



Assuring Quality in the HP StorageWorks EVA



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Introduction

Quality can be elusive—difficult to define and even more difficult to achieve. But at HP we have a clear quality objective and a vision of how to get to it. At HP and the HP StorageWorks Division, our quality measures strive not just for 99.999% availability, but for the much more inclusive goal of complete customer satisfaction, as evidenced in what we call the *total customer experience* (TCE).

We at HP StorageWorks Division believe that the goal of maintaining a positive TCE is both desirable and attainable. Achieving that goal means unparalleled attention to detail throughout the lifecycle, from the first blush of an engineer's idea all the way to ultimate product retirement. It means a world-class support organization that helps differentiate our storage solutions from those of the competition and enables us to deliver the best customer value. And it means testing: constant, demanding testing at every stage of a product's life. This white paper illustrates our emphasis on testing, and on some of the quality assurance (QA) processes and procedures that are brought to bear on the HP StorageWorks Enterprise Virtual Array (EVA) as it is designed, developed, manufactured, installed, and supported.

Quality is elusive—but at HP, it's inclusive. Here's how we reinforce quality in your HP Enterprise Virtual Array.

Meet the HP EVA

Simple in operation but powerful in capability, the HP StorageWorks Enterprise Virtual Array helps midsize organizations save on common, everyday storage administrative tasks and lower costs by right-sizing storage. These arrays are responsible for safeguarding hundreds of terabytes of data and for delivering every bit quickly and without error. What's more, the HP EVA is a proven choice for virtualized storage, with more than 150,000 virtualized arrays shipped by HP since 1994. Designed to provide virtualized storage with a low entry price and low total cost of ownership, these storage workhorses are highly reliable and available, and are based on the proven and trusted architecture of the Enterprise Virtual Array.

The typical EVA encompasses the following:

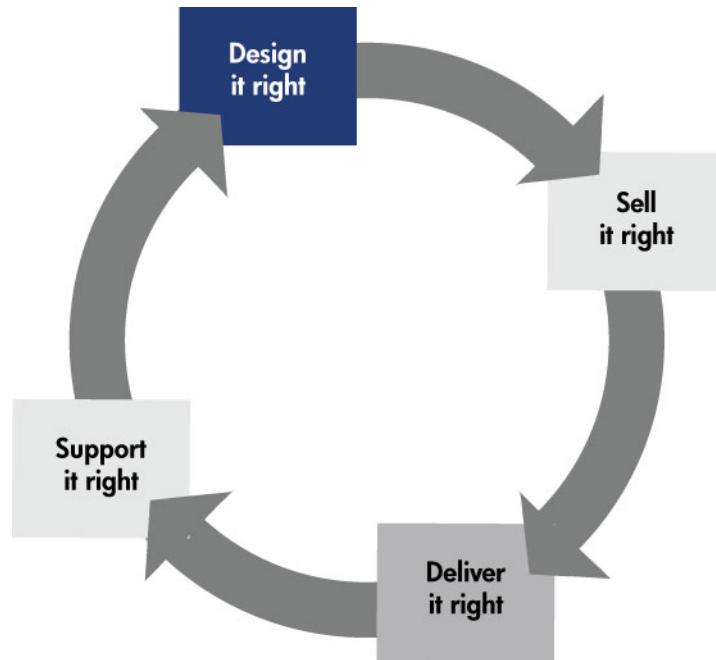
- *Hardware*—comprising the actual disk (and solid state) drives, drive shelves, EVA controllers, cabling and, other components
- *Firmware*—the controllers, shelves, and drives that hold low-level instructions for these components
- Storage management *software*—for example, HP StorageWorks Command View EVA and Replication Solutions Manager—that simplifies, enhances, and maximizes the high performance of the EVA family

Quality assurance for a typical EVA is focused on testing and approving these three basic building blocks, at first separately and later in conjunction, at all stages of the lifecycle.

“Do it right” —the overall HP StorageWorks quality assurance model

Quality at HP StorageWorks begins with an overall philosophy of “doing it right.” Based on a closed-loop process and monitored by metrics, this model promotes the highest levels of quality, and includes processes to quickly resolve quality issues if and when they surface.

Figure 1. The HP StorageWorks quality assurance model



Here's how the model works in practice:

- HP begins by *designing it right*. We apply the latest design tools and techniques, including user-centered design (UCD), a structured approach for working with customers during design and development¹. We then track those designs through prototyping, alpha and beta tests, production, and operation at customer sites all over the world. Throughout this process, we use metrics to tell us how we're doing and where we need to make adjustments and improvements.

¹ For more details about UCD, visit:
http://h71028.www7.hp.com/enterprise/us/en/solutions/storage-user-centered-design.html?jumpid=reg_R1002_USEN

Table 1. The “right” metrics

Design and production metrics	Sales metrics	Delivery metrics	Support metrics
<ul style="list-style-type: none">• Annual Intervention Rate (AIR)• No Fault Found (NFF/NTF)• Annual Return Rate (ARR)• Factory Total Defects per Unit (TDU)• Supplier Defect Rates (PPM)• Ongoing Reliability Test Failure Rates (ORT)• Mean Time to Repair (MTTR)• Product Availability/Uptime• Peer Inspections/Code Reviews• Software Defect Arrival Rates• Warranty as % of Revenue• Automation Testing	<ul style="list-style-type: none">• Customer First Requests• Services Uplift Request Rates• Business Escalations• Sales Training• Connectivity Database• Customer Loyalty Index (CLI)	<ul style="list-style-type: none">• On-Time Delivery• Installation Surveys• HP Welcome Checklist• C&I Training Completion• Documentation Delivery• Installation Elevations• Customer Loyalty Index (CLI)	<ul style="list-style-type: none">• Total Time to Resolve (TTR)• Time To Elevate (TTE)• Time to Solution (TTS)• ISEE/WEBES Deployment• Services Readiness Training• Proactive Communication Cycle Times• Engineering Elevation Backlog• Severity One Elevations• Business Escalations• Customer Found Defects (CFI)• HPS Customer Satisfaction Surveys• Customer Loyalty Index (CLI)

We also focus on *selling it right*. The HP EVA is a great choice for most midsize organizations and enterprises that want reliable, high-availability data storage at a competitive price point. With over 150,000 virtualized storage arrays shipped during the last decade, our sales engineers know when the HP EVA will be the best option to improve efficiency, simplify operations, and lower total cost of ownership (TCO) while accommodating explosive data growth, increased data center complexity, and the latest application requirements. We track customer engagements with metrics that tell us our EVA arrays are solving the right business problems for the right customers.

After HP storage is sold, a program of *delivering it right* helps ensure that the EVA or other storage product is deployed correctly and that the customer is satisfied, both on the day of delivery and for years to come. Metrics, surveys, and checklists help produce a smooth process and repeatable success.

Finally, HP StorageWorks engineers are experts at *supporting it right*. Because no product that operates in as many different environments as the HP EVA can be entirely without issues, our support organization is continually delivering patches and product enhancements, helping customers deal with changing business needs, and standing ready to step in and solve any customer problems that might arise. The closed feedback loop means that customers and support engineers can directly influence design, sales, and delivery processes—and that metrics monitor support performance and highlight areas with potential for improvement.

The HP StorageWorks quality assurance model is a closed-loop process that is constantly evolving. It reinforces quality across the product lineup.

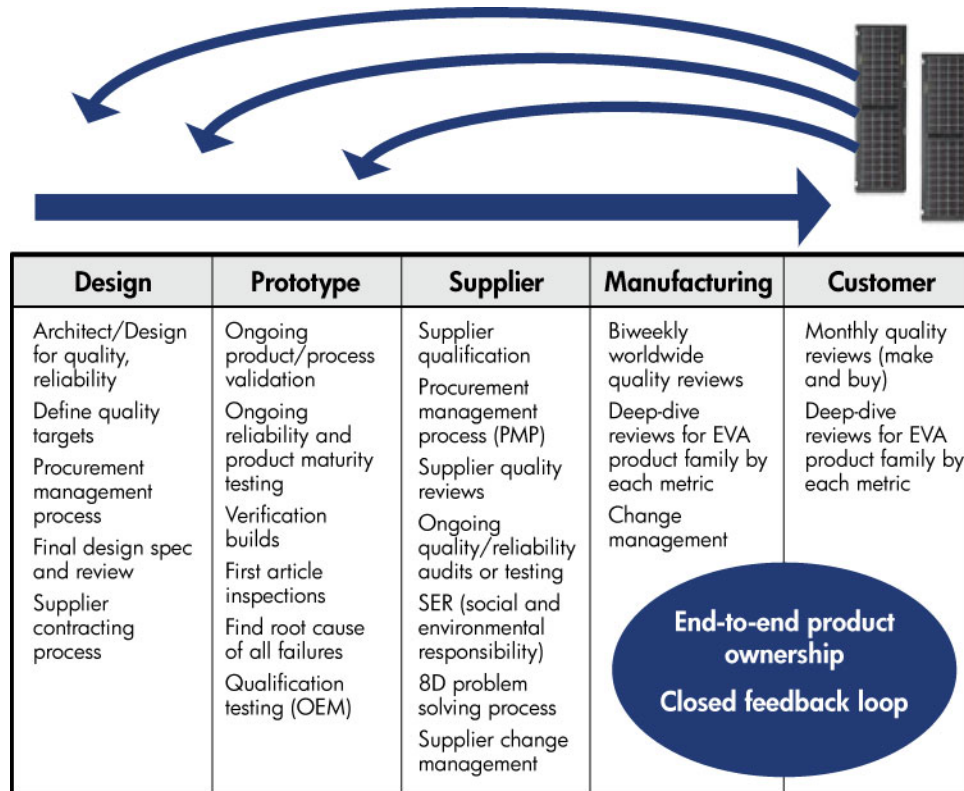
“We have had no downtime since installing the HP [EVA5000] SAN. And, because we trust the resilience and reliability of the system fully, we’ve placed all of our mission-critical applications on the system.”

—Ken Savage, UNIX® system administrator, San Diego State University

Total quality management system

Although the entire product lifecycle of an HP StorageWorks EVA encompasses everything from initial concept and scoping of the product all the way to end of life, the bulk of our quality and testing effort is focused on the product’s design and its use by the customer. Here we employ the Total Quality Management System—a process characterized by end-to-end product ownership and feedback loops, with formal and well-defined procedures for transferring knowledge gleaned from later parts of the lifecycle (such as information gathered from customers and regional technical experts) back to earlier phases (such as design and manufacturing).

Figure 2. The HP Total Quality Management System (TQMS) includes feedback loops and processes for continuous improvement, even after customer delivery.



Within this loop, all processes and procedures are based on tested methodologies, formal engagements, and proven best practices. Consider these important facts:

- HP StorageWorks uses a mature business management system for process-based business, quality, and improvement management.
- HP StorageWorks is ISO 9001:2000 certified, and has been since 1992. Each manufacturing and business site is audited regularly.
- HP StorageWorks employs Common Automation for System Test (CAST), a flexible and extensible framework for automatic, end-to-end, system-level testing of mass storage systems integrated with hosts, operating systems, and interconnect components. This framework automates test setup, execution, and cleanup and reporting of results.

- Testing and certification is conducted by a systems integration lab, assuring our customers of a broad connectivity and storage solution portfolio that differentiates HP from the competition.
- User-centered design (UCD) makes it easy for customers to interact with HP designers.
- Customer-focused testing develops application-based best practices for Microsoft® Exchange, Microsoft SQL Server, Oracle, and SAP using HP servers, storage (including HP StorageWorks EVAs), infrastructure, and software.
- A well-defined customer problem resolution (CPR) process deals with customer issues and has a feedback path to the design, manufacturing, integration, and test teams to eliminate repeat occurrences.
- HP storage customer leadership programs offer selected customers and partners unprecedented access to their peer levels within the HP StorageWorks organization, giving them the opportunity to actively influence the future of not only HP's storage products and services, but all components of the HP computing portfolio. We use a closed-loop feedback cycle to listen, internalize, act, and communicate decisions.
- The Total Customer Experience (TCE) organization examines customer pain points from the outset of the new product introduction stage, and provides support for customers and closed-loop corrective feedback to engineering during the usage stage.
- On the product development team, remarkably diverse participation—including marketing, services, supply chain, and TCE organization representatives, as well as engineering staff—spans the entire value chain. Such a multi-dimensional perspective helps make our products more robust and capable when they emerge into the real world.

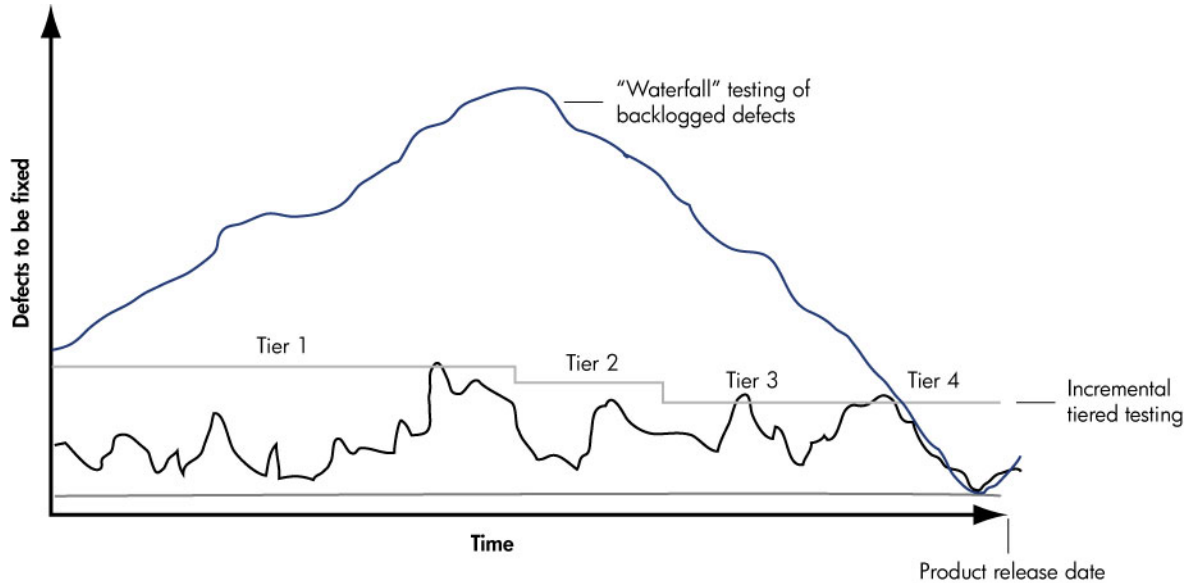
Case study: user-centered design (UCD)

To simplify startup of the EVA4400, the design team produced the HP SmartStart EVA Storage Media Kit, which makes installation and configuration less complex. From the outset of EVA SmartStart conceptualization and development, the team used rapid prototyping to refine and test product ideas. Several complete models of the product were created, and customers and channel partners were then engaged to validate the design. This user-centered design approach resulted in a software kit that greatly reduces the EVA4400 array's setup time.

Continuous development, integration, and test

In many industries, the “waterfall” approach to testing—allowing defects to build up and then resolving them all at once—is all too common. This approach may also combine all a system's components in a “big bang” integration, with all testing moved to the end of the project. The waterfall methodology can introduce problems stemming from the use of untested components, and it can make thorough testing more difficult because of the interdependencies of the different major systems. This approach also constrains testing and QA with schedules and time-to-market pressures.

Figure 3. Incremental, tiered testing avoids the “waterfall” effect.



At HP, testing occurs throughout product development and production, using a tiered model that calls for testing and stabilization at each stage of development before proceeding to the next stage. The continuously repeated cycle of development, integration, and test is based upon incremental test-driven development and frequent small releases. This methodology makes the development process more stable and reduces a large backlog of defects to a series of small, manageable peaks. Such incremental development processes—along with iterative testing—result in stable product development, higher product quality, lower risk, and improved time to market.

“The EVA delivers high quality, reliable, resilient storage. And the EVAs are 100 percent redundant, so we have experienced zero storage downtime. In three years we have had no EVA failure that affected the host systems.”

—Dennis Rich, senior system administrator, Eastern Municipal Water District, Southern California

Incremental development and testing

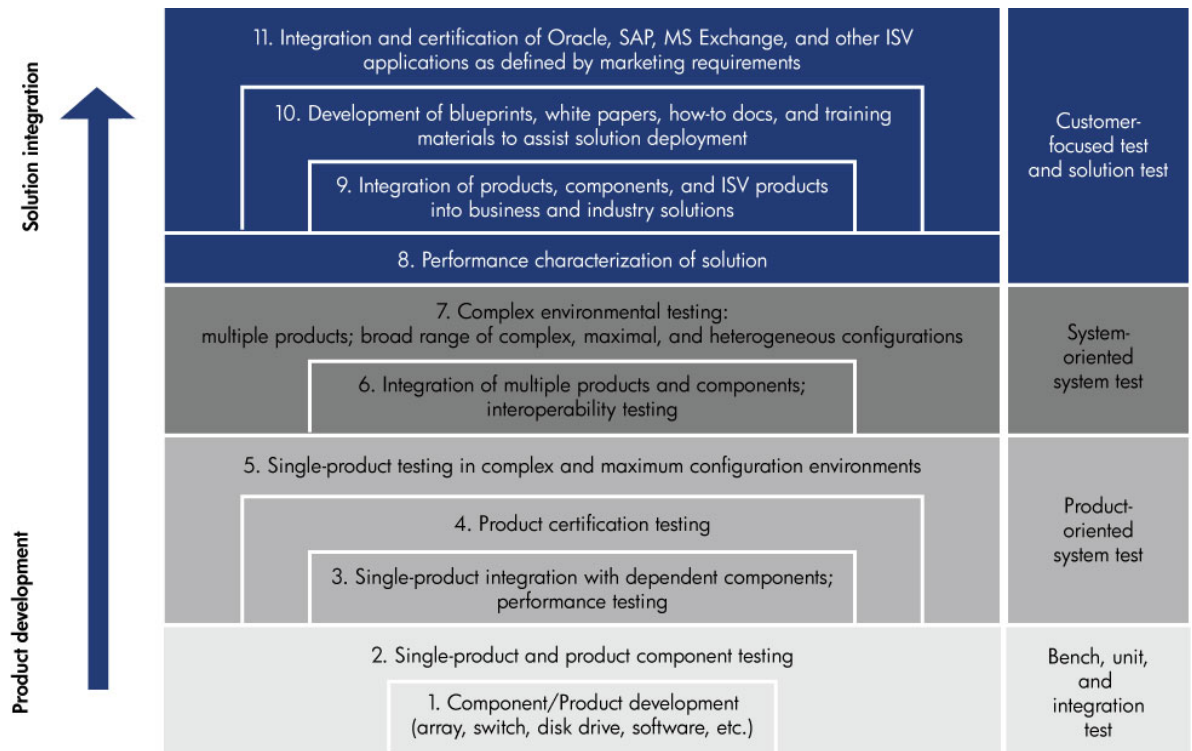
At HP StorageWorks, product testing is an important contributor to customer satisfaction as well as a key reason for the extraordinary availability and reliability of the HP Enterprise Virtual Array. HP conducts testing at every phase of the product lifecycle, from product idea to product retirement, in order to anticipate and forestall any potential problems.

In hardware, firmware, and software alike, the goal of testing and verification for the HP EVA is to find problems at the lowest possible level of testing, in environments that are narrow and where diagnosis is relatively simple. Finding defects in a small test environment makes testing, debugging, and verification easier and helps reduce the time needed to get the product to market.

The big test picture

Figure 4 provides an overall view of testing and verification. This organizational and functional diagram shows “the big picture” of EVA testing, illustrating how different HP teams conduct testing and verification at all stages of product development. Beginning with basic component testing and proceeding incrementally through system testing to the verification of full, comprehensive solutions, HP StorageWorks reinforces the excellent quality and reliability of its products, helping to ensure their ultimate operation in demanding customer environments.

Figure 4. HP StorageWorks testing occurs at every stage—from basic components to complex, integrated systems.



- Bench, unit, and integration testing:** Hardware testing at this stage includes inspection and testing of individual components and single products, such as disk drives, switches, shelves, and other hardware, to make sure that they meet specifications and will operate correctly. Code testing—whether for software such as Command View and Replication Solutions Manager modules or for firmware routines used in controllers, drives, and other components—is also at a basic level. This testing is largely done in isolation from other components and products.

Basic unit testing covers areas that are easily automated, and it uncovers and repairs about 90% of the problems that will occur in these areas. Testing in a simple environment speeds turnaround and root cause analysis. It reduces variability to its lowest common denominator. And, because of automation, it costs less than testing conducted in more complex environments. By focusing on problems early, HP is able to reduce costs and improve testing efficiency.

Central to the success of unit testing is supplier management and monitoring. In particular, HP testing and qualification of hard disk drives is commended by customers and vendors alike. We use a 5-stage process, consisting of more than 50 individual steps, to qualify our HDD suppliers; and we use monitoring and testing to make sure they continue to meet goals and expectations. Suppliers

of hard disk drives actually praise HP for the focus we place on continuous product improvement, a process that ultimately benefits the entire HDD industry—and all of our customers.

- **Product-oriented system testing:** After individual components have been tested, they are integrated into an individual EVA, and then hardware, firmware, and software teams all conduct thorough system-level testing. Next, the EVA is integrated with a range of loosely coupled components and devices that can interoperate on a SAN to form a computer system (host, OS, storage, and interconnect components) and then tested with a focus on the system as a whole. This environment is still a relatively simple one, so finding problems at this stage is easier and more cost-effective than diagnosing them in more complex environments.
- **System-oriented system testing:** At this stage, the EVA environment may encompass several EVAs and host systems with different operating systems, along with SAN components and multipathing software. Testing at this level involves multiple EVAs in complex configurations with a broad range of heterogeneous systems and software.
- **Customer-focused testing and solution testing:** Customer-focused testing is aimed at the business objectives of a particular customer; solution tests are concerned with general solution capability. Both types of testing occur in what is effectively a customer environment, where one or multiple EVAs are tested in concert with related applications, middleware, and software. The EVA is integrated with end-user applications such as Oracle Database, Microsoft Exchange, and SAP, along with high-availability packages (clustering, Serviceguard, etc.) to form a solution that satisfies end-user business objectives. Support materials such as white papers, best practices guides, and training materials are also developed during this stage.

Where failure equals success

Testing of HP StorageWorks EVAs is continual and demanding, and its defined goal is to cause faults. Especially in the product-oriented system testing phase, the tests are expressly designed to actively seek out problems. As part of our efforts to test effectively, we use specialized fault injection hardware, I/O load generators, and hardware stress tests to simulate—and exceed—the demands of a customer environment. And we go far beyond customer testing, devising tests that are intense and aggressive. As a sign in our test lab points out, “Failure = Success!”

Figure 5. Axiom of the HP EVA Test Lab



“We live to wreck things. Every failure we get in our testing is a problem that we can fix, and an opportunity to solve a customer issue before it ever happens. In that sense, a test failure is good news!”

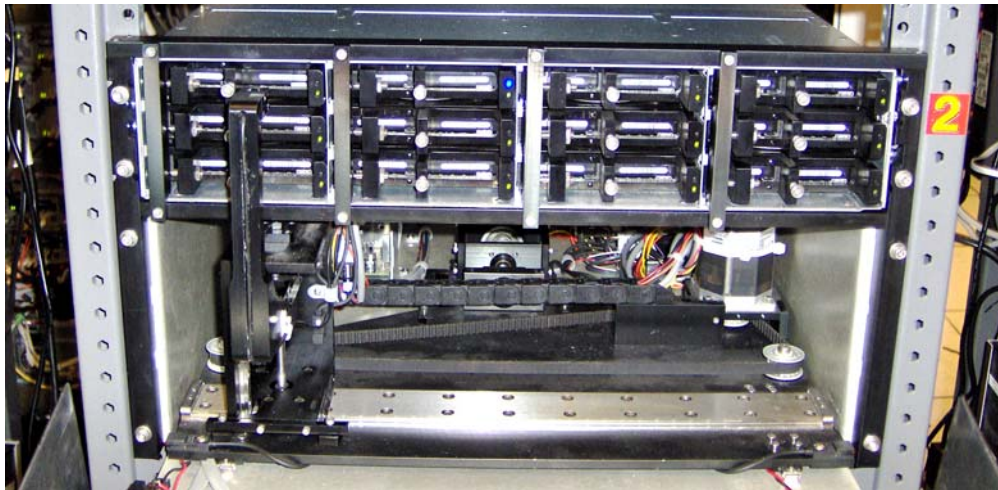
—Bryan Diamond, HP EVA test architect

For example, during the development of the EVA4400, the unit was subjected to:

- More than 300,000 hours of test time
- More than 400,000 “perturbations”
- Multiple hardware component failures, including controllers, disk drives, back-end loops, Fibre Channel cables, switches, servers, HBAs, intersite links, FC/IP gateways, and more
- More than 100 different test configurations, from simple to complex

Our testing for the EVA4400 was the equivalent of the successful transfer of more than 55 petabytes (about the amount of data in 18 Libraries of Congress) to the EVA, checking the integrity of every byte of data as we continuously did everything we could to trip up the array. We pulled disk drives, cut power, fiddled with the operator control panel, injected loop errors into backplanes, and pulled out every cable we could find. And we wouldn't ship the EVA until it passed our tests.

Figure 6. This hot-plug test tool can remove and reinsert 180 disk drives per hour, part of an automated test sequence that requires no human contact during operation.



Result: storage you can count on

All of our incremental and closed-loop testing has a single goal: to deliver storage you can count on to unleash the potential of your data center and your business. HP StorageWorks positions the Enterprise Virtual Array as a 99.999% availability solution, and the data substantiates this figure. You can count on the HP StorageWorks EVA.

“The fact that they have 1200 servers and 500 EVA arrays was pretty impressive but they also happen to have about 20PB of storage over that 500 arrays... What HP’s EVA lab tells me is that they spare no expense to insure their product is literally bulletproof, bug proof, and works every time for their customer base. I must say I was pretty impressed.”

—“The price of quality,” RayOnStorage Blog at www.silvertonconsulting.com/blog/2009/09/30/the-price-of-quality/

Summing up

HP takes EVA quality seriously, and quality assurance is built in at every stage of the end-to-end lifecycle of the product—including design, sales, delivery, and support. As part of the overall quality framework captured in the motto “Design it right, sell it right, deliver it right, support it right,” EVA testing is structured to enable early defect detection, progressing from simple to complex in a way that streamlines the testing process and minimizes time to market.

Where to go from here

For more information or to schedule a demo, please contact your HP sales representative, or visit our website: www.hp.com/go/eva

To see success stories about the HP Enterprise Virtual Array and other HP StorageWorks products, visit: http://h18006.www1.hp.com/storage/customer_stories/index.html#jump

Technology for better business outcomes

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4AA0-7602ENW, January 2010



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