of training the DL model. Also, manufacturers get

- Unprecedented performance
- An economical AI/DL platform
- Rock-solid enterprise-level reliability, availability, serviceability (RAS) features
- Easier system management
- Flexibility to support a wide range of workloads, including DL and typical HPC/CAE workloads



**Figure 4.** HPE Apollo 6500 Gen10 system and NVIDIA® Tesla® V100

With eight—the highest in the HPE portfolio—high-performance GPUs per server, including NVIDIA Tesla V100, P100, and P40, the HPE Apollo 6500 Gen10 system provides superior performance per dollar for GPU-intensive workloads—delivering up to 125 TFLOPs single-precision compute.<sup>5</sup> Purpose-built for accelerated computing, this platform features both PCIe and NVIDIA NVLink™ GPU interconnects, providing the flexibility to suit a wide variety of requirements.

The second generation NVLink GPU interconnect is particularly useful for DL workloads, characterized by heavy GPU-to-GPU communications. High-bandwidth, low-latency networking adapters (up to four high-speed Ethernet, Intel Omni-Path Architecture, InfiniBand Enhanced Data Rate (EDR), and future InfiniBand HDR per server) are tightly coupled with the GPU accelerators, which allows the system to take full advantage of the network bandwidth.

In addition to the flagship HPE Apollo 6500 Gen10 system, HPE provides manufacturers a unique portfolio of high-value capabilities and resources to ramp up their AI/DL initiatives.

<sup>5</sup> Theoretical Peak Performance, 2018







## Unique solutions and resources for manufacturers to ramp up AI and DL

As the AI/DL market continues to grow, HPE provides manufacturers unique offerings and resources to explore, experiment, and expand their AI/DL initiatives:

- **HPE Rapid Software Installation for AI:** HPE introduced an integrated hardware and software solution, purpose-built for HPC and DL applications. Based on the HPE Apollo 6500 Gen10 system with NVIDIA GPU's and in collaboration with Bright Computing to enable rapid DL application development, this solution includes preconfigured DL software frameworks, libraries, automated software updates, and cluster management optimized for DL. HPE Rapid Software Installation for AI supports NVIDIA Tesla V100 GPU's as well as uses NVIDIA Data Center GPU Manager (DCGM) for GPU monitoring and includes CUDA and the NVIDIA Collective Communications Library (NCCL) in its DL software distribution.
- **HPE Deep Learning Cookbook:** Built by the AI Research team at Hewlett Packard Labs, the HPE DL Cookbook is a set of tools to guide clients in selecting the best hardware and software environment for different DL tasks. These tools help manufacturers estimate performance of various hardware platforms, characterize the most popular DL frameworks, and select the ideal hardware and software stacks to fit their individual needs. The **HPE Deep Learning Cookbook** can also be used to validate the performance and tune the configuration of already purchased hardware and software stacks.
- **Remote Visualization (RV):** For manufacturers, RV 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 such) utilization; and promotes retention of highly skilled staff with better work-life balance and location flexibility.
- **HPE AI Innovation Center:** Designed for long-term research projects, the innovation center serves as a platform for research collaboration between universities, manufacturers on the cutting edge of AI research, and HPE researchers.
- **Enhanced HPE Centers of Excellence (CoE):** Designed to assist IT departments and data scientists who are looking to accelerate their DL applications and realize better ROI from their DL deployments in the near term, the HPE CoE offer select manufacturing clients access to the latest technology and expertise. This includes the latest NVIDIA GPUs on HPE systems. The current HPE CoE are spread across five locations: Houston; Palo Alto; Tokyo; Bangalore, India; and Grenoble, France.

By leveraging HPE capabilities and offerings, especially the HPE Apollo 6500 Gen10 system, every manufacturer has the potential to integrate AI/DL into their operations and become more competitive.





## How manufacturing clients can benefit from HPE Apollo 6500 Gen10 system

HPE Apollo 6500 Gen10 system with NVIDIA GPUs and specific ISV application software help accelerate key DL use cases in many manufacturing subsegments, including automotive, aerospace, electronics or high-tech, and industrial. Figure 5 outlines some of the growing number of high-value business use cases in manufacturing mapped by application and data type.

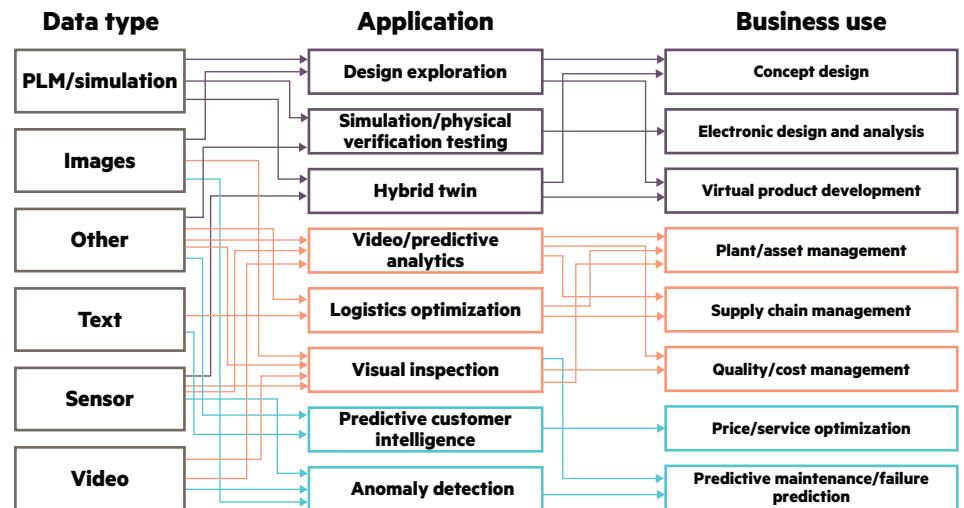


Figure 5. Key manufacturing AI/DL business use cases by application and data type



**Concept design and virtual product development:** Altair is helping its clients by using ML, including DL on existing data, to supplement physics-based, nonlinear, multiphysics simulations such as automotive crash simulation. This helps leverage past experiences, improves predictive accuracy, and reduces expensive design iterations and rework. Altair is also working on improving predictive maintenance using IoT data and digital twins. Digital twins allow a manufacturer to digitally replicate a product, process (that is, production line), or service (for example, maintenance procedures).

By combining and complementing physics-based CAE models with digital twins and AI/DL models, the ESI Group produces three synergistic views (future—using simulation; present—from real-time sensor data; and past—images of crashed vehicles) of manufacturing events. This hybrid twin empowers users and managers to make better design and development decisions. The ESI Group has also demonstrated this to improve predictive maintenance, anomaly detection, and process optimization.

Also, Dassault Systèmes can add and integrate product lifecycle management (PLM) data that's already parametrized to simplify the deployment of ML models to augment physics-based, nonlinear, multiphysics simulations.

**Electronic design and analysis (EDA):** Manually analyzing the results generated by EDA tools to waive or fix any design issues is a tedious, error-prone, and time-consuming process. ANSYS helps automate these time-consuming rigorous manual procedures by using DL to aggregate key insights across different designs using ongoing and historical simulation data. In fact, NVIDIA is using ANSYS in product development and physical verification testing.<sup>6</sup> The EDA industry is also exploring opportunities to complement today's simulators with AI/DL models that run more than an order of magnitude faster.<sup>7</sup>

**Plant, asset, and supply chain management:** By combining video, voice, sensor, and other data into DL models, manufacturers can create alerts to improve safety, reduce operational violations, protect assets on production lines, and improve warehouse or supply chain logistics—balancing supply and optimizing inventory in real time. PTC and others are developing AI/DL solutions for better predictive analytics on these real-time information flows.

**Quality and cost management:** Visual inspections with cameras and drones are being augmented with DL and virtual assistants to quickly identify quality issues and detect anomalies throughout the product lifecycle.

**Service and pricing optimization:** Manufacturers can use real-time sensor data to monitor the actual use of their products and provide highly customized pay-as-you-go services using AI/DL.

**Predictive maintenance and failure prediction:** This is arguably the most widespread AI/DL use case in manufacturing. HPE is using DL to predict failures—including the time to failure—of enterprise-grade drives in the field, based on data about their voltage, temperature, and current. HPE is also investigating causal inference models to better predict failure of complex systems. PTC is also using DL techniques to improve failure prediction and improve predictive maintenance.<sup>8</sup>

<sup>6</sup> **Machine Learning based Generic Violation Waiver System with Application on Electromigration Sign-off**, N. Chang, A. Baranwal, H. Zhuang, M. Shih, R. Rajan, Y. Jia, H. Liao, Y. Li, T. Ku, R. Lin, ANSYS, Inc. and NVIDIA Corporation, 2018

<sup>7</sup> **AI Expands Role in Design**, EE Times, 2018

<sup>8</sup> **Predictive Analytics Enabled by Machine Learning**, PTC



## HPE advantage for AI and DL for manufacturing

As more manufacturers embark on their AI and DL journey, they need a reliable partner with deep HPC, AI/DL, and manufacturing expertise. Working jointly with NVIDIA, HPE provides a comprehensive portfolio of enterprise-grade, high-performance systems and software, high-value services, and the best ecosystem of ISV partners to help manufacturing customers deploy AI and DL throughout the value chain and product lifecycle.

Worldwide, many manufacturing companies are already using CAE, IoT, and other enterprise solutions from HPE. As AI/DL technologies evolve to become an integral part of end-to-end operations in manufacturing, HPE is well positioned to help manufacturers innovate, improve product and service quality, and optimize operations to achieve new levels of profits and performance.

As a market leader in CAE solutions, HPE delivers a purpose-built solutions portfolio jointly with NVIDIA and several ISVs in the manufacturing industry to help manufacturers enhance their AI/DL implementation journey. The flagship member of this portfolio is the HPE Apollo 6500 Gen10 system powered by NVIDIA GPUs.

### Resources

[HPE Deep Learning Solutions](#)

[HPE High Performance Computing Solutions](#)

[HPE HPC for Manufacturing and Engineering solutions](#)

[Market-leading HPC solutions for manufacturing, business white paper](#)

[HPE Digital Prescriptive Maintenance Services](#)

**From NVIDIA**

[AI in the enterprise](#)

[Find the Right Accelerator for Your Deep Learning Needs](#)

Social handles: [@NvidiaAI](#), [@NVIDIADC](#)

Learn more at  
[hpe.com/info/deep-learning](https://hpe.com/info/deep-learning)



Make the right purchase decision. Click here to chat with our presales specialists.



Sign up for updates

© Copyright 2018 Hewlett Packard Enterprise Development LP. The information contained herein is subject to change without notice. The only warranties for Hewlett Packard Enterprise products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. Hewlett Packard Enterprise shall not be liable for technical or editorial errors or omissions contained herein.

Intel is a trademark of Intel Corporation in the U.S. and other countries. NVIDIA is a trademark and/or registered trademark of NVIDIA Corporation in the U.S. and other countries. All other third-party trademark(s) is/are property of their respective owner(s).

a00043814ENW, April 2018, Rev. 1

