SPC BENCHMARK 2™

EXECUTIVE SUMMARY

NETAPP, INC.

NETAPP EF560 ALL-FLASH ARRAY

SPC-2™ V1.5

Submitted for Review: April 29, 2016
Submission Identifier: B00078

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	NetApp, Inc. – http://www.netapp.com Mark Regester – mark.regester@netapp.com 3718 North Rock Road Wichita, KS 67226 Phone: (316) 636-8340
Test Sponsor Alternate Contact	NetApp, Inc. – http://www.netapp.com Mike Phelan – mike.phelan@netapp.com 5400 Airport Blvd., Suite 100 Boulder, CO 80301 Phone: (303) 544-5414
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-2 Specification revision number	V1.5
SPC-2 Workload Generator revision number	V1.2
Date Results were first used publicly	April 29, 2016
Date FDR was submitted to the SPC	April 29, 2016
Date the TSC will be available for shipment to customers	currently available
Date the TSC completed audit certification	April 27, 2016

Tested Storage Product (TSP) Description

The NetApp® EF560 flash array is an all-SSD storage system that brings together extreme performance and enterprise-grade reliability to create a system optimized for latency-sensitive workloads. Designed for applications demanding the highest levels of performance, reliability, and availability and requiring just 2U of rack space, the EF560 flash array delivers consistent microsecond latency response times, and enterprise-proven availability features. Additionally, the EF560 can be seamlessly expanded to 120 SSDs to a maximum raw capacity of 384TB. The EF560's core architecture has been proven in the world's most demanding and complex computing environments. Its field-proven design is the culmination of over 20 years of industry knowledge focused on designing enterprise-class storage. The fully redundant EF-Series all-flash array is architected to provide the highest levels of reliability, availability, and data protection.

SPC-2 Reported Data

SPC-2 Reported Data consists of three groups of information:

- The following SPC-2 Primary Metrics, which characterize the overall benchmark result:
    - SPC-2 MBPS™
    - SPC-2 Price Performance
    - Application Storage Unit (ASU) Capacity

- Supplemental data to the SPC-2 Primary Metrics.
    - Total Price
    - Data Protection Level
    - Currency Used
    - Target Country

- Reported Data for each SPC Test: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand Delivery (VOD) Test.

SPC-2 MBPS™ represents the aggregate data rate, in megabytes per second, of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand (VOD).

SPC-2 Price-Performance™ is the ratio of **Total Price** to **SPC-2 MBPS™**.

ASU *(Application Storage Unit)* **Capacity** represents the total storage capacity available to be read and written in the course of executing the SPC-2 benchmark.

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page on page 8.

Data Protection Level of **Protected 2** using *RAID-6*, which provides double-party RAID protection again data loss.

> **Protected 2:** *The single point of failure of any **component** in the configuration will not result in permanent loss of access to or integrity of the SPC-2 Data Repository.*

Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-2 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency)*.

The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.
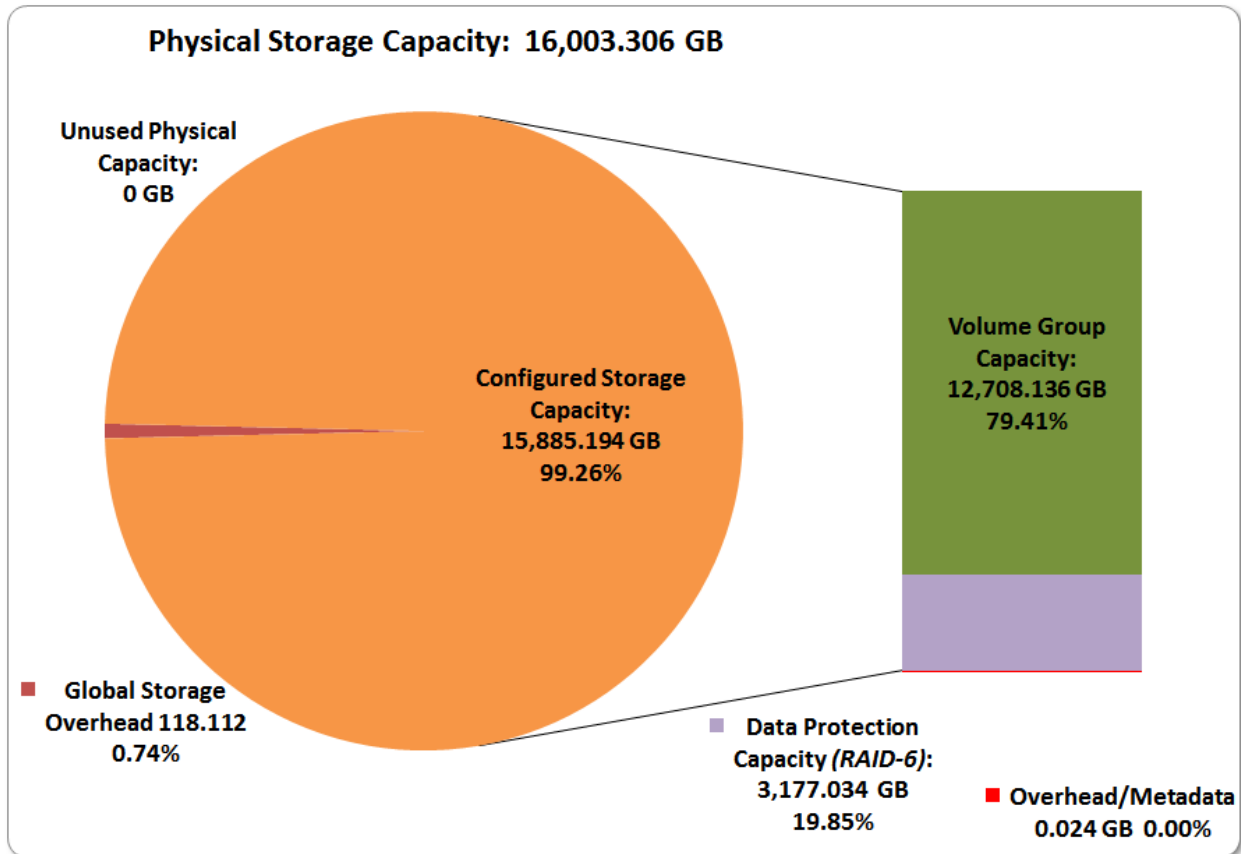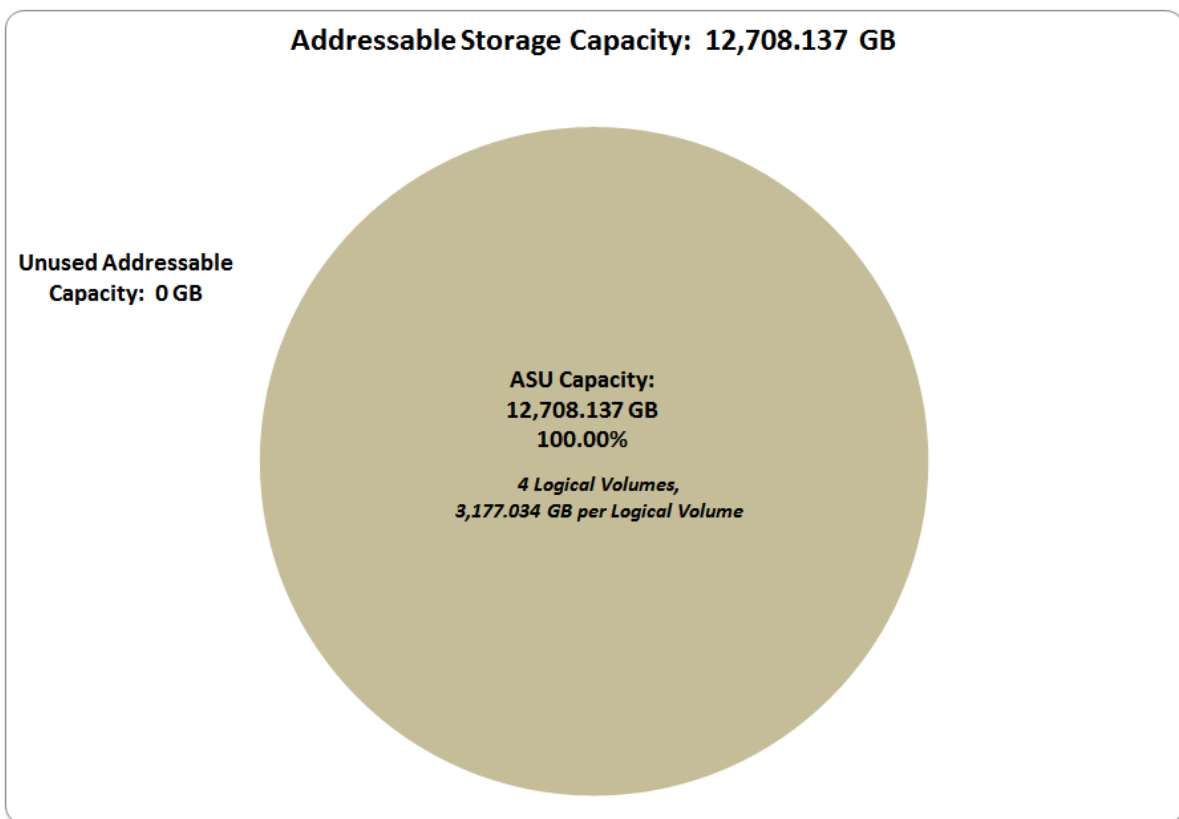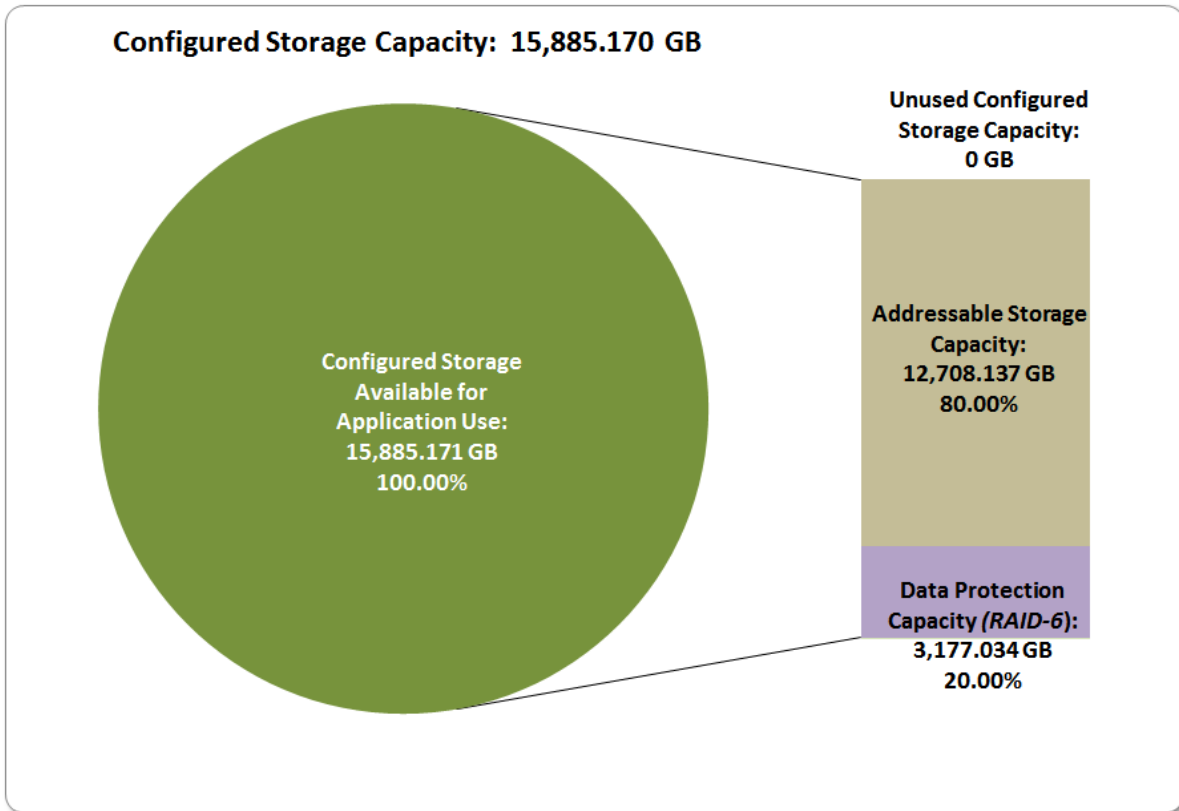
SPC-2 Reported Data *(continued)*

SPC-2 Reported Data				
NetApp EF560 All-Flash Array				
SPC-2 MBPS™	**SPC-2 Price-Performance**	**ASU Capacity (GB)**	**Total Price**	**Data Protection Level**
11,352.17	$8.12	12,708.137	$92,207.01	Protected 2 *(RAID-6)*
The above SPC-2 MBPS™ value represents the aggregate data rate of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video On Demand (VOD)				
Currency Used:		**"Target Country":**		
U.S. dollars		USA		
SPC-2 Large File Processing (LFP) Reported Data				
	Data Rate (MB/second)	**Number of Streams**	**Data Rate per Stream**	**Price-Performance**
LFP Composite	10,020.15			$9.20
Write Only:				
1024 KiB Transfer	6,790.89	96	70.74	
256 KiB Transfer	6,562.37	96	68.36	
Read-Write:				
1024 KiB Transfer	10,179.46	96	106.04	
256 KiB Transfer	10,685.71	96	111.31	
Read Only:				
1024 KiB Transfer	13,185.58	96	137.35	
256 KiB Transfer	12,716.91	96	132.47	
The above SPC-2 Data Rate value for LFP Composite represents the aggregate performance of all three LFP Test Phases: (Write Only, Read-Write, and Read Only).				
SPC-2 Large Database Query (LDQ) Reported Data				
	Data Rate (MB/second)	**Number of Streams**	**Data Rate per Stream**	**Price-Performance**
LDQ Composite	13,026.34			$7.08
1024 KiB Transfer Size				
4 I/Os Outstanding	13,303.28	96	138.58	
1 I/O Outstanding	13,292.79	96	138.47	
64 KiB Transfer Size				
4 I/Os Outstanding	12,756.95	96	132.88	
1 I/O Outstanding	12,752.32	96	132.84	
The above SPC-2 Data Rate value for LDQ Composite represents the aggregate performance of the two LDQ Test Phases: (1024 KiB and 64 KiB Transfer Sizes).				
SPC-2 Video On Demand (VOD) Reported Data				
	Data Rate (MB/second)	**Number of Streams**	**Data Rate per Stream**	**Price-Performance**
	11,010.03	14,000	0.79	$8.37

Storage Capacities and Relationships

The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts are listed as integer values, for readability, rather than the decimal values listed elsewhere in this document.

Physical Storage Capacity: 16,003.306 GB

Unused Physical Capacity: 0 GB

Configured Storage Capacity: 15,885.194 GB 99.26%

Global Storage Overhead 118.112 0.74%

Volume Group Capacity: 12,708.136 GB 79.41%

Data Protection Capacity *(RAID-6)*: 3,177.034 GB 19.85%

Overhead/Metadata 0.024 GB 0.00%

Configured Storage Capacity: 15,885.170 GB

Configured Storage
Available for
Application Use:
15,885.171 GB
100.00%

Unused Configured
Storage Capacity:
0 GB

Addressable Storage
Capacity:
12,708.137 GB
80.00%

Data Protection
Capacity *(RAID-6)*:
3,177.034 GB
20.00%

Addressable Storage Capacity: 12,708.137 GB

Unused Addressable
Capacity: 0 GB

ASU Capacity:
12,708.137 GB
100.00%

*4 Logical Volumes,
3,177.034 GB per Logical Volume*

Total Unused Storage Capacity Ratio and Details

Physical Storage Capacity:
16,003.306 GB

Physical Storage
Capacity Used:
16,003.306 GB
100.00%

**Total Unused Storage
Capacity:
0 GB**

**Unused Physical
Capacity: 0 GB**

**Unused Configured
Capacity: 0 GB**

**Unused Addressable
Capacity: 0 GB**

SPC-2 Storage Capacity Utilization	
Application Utilization	79.41%
Protected Application Utilization	99.26%
Unused Storage Ratio	0.00%

Application Utilization: ASU Capacity *(12,708.137 GB)* divided by Physical Storage Capacity *(16,003.306 GB).*

Protected Application Utilization: ASU Capacity *(12,708.137 GB)* plus total Data Protection Capacity *(3,177.034 GB)* minus unused Data Protection Capacity *(0.000 GB)* divided by Physical Storage Capacity *(16,003.306 GB).*

Unused Storage Ratio: Total Unused Capacity *(0.000 GB)* divided by Physical Storage Capacity *(16,003.306 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 25-26 in the Full Disclosure Report.

Priced Storage Configuration Pricing

Part Number	Description	Quantity	Unit List Price	Extended LP
EF-X5681A-R6-C	Enclosure,EF5X0,Empty,2PSU,-C	1	$ 3,880.00	$ 3,880.00
EF-X5681A-DM-R6-C	Enclosure,EF5X0,Empty,2PSU,DM,-C	1	$ 3,880.00	$ 3,880.00
EF-X561202A-R6-C	EF560A,12GB Controller,16Gb FC,4-ports,-C	2	$ 21,925.00	$ 43,850.00
E-X30030A-R6-C	ESM,SBB-2,-C	2	$ 2,630.00	$ 5,260.00
EF-X4041C-C	SSD,800GB,Non-FDE,EF5X0,-C	20	$ 2,705.00	$ 54,100.00
OS-SANTRCTY-CAP3-EF-C	OS Enable,Per-0.1TB,SANTRCTY,Ultra-Stor,EF,-C	160	$ 284.00	$ 45,440.00
X-35610-00-R6-C	Blank,Dsk Drv Filler,DE5600,-C	28	$ 25.00	$ 700.00
X-20004-00-R6-C	Cable,miniSAS,1m,-C	4	$ 125.00	$ 500.00
X-48895-00-R6-C	SFP,10Gb iSCSI/16Gb FC,Unified,E-Series,-C	8	$ 600.00	$ 4,800.00
	NetApp Hardware/Software Subtotal			$ 162,410.00
CS-A2-4R-VA	Support, 3-yr 24/7, 4 hour on-site	1	$ 11,236.18	$ 11,236.18
ServerSupply QLE2672-CK	QLE2672-CK Qlogic HBA, 16Gb FC, 2-ports	4	$ 1,300.00	$ 5,200.00
CDW 1148024	Tripp Lite, OM3 Optical cable, 2	8	$ 22.99	$ 183.92
	Third-Party Subtotal			$ 5,383.92

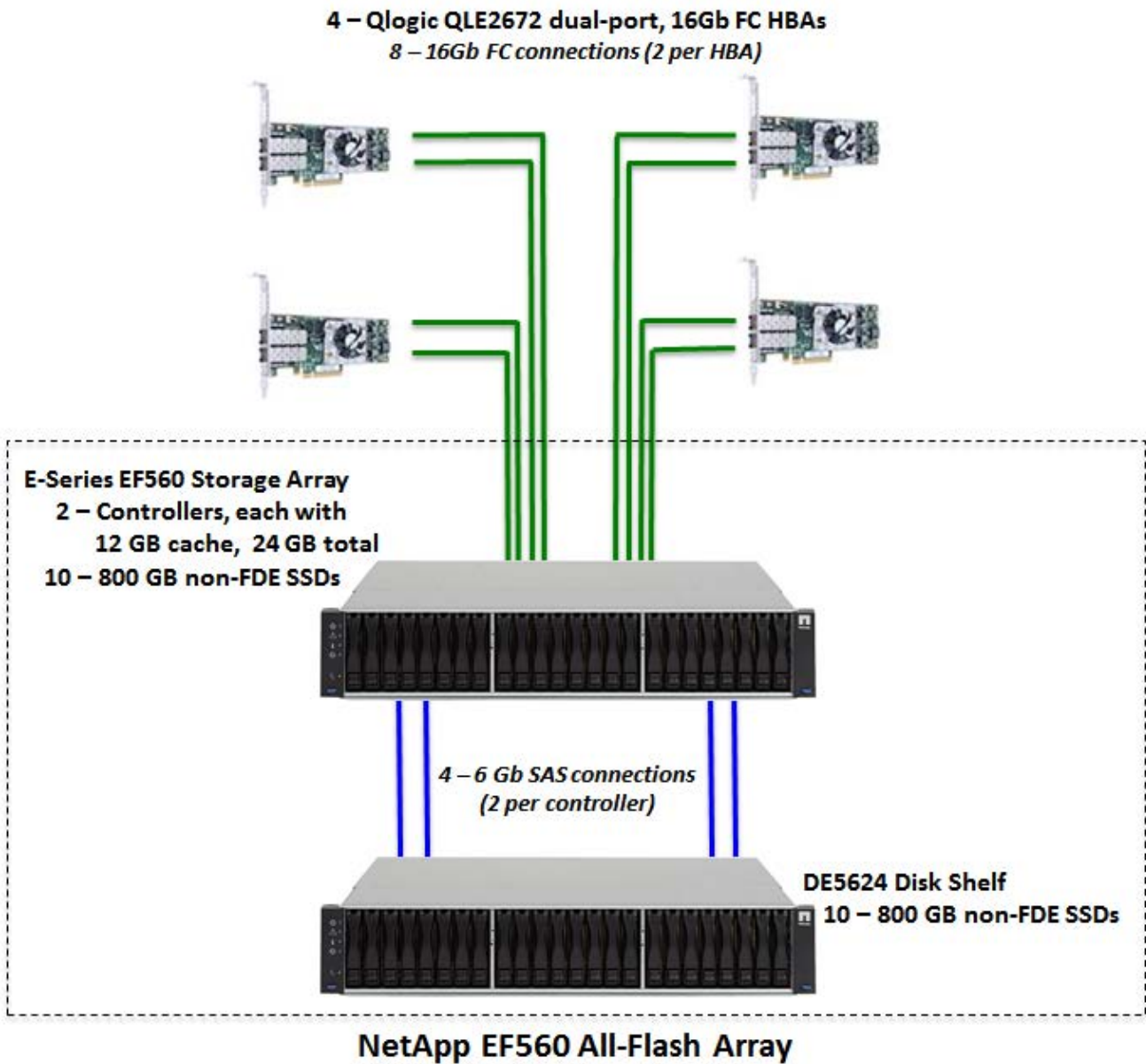| Description	Extended LP	Discount	Discounted Price
NetApp Hardware/Software Subtotal	$ 162,410.00	50%	$ 81,205.00
Support	$ 11,236.18	50%	$ 5,618.09
Third-Party Subtotal	$ 5,383.92	0%	$ 5,383.92
Totals	**$ 179,030.10**		**$ 92,207.01**

The following pricing includes the following:

- Acknowledgement of new and existing hardware and/or software problems within four hours.

- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four hours of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration component.

Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

There were no differences between the Tested Storage Configuration and the Priced Storage Configuration.

Priced Storage Configuration Diagram

SPC BENCHMARK 2™ V1.5   EXECUTIVE SUMMARY   Submitted for Review: APRIL 29, 2016
NetApp, Inc.   Submission Identifier: B00078
NetApp EF560 All-Flash Array

Priced Storage Configuration Components

Priced Storage Configuration
4 – QLogic QLE2672-CK dual-port, 16Gb, FC HBAs

NetApp EF560 All-Flash Array
   1 – E-Series EF560 Storage Array with
      2 –Controllers, each Controller includes:
         12 GB cache *(24 GB total)*
            4 – 16 Gb FC front-end connections *(8 total and used)*
            5 – 4 x 6Gb SAS backend connections *(10 total and used)*

1 – DE5624 Disk Shelf
20 – 800 GB non-FDE SSDs   *(10 SSDs in Storage Array) (10 SSDs in Disk Shelf)*