High Value Computer Aided Engineering Solutions from Hewlett Packard Enterprise (HPE) – a Quantitative Assessment

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Executive Summary

As manufacturers struggle to overcome competitive and cost pressures, the economic benefit of Computer Aided Engineering (CAE) is enormous; often delivering 100s of percent in Return on Investment (ROI). With CAE, manufacturers can deliver higher quality products faster while lowering overall costs and risks. CAE and Manufacturing Data Analytics (fueled by the rapid proliferation of the Internet of Things (IoT)) is driving the robust growth of High Performance Computing (HPC) infrastructures in Manufacturing.

Compared to white box (proxy for commodity clusters) alternatives, the HPE CAE solutions portfolio – anchored on HPE Apollo servers with Intel component level technologies – has several novel features to reduce complexity and bring high-performance and scalability to run multiple complex CAE and Analytics that maximize value for manufacturers. The integration of processors, networks, software (including performance-optimized CAE and Data Analytics software) and storage, leads to quicker deployments and faster time to value. It also requires minimal ongoing administration or tuning, allowing manufacturers to optimize their ***Total Value of Ownership*** *(TVO), which is (Total Benefits – Total Costs).*

The comprehensive TVO analysis presented in this paper compares HPE CAE solutions with a corresponding white box cluster for three configurations – small, medium and large. This cost-benefit analysis framework considers cost/benefit drivers in a 2 by 2 continuum: Direct vs. Derived and Technology vs. Business mapped into four quantified quadrants: Costs, Productivity/Quality, Revenues/Profits and Risks.

Compared to using a white box cluster, HPE clients deploying CAE workflows ***can improve the three-year ROI for all configurations*** *despite modestly higher acquisition costs. Likewise, the Payback Period (PP) for HPE solutions is shorter than white box clusters; providing manufacturers faster time to value. In fact, these ROI/PP improvements grow with configuration size; offering clients better investment protection as data volumes and CAE/Analytics model complexities continue to grow.*

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Optimizing Business Value

Growing Value of Computer Aided Engineering in Manufacturing

ROI from CAE in 100s of percent

Manufacturers are prioritizing investments in Computer-Aided Engineering (CAE) and Data Analytics. This is because CAE continues to help slash production time, optimize designs, enhance productivity of engineers and suppliers, improve product quality, prevent expensive rework and spur innovation. In fact, spending on CAE software is expected to grow over 11% annually and cross $5.8B in 2021.[1] The return on investment (ROI) from virtual product design with CAE – the largest commercial High Performance Computing (HPC) segment[2] – can be in the 100s of percent[3].

Fueled in large part by the growth of the Internet of Things (IoT), the Manufacturing Data Analytics software and services market is expected to grow even more – 21.9% annually from $3.14B in 2016 to $8.45B by 2021.[4] Over 60% of manufacturing executives surveyed[5] recently, agree that Data Analytics can reduce occurrences of equipment breakdowns, unscheduled downtime/maintenance, and supply chain issues. Investments in CAE and Data Analytics help Manufacturers maximize value.

But as data volumes and virtual model complexity/fidelity continue to grow, CAE and Data Analytics require highly reliable HPC infrastructures that scale and perform consistently to generate time-critical insights and maximize the Total Value of Ownership (TVO) for manufacturers.

Total Value of Ownership (TVO) provides holistic cost-benefit analysis

This paper uses a Total Value of Ownership (TVO) model that quantifies some of the key interrelated cost and benefit drivers and differentiators of Hewlett Packard Enterprise (HPE) compute clusters over white box (proxy for commodity) clusters. These cost and value drivers were identified using over a dozen in-depth interviews representing HPE customers and HPC/CAE experts across multiple industries and company sizes, HPE input and other research. This holistic cost-benefit analysis examines various configuration sizes (small, medium and large) for high-value HPE CAE solutions over white box alternatives.

High Value CAE Solutions from Hewlett Packard Enterprise (HPE)

As the market leader in HPC systems with about 36.8 percent market share[6], HPE delivers unified compute and storage solutions that simplify system and data management, reduce costs and complexity and scale to deliver excellent performance for next-generation CAE and Data Analytics workloads.

These solutions[7] have three pillars – partnerships, platforms and services that ***improve TVO for CAE:***

HPE delivers partnerships, platforms and services that improve TVO for CAE

Partnerships: Deep technical collaborations with all major CAE applications providers produce reliable and optimized implementations of CAE applications to deliver excellent performance.

Platforms: High-performance hardware and software improve efficiency, reliability and scalability of CAE workflows with remote visualization capabilities. HPE Cluster Platforms provide a choice of servers (e.g. HPE Apollo family), processors (e.g. Intel® Xeon® Scalable Processors – the latest Intel Xeon processors deliver the world's best performance for compute and data-intensive workloads. Faster performance is due also to significant increases in memory and I/O bandwidth with six memory channels and 48 PCIe lanes), operating systems, interconnects (e.g. Intel Omni-Path Architecture – OPA provides 100Gbps bandwidth and low-latency next-generation fabric for HPC clusters. The denser 48-port switch chip delivers a 33 percent increase over the traditional 36-port switch), storage (Intel 3D NAND SSDs – solid state drives – offer the higher performance and reliability that users expect from modern storage systems while supporting increased densities, making them an excellent choice to replace older hard disk drive-based storage solutions, and high-value cluster software from HPE/ partners.

HPE's flagship Apollo Gen10 servers are high-density, energy-efficient, memory-intensive systems that scale from small (Apollo 2000) to medium (Apollo 6000) to large supercomputers (HPE SGI

[1] Zion Market Research, https://www.zionmarketresearch.com/report/computer-aided-engineering-market
[2] https://www.enterprisetech.com/2017/11/15/hyperion-market-update-fairly-decent-growth-led-hpe-ai-transparency-risk-issue/
[3] https://www.hpcwire.com/2017/04/20/hyperion-idc-paints-bullish-picture-hpc-future/
[4] https://www.marketsandmarkets.com/Market-Reports/manufacturing-analytics-market-125191578.html
[5] http://www.multivu.com/players/English/7917551-honeywell-iiot-data-analytics-survey/
[6] https://www.hpcwire.com/2017/11/15/hyperion-hpc-market-update-decent-growth-led-hpe-ai-transparency-risk-issue/
[7] https://www.hpe.com/h20195/v2/getpdf.aspx/a00021803enw.pdf?ver=1.0

8600). HPE Apollo combines a modular design with power distribution, and air/liquid cooling techniques, providing up to four times more performance per square foot than white box rack servers.[8]

Services: Purpose-built CAE solutions and advisory services deliver faster time to value. HPE Centers of Excellence (COE) and 24/7 support ensure efficient operations with minimal disruptions.

These three pillars of differentiation of HPE solutions are included in the TVO Framework for CAE.

TVO Framework organized by Technology/ Business and Direct/ Derived cost and value drivers

High Level TVO Framework with Key Cost and Value Drivers for CAE

The TVO framework (Figure 1) categorizes the interrelated cost/value drivers (circles) for CAE solutions by each quadrant: Costs, Productivity/Quality, Revenue/Growth and Risks. Along the horizontal axis, the drivers are arranged based on whether they are primarily **Technology** or **Business** drivers. Along the vertical axis, drivers are arranged based on ease of measurability: **Direct** or **Derived**.

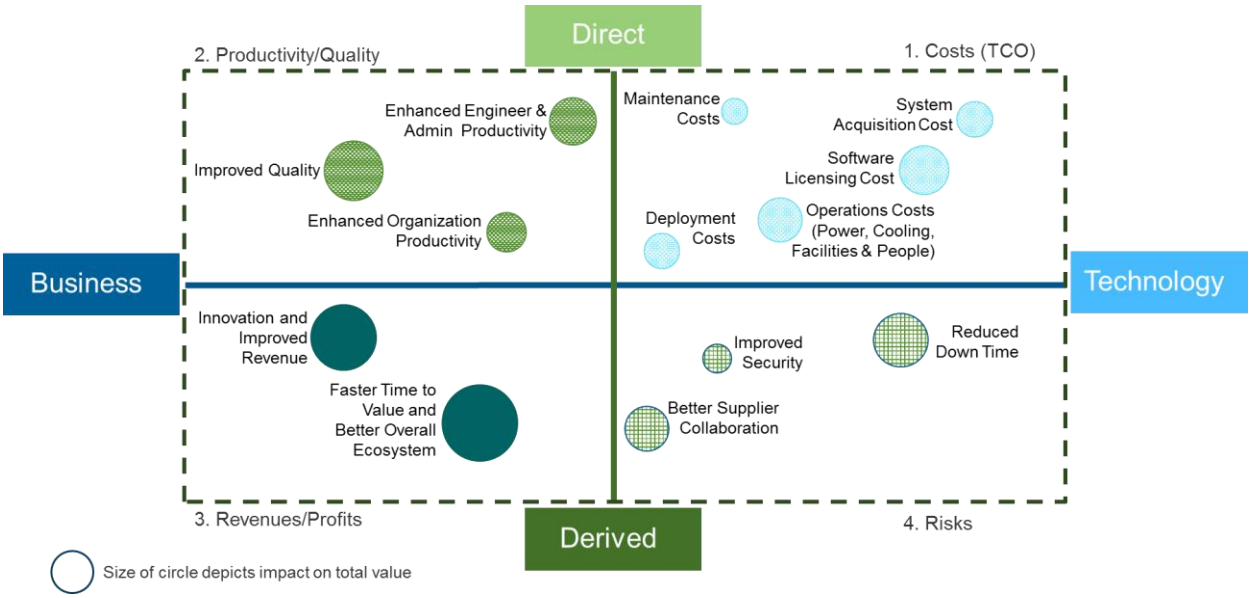

Figure 1: TVO Framework for CAE with Cost/Value Drivers

Key cost/value drivers identified and quantified holistically

The cost/value drivers for CAE are depicted as a circle whose size is proportional to the potential impact on a manufacturing client's Total Value (Benefits – Cost) of Ownership or TVO as follows:

1. **Total Costs of Ownership (TCO):** Typical costs include: one-time acquisition costs for the hardware and deployment, and annual costs for software, maintenance and operations.
2. **Improved Productivity/Quality:** The TVO model quantifies the value of productivity gains of administrators, engineers and the organization. It also estimates improvements in product quality.
3. **Revenue and Growth:** Faster time to value with a better optimized and more comprehensive CAE ecosystem. Greater innovation capabilities for manufacturers spur growth, revenues and improve profits.
4. **Risk Mitigation:** A streamlined process, lower system downtime and better business and IT understanding/collaboration with suppliers minimize cumbersome iterations in rework and delays. Improved security, process consistency and data quality mitigate risks of failed/poor analysis outcomes.

Value includes lower costs, enhanced productivity/ quality, higher revenues/ profits and lower risks

The TVO for both HPE and white box systems typically grow by CAE solution size, with key differentiated features in the HPE solution (detailed in the Appendix) driving added value over white box alternatives.

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

Total Value of Ownership (TVO) for CAE – Results

TVO analysis for three configurations: small, medium and large

The Cost-Benefit Analysis presented here quantifies the Total Value (Total Benefits – Total Costs) for Three Years of the HPE CAE Portfolio over corresponding white box clusters. Three configurations (Table 1) are analyzed: small, medium and large. All costs and benefits grow with configuration size for both HPE and white box clusters. HPE hardware acquisition and maintenance costs are assumed to be 8% higher than corresponding white box clusters for all cases.

CONFIGURATIONS	SMALL		MEDIUM		LARGE	
	White Box	HPE Apollo 2000	White Box	HPE Apollo 6000	White Box	HPE Apollo SGI 8600
Number of Racks	0.20	0.20	1	1	4	4
Number of Servers	16	16	80	80	240	240
Number of Processors	32	32	160	160	480	480
Number of Cores	576	576	2880	2880	11520	11520
RAM (128GB per Server)	2048	2048	10240	10240	30720	30720
Storage (2TB / Server)	32	32	160	160	480	480

Table 1: CAE Configurations - Small, Medium and Large for HPE and White Box Clusters

Results for a Small CAE Configuration: Figure 2 depicts the costs and benefits mapped by each quadrant and value driver. HPE's (Apollo 2000) slightly larger acquisition and maintenance costs are more than offset by higher client benefits in enhanced productivity and quality, higher revenues/profits and lower risks.

Small HPE Apollo 2000 system provides considerably faster time to value and more improved revenue/ growth

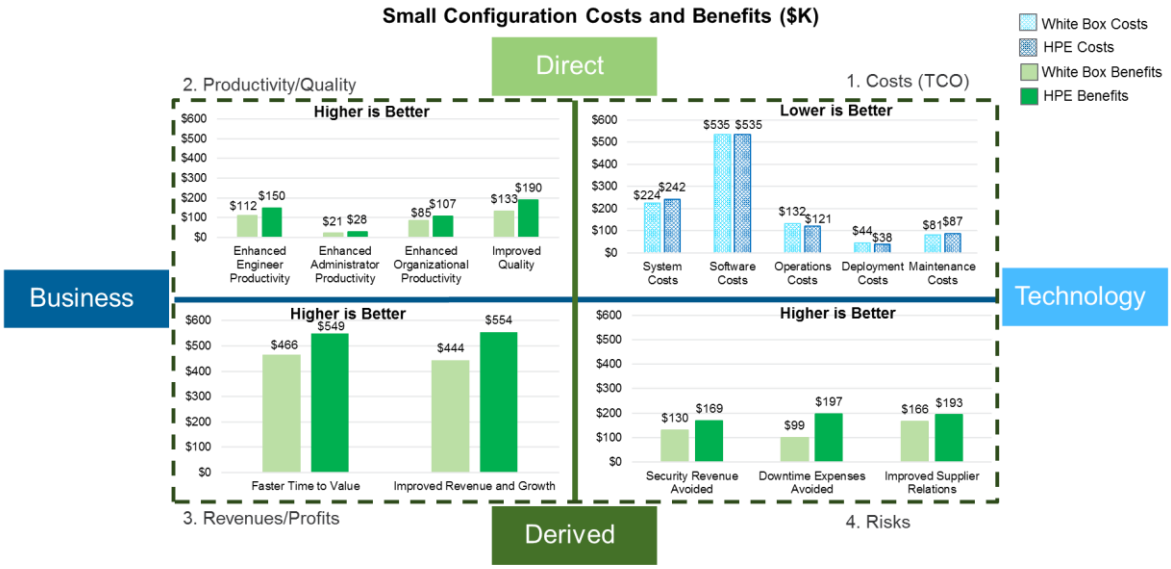

Figure 2: Costs and Benefits by Driver for HPE Systems versus White Box Clusters (Small)

Medium HPE Apollo 6000 systems deliver even more value

Results for a Medium CAE Configuration: Figure 3 (next page) depicts the costs and benefits mapped by each quadrant and value driver. Again, HPE's (Apollo 6000) slightly larger acquisition and maintenance costs are more than offset by even greater client benefits in enhanced productivity and quality, higher revenues/profits and lower risks.

Better quality, faster time to value, improved revenues/ growth with HPE Apollo 6000

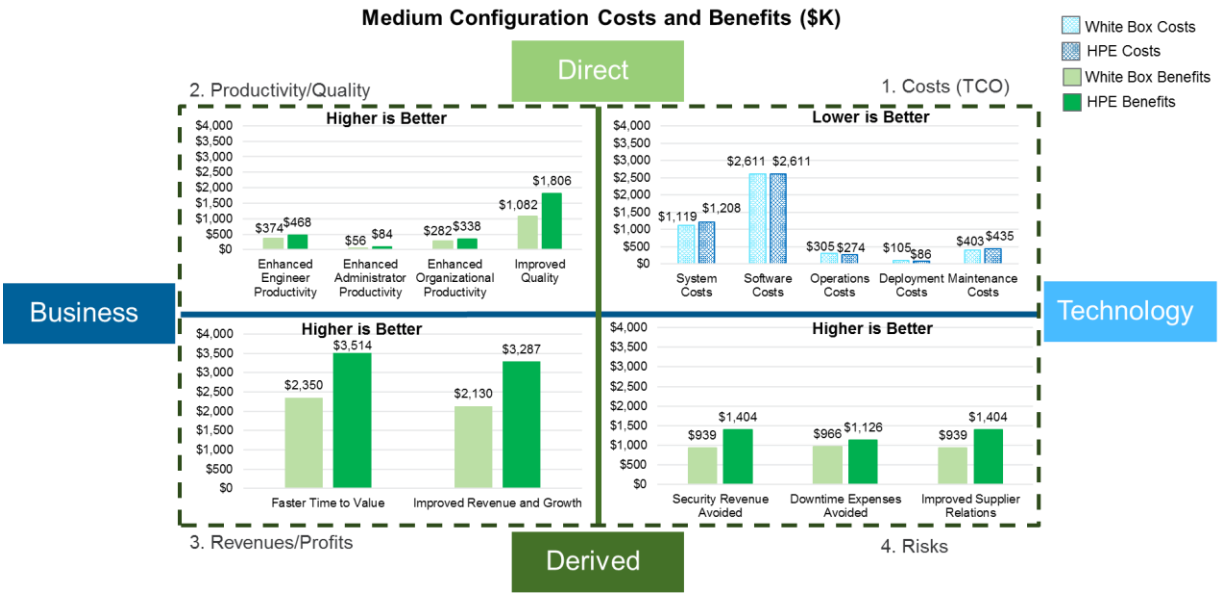

Figure 3: Costs and Benefits by Driver for HPE Systems versus White Box Clusters (Medium)

Results for a Large CAE Configuration: Figure 4 depicts the costs and benefits mapped by each quadrant and value driver. Again, HPE SGI 8600's slightly larger acquisition and maintenance costs, including for water cooling, are considerably more than offset by even greater client benefits in enhanced productivity and quality, higher revenues/profits and lower risks. Manufacturers can get significant returns because of unique CAE capabilities that help drive radical innovation and have the potential of creating entirely new product categories.

HPE SGI 8600 can drive radical innovation by solving "intractable" problems

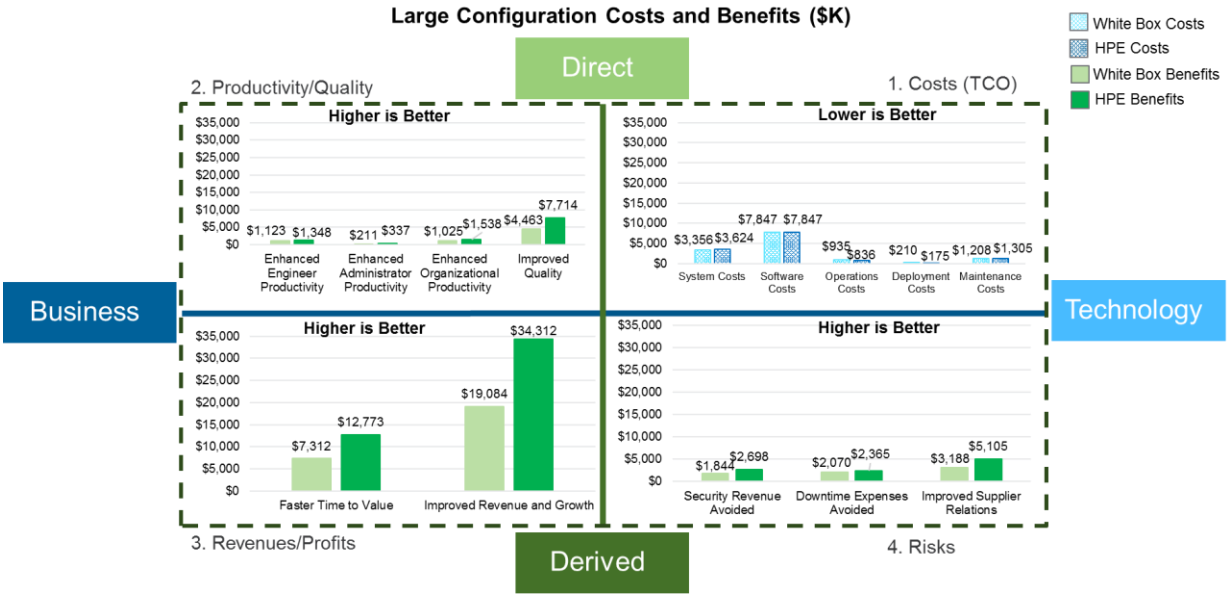

Figure 4: Costs and Benefits by Driver for HPE Systems versus White Box Clusters (Large)

TVO Model Assumptions and Discussions of Results

HPE system acquisition and maintenance costs are assumed to be 8% higher

Most Total Cost of Ownership (TCO) models only quantify the costs in Quadrant 1. The TVO model outlined here not only considers these costs but also the benefits from the value drivers in the remaining three quadrants. For each configuration size, these costs and benefits are computed as follows:

1. Costs: HPE hardware acquisition (one-time) and maintenance costs (annual after year 2) are assumed to be 8% greater than the corresponding white box cluster. The licensing costs (annual) for CAE application software are the largest cost component and are assumed to be same for both alternatives. Electricity costs are $.09/kWh. Same competitive salaries are assumed for personnel.

   Compared with white box clusters, HPE Apollo systems lower data center facilities, power and cooling costs, and require fewer systems administrators to manage CAE environments; reducing operations costs (annual). Often pre-configured in the factory, HPE systems have easy to use integration templates for commonly deployed CAE applications. This helps lower deployment times (one-time cost) and improve productivity. All these differential savings with HPE systems grow with configuration size.

HPE systems lower deployment and operating costs for CAE

2. Productivity/Quality: With fewer downtimes and better streamlined/performance-optimized CAE solutions, HPE systems enhance the productivity of engineers. Systems administrator productivity for HPE systems is also enhanced with turnkey HPC cluster solutions and software for comprehensive ongoing node to rack to job management. Organizational productivity is further enhanced with other HPE value-added services tailored for the Manufacturing industry. These productivity improvements and differentials grow with configuration size.

   Manufacturers can improve the quality of products and the CAE process by easily integrating with other HPE Manufacturing solutions: Edge, IoT, Machine Learning, etc., and detecting problems faster to reduce rework and costs. Greater Quality benefits accrue with larger configurations that enable more realistic Multiphysics CAE models.

3. Revenues and Profits: HPE solutions also deliver faster time to value through a better and more comprehensive ecosystem of CAE partners whose applications are optimized for predictable performance, scale, ease of deployment and integration. Value added HPC software from HPE and partners enable manufacturers to optimize complex CAE workflows and automate cluster installation which becomes very cumbersome for white box clusters as configuration size grows.

   Manufacturers can innovate more and generate better new product ideas through deeper insights from more accurate Multiphysics simulations which typically require larger configurations. This further improves a manufacturer's competitive advantage, revenues and profits. Revenues and profits grow considerably with larger configurations consistent with other HPC ROI studies.

HPE systems enhance productivity/ quality, revenues/ profits and lower risks

4. Risks: Manufacturers must mitigate risks which typically grow with configuration size. Better reliability, availability and serviceability (RAS) and security features in enterprise-grade HPE systems for CAE help manufacturers contain downtime and security expenses. HPE solutions also promote better collaboration with suppliers to further lower risks and drive revenues/profits.

ROI and Payback Period improve as configuration sizes grow

Better ROI/Payback for CAE with HPE Systems Over White Box

Key financial metrics for a 3-year time horizon for all three configurations for HPE and White Box clusters shown in Figure 5 include: Return on Investment (ROI) and Payback Period (PP).

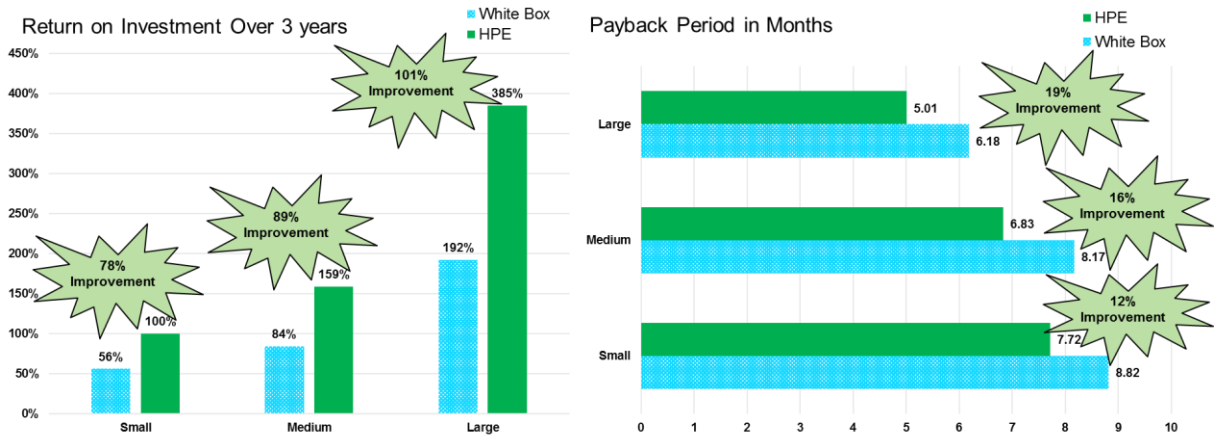

Figure 5: Better ROI and Payback Period with HPE Systems Over White Box (WB) Clusters

HPE consistently delivers better ROI and Payback compared with white box clusters

For all cases, the ROI and Payback Period improve as configuration sizes grow from small to medium to large. This is expected. As HPC systems scale, the marginal value increases because of the very large business benefits for manufacturers driven by innovation and the ability to solve intractable problems; both critical for new product development.

The percent improvements in ROI and Payback Period for HPE systems over white box clusters also grow (Figure 6) with configuration size. This means as manufacturers grow their CAE footprint to drive more innovation, HPE systems will deliver better marginal value compared to white box clusters. HPE systems are also simpler to manage and operate.

Figure 6: Improving ROI and Better Payback Period with HPE Systems Over White Box Clusters

HPE ROI and Payback differentials improve with configuration size

Conclusions and Recommendations

HPE delivers a more comprehensive portfolio of HPC systems and software, high-value services and the best ecosystem of CAE partners

Even with fierce cost pressures, manufacturers continue to grow investments in CAE and Data Analytics to improve productivity and quality, grow revenues and profits, and mitigate risks. The ROI from CAE investments can be 100s of percent. However, as data volumes and engineering model complexities grow, enterprise-grade HPC clusters are typically required to produce more realistic, reliable, actionable and time-critical analyses. HPE provides these infrastructure solutions.

Compared with white box clusters, HPE delivers a more comprehensive portfolio of HPC systems and software, high-value services and the best ecosystem of CAE partners to help manufacturing customers maximize their Total Value of Ownership (TVO). Anchored on Apollo servers with Intel Xeon Scalable Processors and the Intel Omni-Path Architecture (OPA), some key features/benefits of HPE solutions for CAE include:

- Faster time to value with factory pre-configured CAE and other software installed before shipping the system.
- Greater productivity with lower job completion times, higher throughput and less downtime.
- More new product ideas and innovation from deeper insights gleaned by solving very complex CAE/Analytics problems with greater accuracy.
- Better employee and supplier collaboration with enhanced data quality, consistency, and security by keeping data within the data center and with remote visualization capabilities.

For manufacturers, these features/benefits (and the longer list in the Appendix) collectively reduce costs, enhance productivity and quality, drive revenues/profits and mitigate risks.

HPE systems deliver a considerable ROI improvement of 78% (small) to 101% (large) over corresponding white box clusters

The 3-year TVO analysis presented here quantifies all these cost/value drivers holistically for three configurations: small, medium and large. The ROI for an HPE solution ranges from 100% (small) to 386% (large) while an equivalent white box cluster delivers an ROI of 56% (small) to 192% (large). This implies that HPE systems deliver a considerable ROI improvement of 78% (small) to 101% (large) over corresponding white box clusters.

Likewise, the Payback Period (PP) in months for an HPE solution ranges from 5.01 (large) to 7.72 (small) while the corresponding white box cluster delivers a PP in months of 6.18 (large) to 8.82 (small). This implies that HPE systems also deliver better Payback improvements from 19% (large) to 12% (small) over corresponding white box clusters.

Despite the small acquisition cost differential over commodity white box clusters, manufacturing clients deploying CAE and Data Analytics solutions should seriously consider HPE solutions for the following reasons:

1. The cost-benefit analysis and business case are compelling for all configurations.
2. The business value and ROI/PP differential improve as configurations get larger.
3. This investment is protected and can continue to deliver even greater marginal value for more complex analytics including the rapidly growing use of Artificial Intelligence and Machine Learning (AI/ML) techniques coupled with the Internet of Things (IoT) – all areas where HPE continues to make substantial investments.
4. HPE is the market leader in HPC and CAE and is a reliable partner for manufacturers worldwide.

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Appendix: How HPE CAE Solution Portfolio Features Improve TVO

As the market leader in CAE infrastructure, HPE solutions provide the following features and client benefits that improve a manufacturers ROI and reduce the payback period over white box systems:

Lower TCO

1. **Lower TCO:** Even with slightly larger acquisition costs over corresponding white box systems, HPE CAE platforms, anchored on Apollo servers with Intel Xeon Scalable Processors and the Intel Omni-Path Architecture (OPA) for HPC interconnects, improve operating costs by:

- Enhancing CAE solution performance with the same or smaller data center footprint; potentially lowering CAE software licensing costs.
- Reducing process and operations variability with more reliable and optimized CAE solutions
- Lowering data center facilities, power and cooling costs.
- Requiring fewer systems administrators to manage CAE environments particularly large systems.

In addition, HPE CAE solutions can reduce deployment times (compared with white box systems) with:

- Easy to use integration templates for commonly deployed CAE applications.
- Pre-configured systems from the factory.
- Secure job execution and data access.
- Ability to provision more than 1000 nodes in less than 30 minutes.

Improved productivity

2. **Improved Productivity/Quality:** HPE's unified compute, storage and software solutions simplify system and data management to enhance productivity of engineers, administrators and the manufacturer:

- Enhanced productivity of engineers by:
    - Improving the efficiency and effectiveness of users by streamlining the process, automating critical bottlenecks, minimizing downtime and system outages
    - Providing feedback to manage recalls and tracking requirements continuously
    - Delivering purpose-built, secure platforms for extreme performance, scale and efficiency for time-critical actionable insights
    - Decreasing job completion times and increasing throughput for CAE
    - Performing larger, more detailed simulations without break (solving the unsolvable), and
    - Evaluating more design variations before expensive real physical prototyping.

- Enhanced productivity of administrators by providing:
    - Integrated turnkey HPC cluster solutions with compute, storage, networking and software
    - Simplified setup, deployment and built-in diagnostics
    - Easy integration (often in the factory) with existing IT infrastructure and policies
    - Extensive set of tools for comprehensive ongoing node to rack to job management.

- Organizational productivity is further enhanced with other HPE value-added services that deliver:
    - Expertise to advise, deploy, integrate and support throughout the design and analysis process
    - Easy to use integration templates for commonly deployed CAE applications
    - Pre-configured, customized and optimized CAE solutions pre-built at the HPE factory
    - Global 24 x 7 x 52 Support to expedite problem resolution.

Better quality

HPE solutions also allow manufacturers to improve the quality of products and the CAE process by:

- Integrating easily with other HPE Manufacturing solutions i.e. Edge, IoT, Machine Learning, etc.
- Better interpreting technical requirements and eliminating ambiguity in original requirements
- Detecting problems much faster, deploy and monitor fixes, and reduce rework and costs.

Faster time to value

Better CAE ecosystem

Lower risks with reduced downtime and better security

3. **Higher Revenue and Growth:** In addition to enhancing productivity and quality, HPE solutions also deliver faster time to value through a better and more comprehensive ecosystem of CAE partners:

- Faster time to value with:
  - Preconfigured CAE and other software before shipping the system lower deployment and runtimes for design prototyping
  - Streamlined and automated processes across compute, storage and fabrics
  - Up to 2X performance on latest Intel Scalable Processors and Omni-Path Architecture (OPA)
  - Reduced cluster installation times with simple, automated installation process provided in various HPE cluster software solutions
    - Installing a cluster from scratch, or using open-source toolkits, can be time-consuming
    - May require specialized, scarce and often expensive skills.

- More comprehensive and better-optimized CAE (and Manufacturing) ecosystem
  - HPE is the market leader in HPC and the top technology partner for CAE application providers
  - HPE systems deliver twice the density of traditional rack mount systems and firmware-level server security with a flexible scale-out architecture for Data Analytics and HPC workloads.

In addition, manufacturers can drive innovation, revenues and profits with HPE systems.

- Drive more innovation and develop smarter products by:
  - Spurring new product ideas from deeper insights gleaned by solving more complex Multiphysics problems with greater accuracy
  - Addressing intractable problems through supercomputing.

- Improved revenues and profits with:
  - Faster applications performance allows more CAE simulations and virtual prototyping; translating to better products and competitive and first-mover advantage for manufacturers
  - Up to 50% decrease in compute costs with optimized, ready to deploy configurations.

4. **Risk Mitigation:** Better reliability, availability and serviceability (RAS) and security features in enterprise-grade HPE systems for CAE help manufacturers contain downtime and security expenses. HPE solutions also promote better collaboration with suppliers to lower risks and drive revenues/profits.

- Reduced downtime with:
  - Highly reliable system with very stringent Service Level Agreements (SLAs). HPE systems have more than 99.99% availability – larger than standard white box rack systems
  - Deep HPE expertise and enterprise-level support allows manufacturers to resolve issues faster than a typical white box solution provider.
    - Global 24 x 7 x 52 help desk availability and HPC Center of Competency.

- Better and unique security down to the silicon with:
  - Silicon Root of Trust
  - Secure Recovery
  - Firmware Runtime Validation
  - Better security features in HPE DIMS memory

- Better supplier collaboration by:
  - Enhancing data quality, consistency, and security by keeping data within the data center and involving suppliers in the quality process, robust reporting and making risk-based decisions

Better supplier collaboration

- Ensuring business processes are extended to external teams, and across the value chain especially with the pervasive reliance on suppliers and the complexity of products
- Establishing secure and efficient processes that exchange design data from Computer Aided Design (CAD) systems, and incorporate efficient methods for sourcing new parts from suppliers during product development
- Streamlining automation between Insight CMU and other platforms with the Partner Connector Program.