



**SPC BENCHMARK 1™**

**FULL DISCLOSURE REPORT**

**NETAPP, INC.  
NETAPP EF570 ALL-FLASH ARRAY**

**SPC-1 V3.5.0**

**SUBMISSION IDENTIFIER: A31009**

**SUBMITTED FOR REVIEW: SEPTEMBER 19, 2017**

## **Second Edition – February 2018**

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## **Benchmark Specification and Glossary**

The official SPC Benchmark 1™ (SPC-1™) specification is available on the website of the Storage Performance Council (SPC) at [www.storageperformance.org](http://www.storageperformance.org).

The SPC-1™ specification contains a glossary of the SPC-1™ terms used in this publication.

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# AUDIT CERTIFICATION



Eric Stoltman  
 Vice President & GM, HSG.  
 NetApp, Inc.  
 3718 North Rock Road  
 Wichita, KS 67226

September 18, 2017

I verified the SPC Benchmark 1™ (SPC-1™ Revision3.5.0) test execution and performance results of the following Tested Storage Product:

## **NETAPP EF570 ALL-FLASH ARRAY**

The results were:

<b>SPC-1 IOPS™</b>	<b>500,022</b>
<b>SPC-1 Price-Performance™</b>	<b>\$ 0.13/SPC-1 IOPS™</b>
SPC-1 IOPS™ Response Time	0.437 ms
SPC-1 Overall Response Time	0.260 ms
SPC-1 ASU Capacity	9,006 GB
SPC-1 ASU Price	\$ 7.13/GB
SPC-1 Total System Price	\$ 64,212.58

In my opinion, these performance results were produced in compliance with the SPC requirements for the benchmark.

The testing was executed using the SPC-1 Toolkit Version 3.0.2 Build g823a. The audit process was conducted in accordance with the SPC Policies and met the requirements for the benchmark.

A Letter of Good Faith was issued by the Test Sponsor, stating the accuracy and completeness of the documentation and testing data provided in support of the audit of this result.

A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by the Test Sponsor, and can be found at [www.storageperformance.org](http://www.storageperformance.org) under the Submission Identifier **A31009**.

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A31009

NETAPP EF570 ALL-FLASH ARRAY

p.2

The independent audit process conducted by InfoSizing included the verifications of the following items:

- The physical capacity of the data repository;
- The total capacity of the Application Storage Unit (ASU);
- The accuracy of the Benchmark Configuration diagram;
- The tuning parameters used to configure the Benchmark Configuration;
- The Workload Generator commands used to execute the testing;
- The validity and integrity of the test result files;
- The compliance of the results from each performance test;
- The compliance of the results from the persistence test;
- The compliance of the submitted pricing model; and
- The differences between the tested and the priced configuration, if any.

The Full Disclosure Report for this result was prepared in accordance with the disclosure requirements set forth in the specification for the benchmark.

The following benchmark requirements, if any, were waived according to the SPC Policies:

- None.

Respectfully Yours,



François Raab, Certified SPC Auditor

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## LETTER OF GOOD FAITH





## SPC BENCHMARK 1™

### EXECUTIVE SUMMARY

#### NETAPP, INC. NETAPP EF570 ALL-FLASH ARRAY

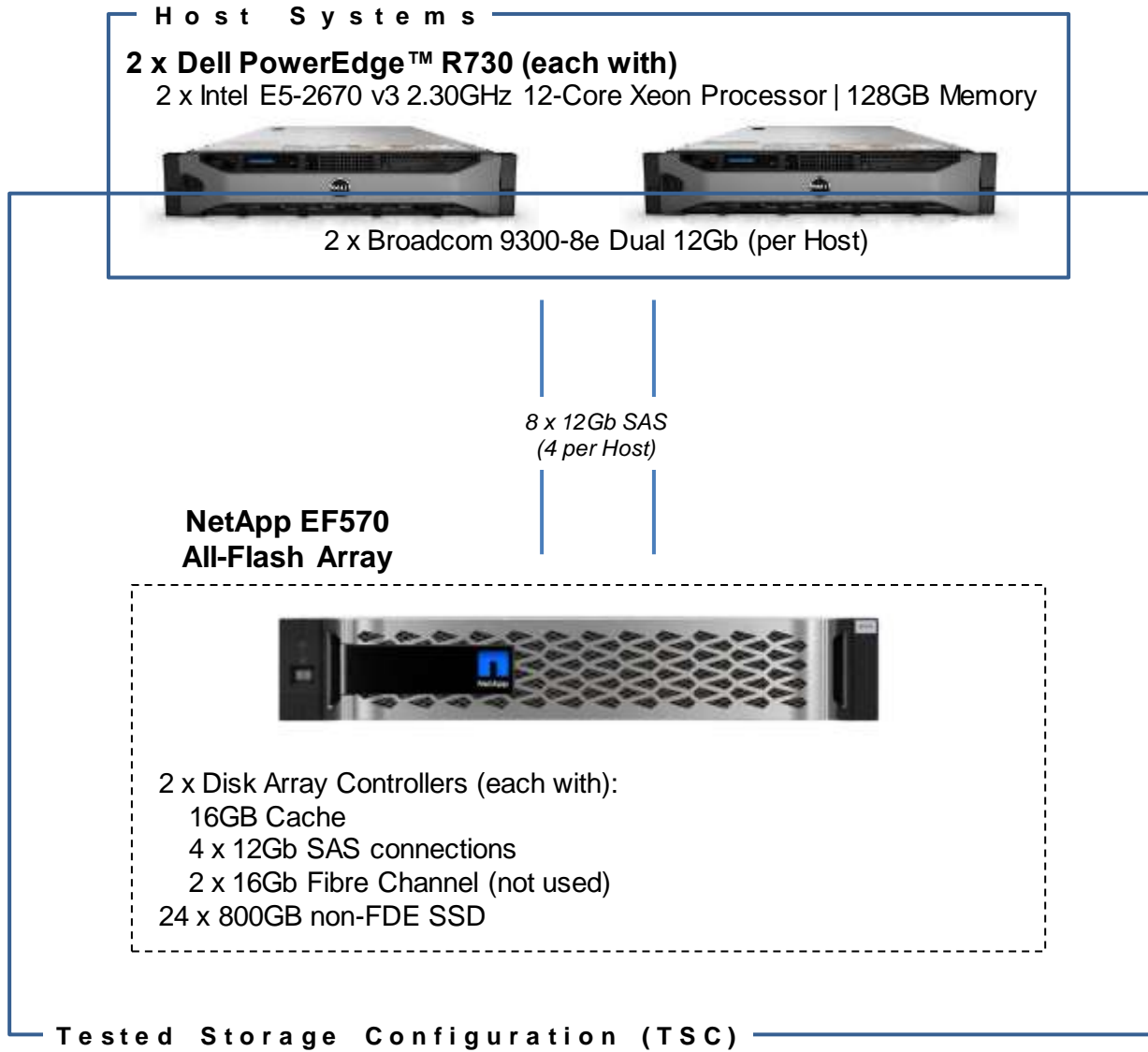
<b>SPC-1 IOPS™</b>	<b>500,022</b>
<b>SPC-1 Price-Performance™</b>	<b>\$ 128.42/SPC-1 KIOPS™</b>
SPC-1 IOPS™ Response Time	0.437 ms
SPC-1 Overall Response Time	0.260 ms
SPC-1 ASU Capacity	9,006 GB
SPC-1 ASU Price	\$ 7.13/GB
SPC-1 Total System Price	\$ 64,212.58
Data Protection Level	Protected 2 (mirroring and full redundancy)
Physical Storage Capacity	19,203 GB
Pricing Currency / Target Country	USD / USA

#### SPC-1 V3.5.0

**SUBMISSION IDENTIFIER: A31009**

**SUBMITTED FOR REVIEW: SEPTEMBER 19, 2017**

### Benchmark Configuration Diagram





## Tested Storage Product Description

NetApp EF570 all flash system is a 4th generation all-flash array designed specifically for performance-intensive workloads such as big data analytics, technical computing and video surveillance. With extremely high throughput, and low latencies, the EF570 is designed to increase application responsiveness and accelerate modern enterprise applications. The system supports 367TB of raw flash capacity in a modular 2U building block that scales to 1.8PB

The EF570 also supports multiple high-speed host interfaces including a new 100Gb NVMe-over-InfiniBand – one of the first enterprise-class arrays with support for NVMe. SANtricity System Manager gives customers the flexibility to manage their NetApp EF570 systems wherever they are at all times through an easy-to-use, on-box, web-based interface. SANtricity Cloud Connector enables NetApp Data Fabric, or Hybrid Cloud capabilities, by providing cost-effective backup and recovery to the cloud.

NetApp E-Series arrays have a rich, 20+ year legacy of providing industry leading price/performance, value and reliability, with over 1 million systems installed.

For more details, visit:

<http://www.netapp.com/us/products/storage-systems/all-flash-array/ef-series.aspx>

## Priced Storage Configuration Components

<b>4 x Broadcom 9300-8e Dual 12Gb</b>
<b>1 x NetApp EF570 All-Flash Array (including)</b> <ul style="list-style-type: none"><li><b>2 x Disk Array Controllers (each with):</b><ul style="list-style-type: none"><li><b>16GB Cache</b></li><li><b>4 x 12Gb SAS connections</b></li><li><b>2 x 16Gb Fibre Channel (not used)</b></li></ul></li><li><b>24 x 800GB non-FDE SSD</b></li></ul>

## Storage Configuration Pricing

	Description	Source	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
<b>Hardware &amp; Software</b>							
E-X5722A-0E-C	Enclosure, 2U-24, DE224C, Empty, 2PSU, 913W, 0E,-C	1	1	2,400.00	2,400.00	55%	1,080.00
EF570A-16GB-FC-0E-C	EF570A, 16GB Cntrlr, No HIC, 16Gb FC, 2-pt,-C	1	2	20,780.00	41,560.00	55%	18,702.00
X-56027-00-0E-C	HIC, E2800, 12Gb SAS, 4-ports,-C	1	2	1,200.00	2,400.00	55%	1,080.00
E-X4086A-0E-C	SSD, 800GB, 12Gb, Non-FDE, DE224C,-0E,C	1	24	2,165.00	51,960.00	55%	23,382.00
OS-SANTRICITY 1-CAP3-0E-C	OS Enable, Per-0.1TB, SANTRCTY, Ultra-Stor,0E,-C	1	192	150.00	28,800.00	55%	12,960.00
CDW 3818102	LSI SAS 9300-8e / SAS 12Gb/s / PCIe 3	2	4	449.99	1,799.96		1,799.96
CDW 3877041	Supermicro SAS external cable - 6.6ft	2	8	69.99	559.92		559.92
CDW Tax & Shipping	CDW Tax and Shipping	2	1	202.17	202.17		202.17
<b>Hardware &amp; Software Subtotal</b>							<b>59,766.05</b>
<b>Support &amp; Maintenance</b>							
CS-A2-4R-VA	Support, 3-yr 24/7, 4 hour on-site	1	1	9,881.16	9,881.16	55%	4,446.53
<b>Support &amp; Maintenance Subtotal</b>							<b>4,446.53</b>
<b>SPC-1 Total System Price</b>							<b>64,212.58</b>
SPC-1 IOPS™							500,022.00
<b>SPC-1 Price-Performance™ (\$/SPC-1 KIOPS™)</b>							<b>128.42</b>
SPC-1 ASU Capacity (GB)							9,006
<b>SPC-1 ASU Price (\$/GB)</b>							<b>7.13</b>

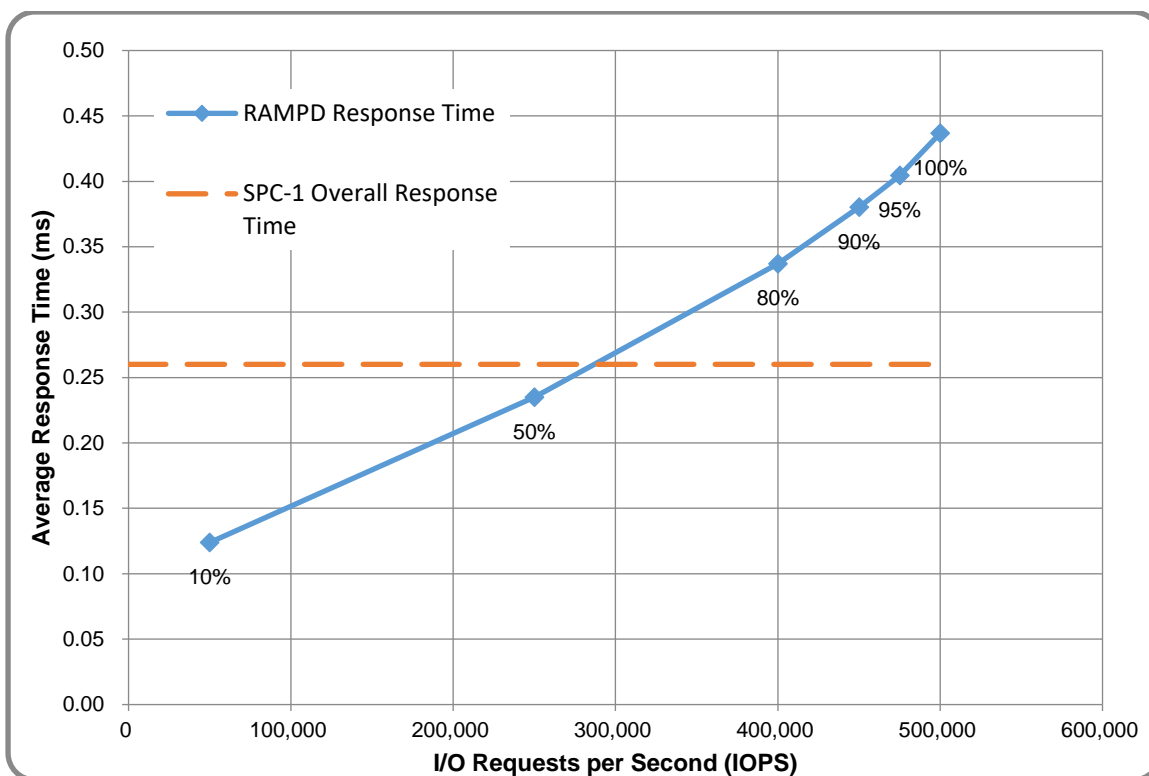
**Third-Party Reseller:** HBA's and cables are provided by CDW (Source 2). The remainder of the components, the support and the maintenance are provided by NetApp (Source 1).

**Discount Details:** The 55% discount used in the pricing above represents the low-end of a “typical”, generally available discount.

**Warranty:** The 3-year maintenance and support included in the above pricing meets or exceeds a 24x7 coverage with a 4-hour response time.

**Availability Date:** The Priced Storage Configuration will be available on October 9, 2017.

### Response Time and Throughput Graph



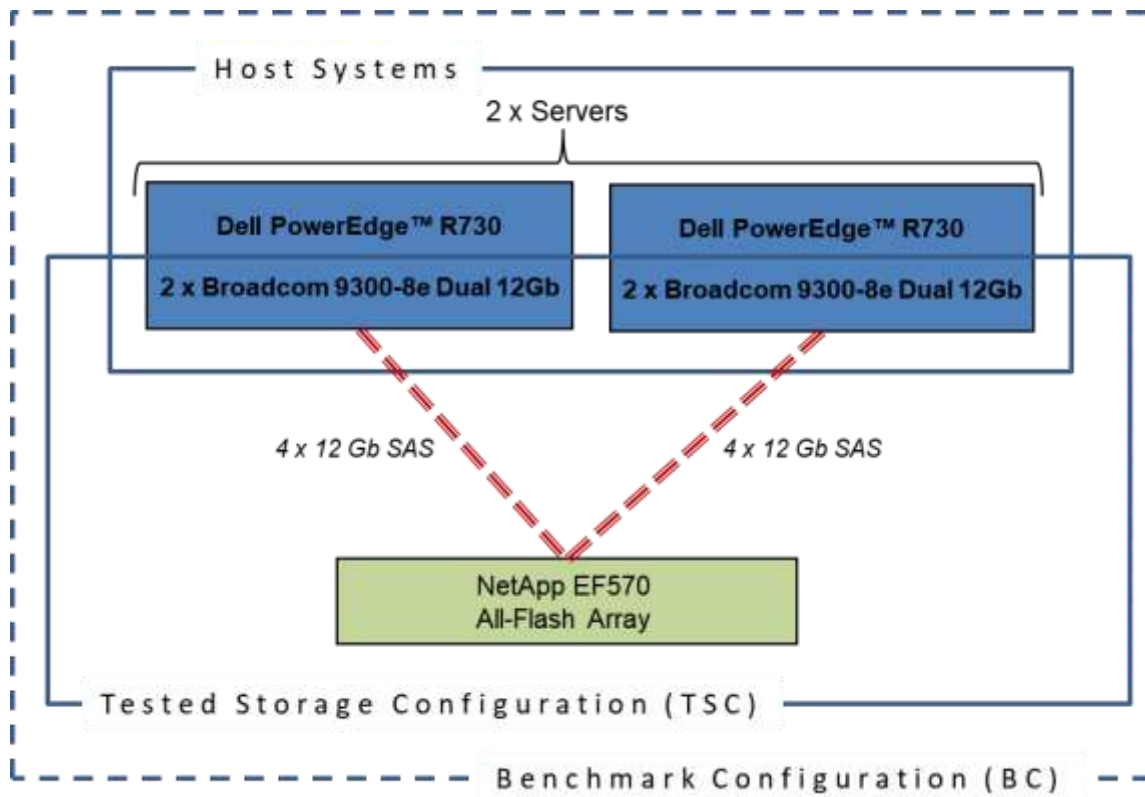
Contact Information	
<b>Test Sponsor Primary Contact</b>	NetApp, Inc. – <a href="http://www.netapp.com">www.netapp.com</a> Mark Register – mark.register@netapp.com
<b>SPC Auditor</b>	InfoSizing – <a href="http://www.sizing.com">www.sizing.com</a> Francois Raab – francois@sizing.com

Revision Information	
<b>SPC Benchmark 1™ Revision</b>	V3.5.0
<b>SPC-1 Workload Generator Revision</b>	V3.0.2 build g823a
<b>Publication Revision History</b>	<ul style="list-style-type: none"> <li>• First Edition: September 19, 2017</li> <li>• Second Edition: February 15, 2018                             <ul style="list-style-type: none"> <li>- Updated SPC-1 Price-Performance™ metric based on SPC-1 v3.6.0 definition.</li> </ul> </li> </ul>

## CONFIGURATION INFORMATION

### **Benchmark Configuration and Tested Storage Configuration**

The following diagram illustrates the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC) and the Host System(s).



### Storage Network Configuration

The Tested Storage Configuration (TSC) involved a single NetApp EF570 All-Flash Array, driven by two Host Systems (Dell PowerEdge R730). Each R730 host was connected one-to-one to the EF570 with four SAS connections operating at 12Gbps.

**Host System and Tested Storage Configuration Components**

The following table lists the components of the Host System(s) and the Tested Storage Configuration (TSC).

Host Systems
2 x Dell PowerEdge R730 servers (each with) 2 x Intel E5-2670 v3 2.30GHz 12-Core Xeon Processor 128GB Memory Windows Server 2012 R2 Data Center
Tested Storage Configuration
4 x Broadcom 9300-8e Dual 12Gb 1 x NetApp EF570 All-Flash Array (including) 2 x Disk Array Controllers (each with): 16GB Cache 4 x 12Gb SAS connections 2 x 16Gb Fibre Channel (not used) 24 x 800GB non-FDE SSD

**Differences Between Tested and Priced Storage Configurations**

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

**Component Changes in Revised Full Disclosure Report**

The following table outlines component changes that were made in revisions to this Full Disclosure Report.

Original Component	Revised Component	Description of Change
n/a	n/a	Initial submission

## Benchmark Configuration Creation Process

### Customer Tuning Parameters and Options

All the customer tuning parameters and options that have been altered from their default values for this benchmark are included in Appendix C and in the Supporting Files (see Appendix A).

### Tested Storage Configuration Creation

A detailed description of how the logical representation of the TSC was created is included in Appendix D and in the Supporting Files (see Appendix A).

### Tested Storage Configuration Inventory

An inventory of the components in the TSC, as seen by the Benchmark Configuration, is included in Appendix E and in the Supporting Files (see Appendix A).

### Workload Generator Storage Configuration

The SPC-1 Workload Generator storage configuration commands and parameters used to invoke the execution of the tests are included in Appendix F and in the Supporting Files (see Appendix A).

### Logical Volume Capacity and ASU Mapping

The following table details the capacity of each ASU and how they are mapped to logical volumes (LV).

	LV per ASU	LV Capacity	Used per LV	Total per ASU	% ASU Capacity
ASU-1	1	4,052.7	4,052.7	4,052.7	45.00%
ASU-2	1	4,052.7	4,052.7	4,052.7	45.00%
ASU-3	1	900.6	900.6	900.6	10.00%
<b>SPC-1 ASU Capacity</b>				<b>9,006.0</b>	

### Physical Storage Capacity and Utilization

The following table details the Physical Capacity of the storage devices and the Physical Capacity Utilization (percentage of Total Physical Capacity used) in support of hosting the ASUs.

Devices	Count	Physical Capacity	Total Capacity
800GB non-FDE SSD	24	800.1	19,203.0
<b>Total Physical Capacity</b>			<b>19,203.0</b>
<b>Physical Capacity Utilization</b>			<b>46.90%</b>

### **Data Protection**

The data protection level used for all logical volumes was **Protected 2**, which was accomplished by creating three Volume Groups of eight drives organized as RAID 1 (mirrored).

## **BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs.

### **Benchmark Execution Overview**

#### **Workload Generator Input Parameters**

The SPC-1 Workload Generator commands and input parameters for the Test Phases are presented in the Supporting Files (see Appendix A).

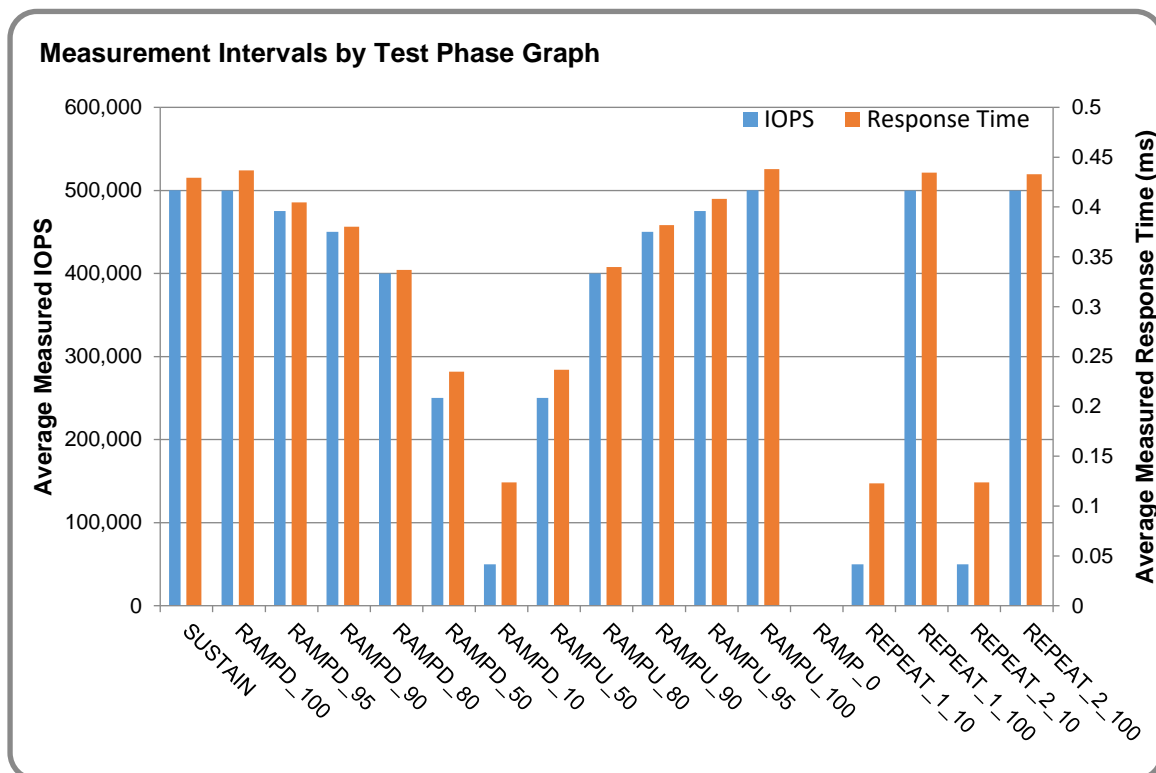
#### **Primary Metrics Test Phases**

The benchmark execution consists of the Primary Metrics Test Phases, including the Test Phases SUSTAIN, RAMPD\_100 to RAMPD\_10, RAMPU\_50 to RAMPU\_100, RAMP\_0, REPEAT\_1 and REPEAT\_2.

Each Test Phase starts with a transition period followed by a Measurement Interval.

#### **Measurement Intervals by Test Phase Graph**

The following graph presents the average IOPS and the average Response Times measured over the Measurement Interval (MI) of each Test Phase.





### **Exception and Waiver**

During the course of the benchmark audit, no exceptions were encountered and no benchmark requirements were waived.

## SUSTAIN Test Phase

### SUSTAIN – Results File

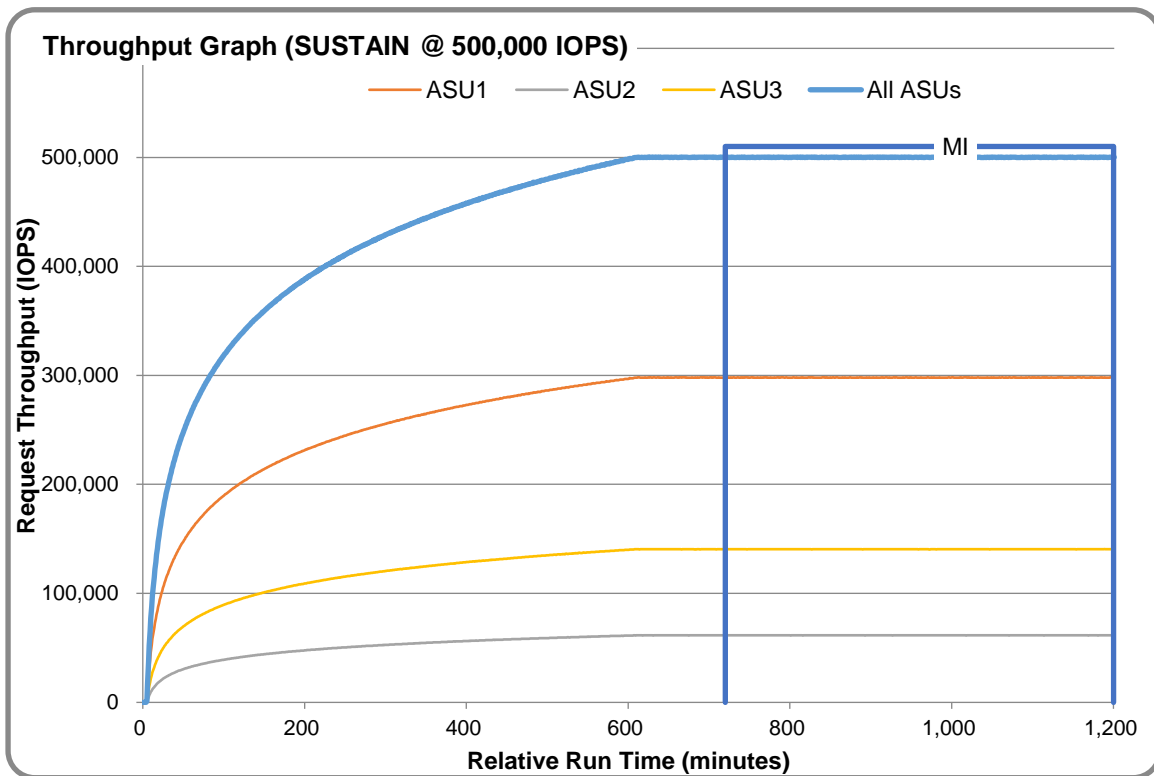
The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1\_METRICS\_0\_Raw\_Results.xlsx

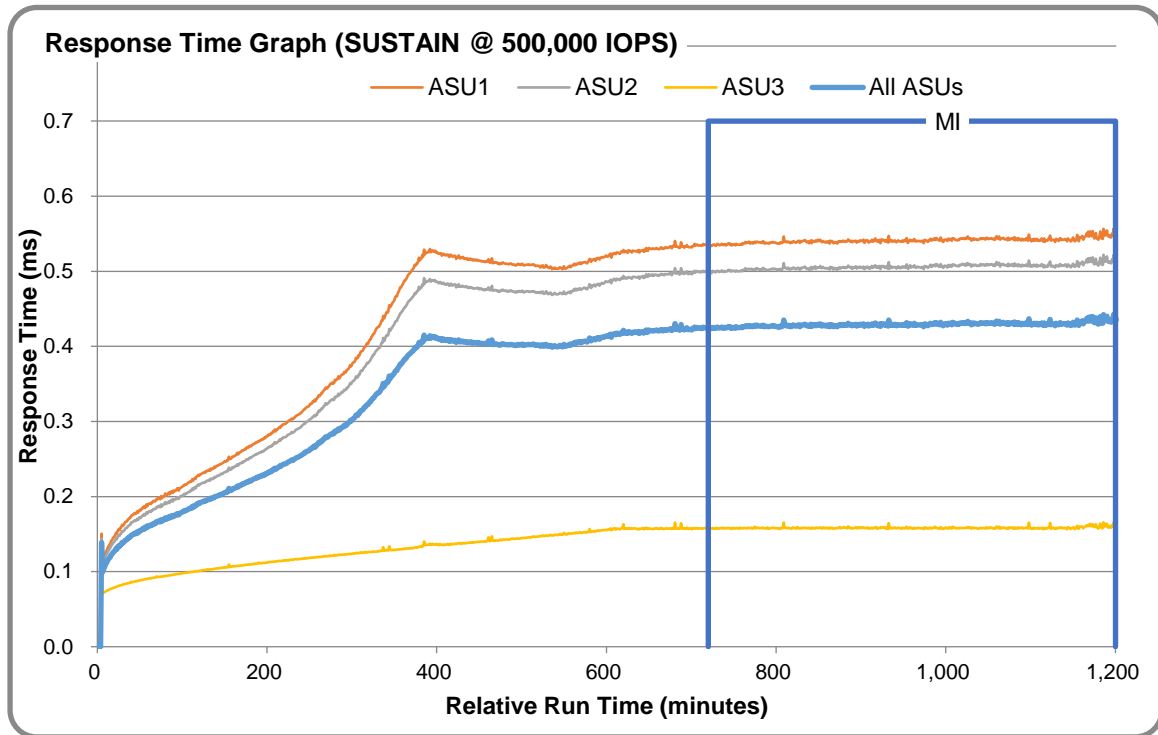
### SUSTAIN – Execution Times

Interval	Start Date & Time	End Date & Time	Duration
Transition Period	14-Sep-17 19:03:42	15-Sep-17 07:03:40	11:59:58
Measurement Interval	15-Sep-17 07:03:40	15-Sep-17 15:03:41	8:00:01

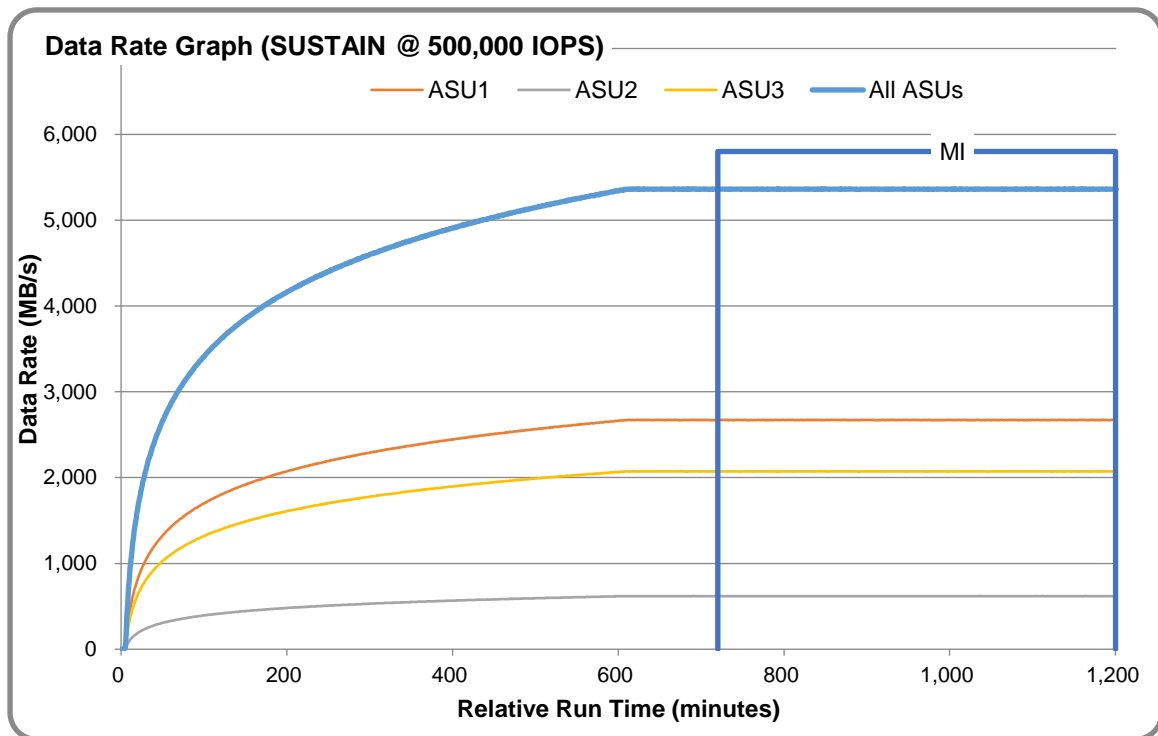
### SUSTAIN – Throughput Graph



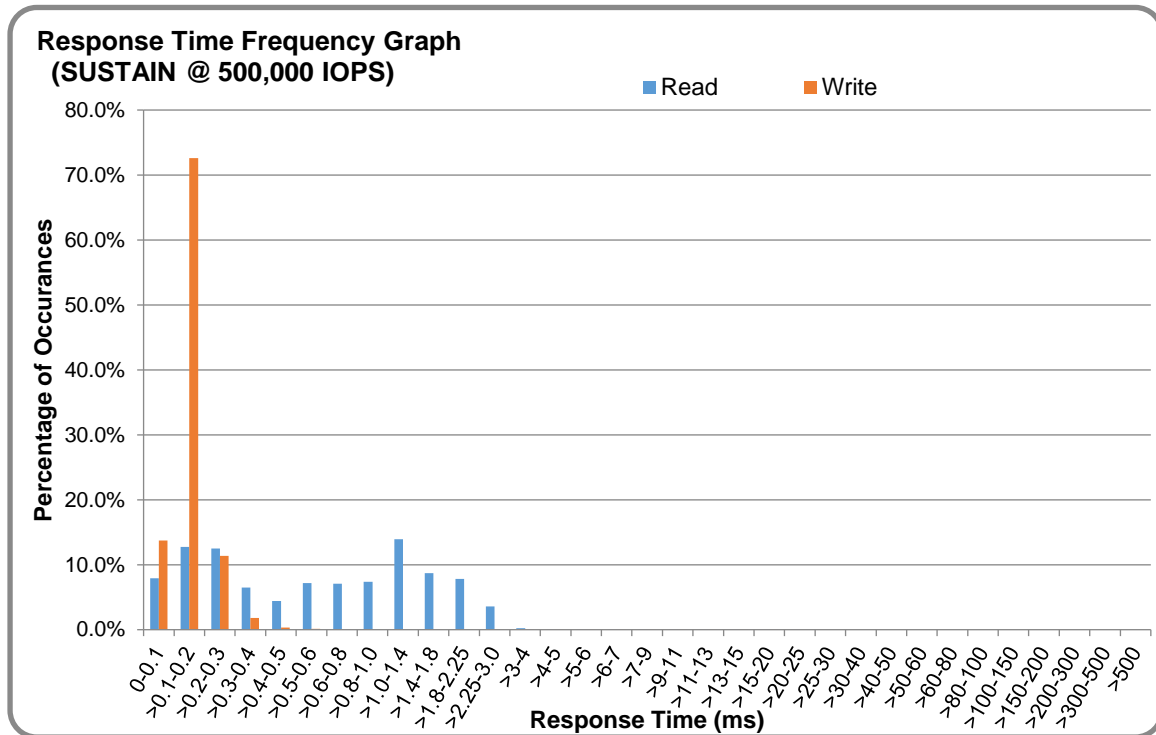
### SUSTAIN – Response Time Graph



### SUSTAIN – Data Rate Graph



### SUSTAIN – Response Time Frequency Graph



### SUSTAIN – Intensity Multiplier

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>Defined</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Measured</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Variation</b>	0.0010	0.0003	0.0006	0.0003	0.0014	0.0007	0.0010	0.0003
<b>Difference</b>	0.006%	0.001%	0.002%	0.001%	0.004%	0.008%	0.002%	0.003%

## RAMPD\_100 Test Phase

### RAMPD 100 – Results File

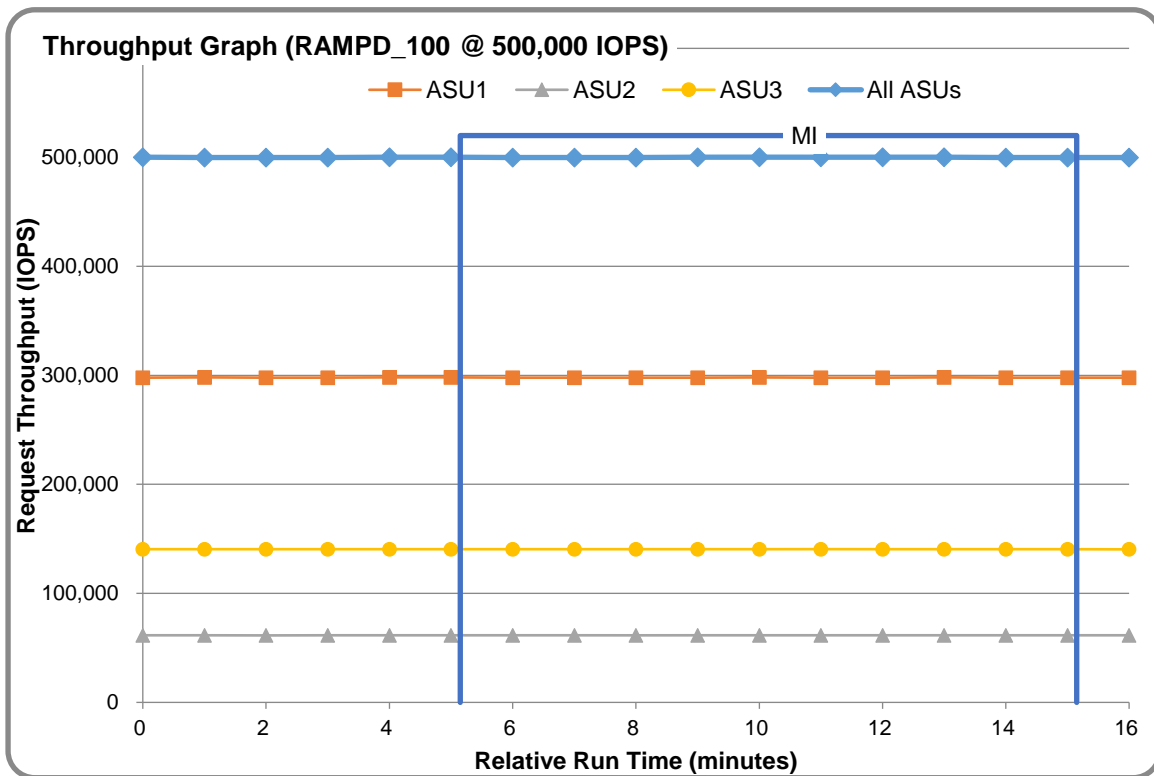
The results file generated during the execution of the RAMPD\_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1\_METRICS\_0\_Raw\_Results.xlsx

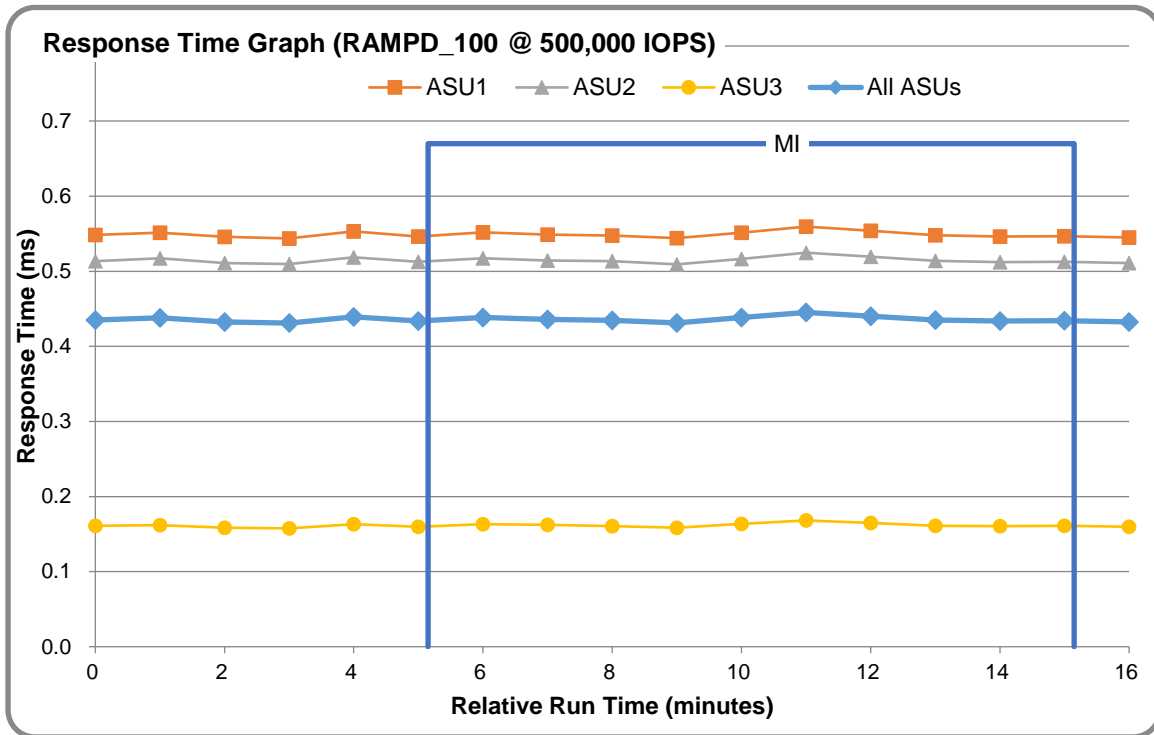
### RAMPD 100 – Execution Times

Interval	Start Date & Time	End Date & Time	Duration
Transition Period	15-Sep-17 15:04:40	15-Sep-17 15:09:40	0:05:00
Measurement Interval	15-Sep-17 15:09:40	15-Sep-17 15:19:41	0:10:01

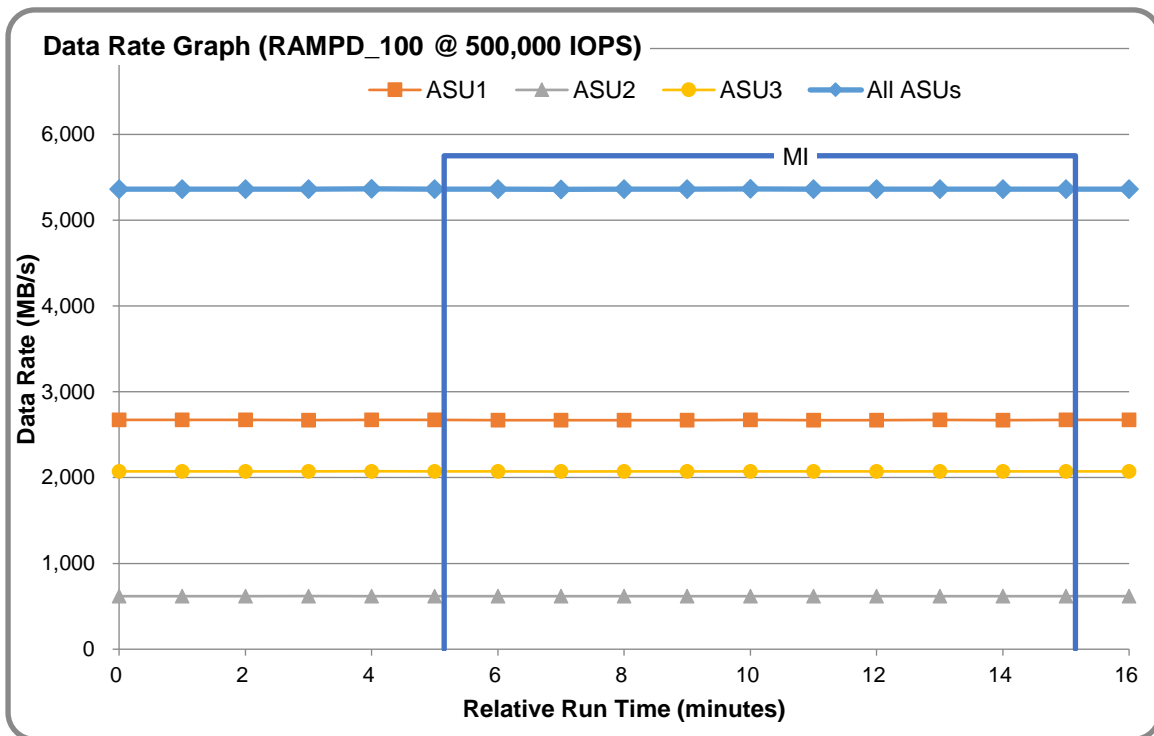
### RAMPD 100 – Throughput Graph



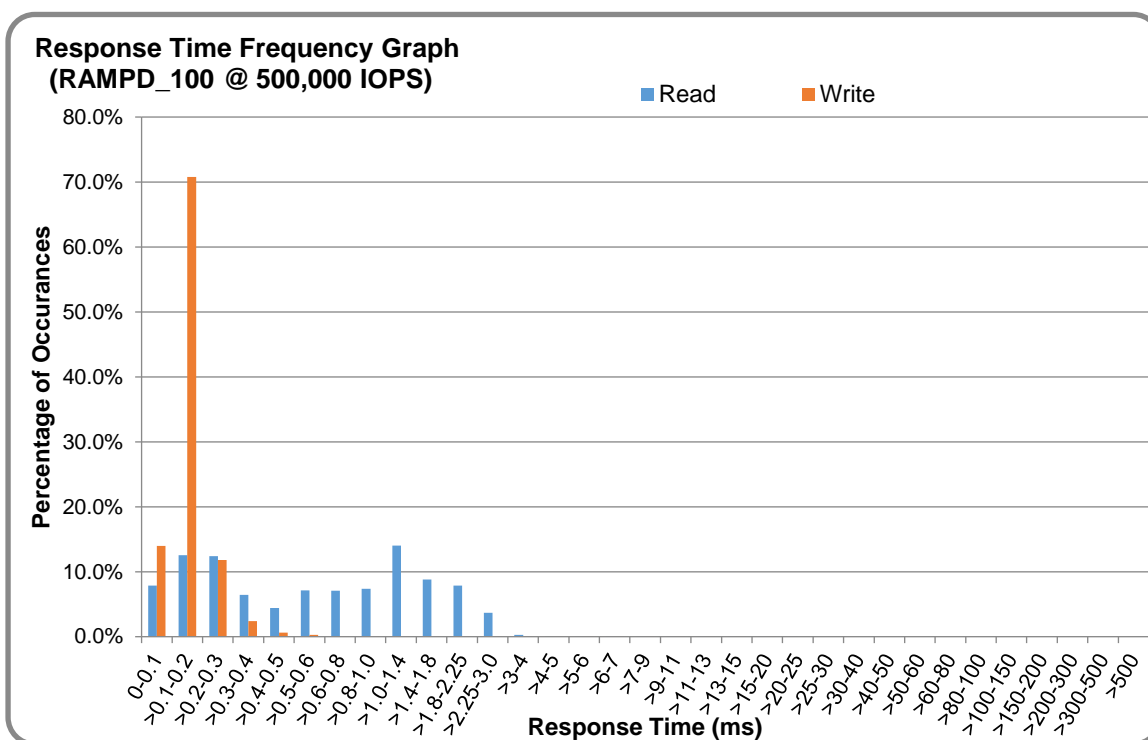
### RAMPD 100 – Response Time Graph



### RAMPD 100 – Data Rate Graph



### RAMPD 100 – Response Time Frequency Graph



### RAMPD 100 – Intensity Multiplier

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>Defined</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Measured</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Variation</b>	0.0006	0.0003	0.0006	0.0003	0.0009	0.0006	0.0011	0.0003
<b>Difference</b>	0.025%	0.001%	0.007%	0.001%	0.048%	0.023%	0.014%	0.008%

### RAMPD 100 – I/O Request Summary

<b>I/O Requests Completed in the Measurement Interval</b>	300,007,977
<b>I/O Requests Completed with Response Time &lt;= 30 ms</b>	300,007,974
<b>I/O Requests Completed with Response Time &gt; 30 ms</b>	3

## Response Time Ramp Test

### Response Time Ramp Test – Results File

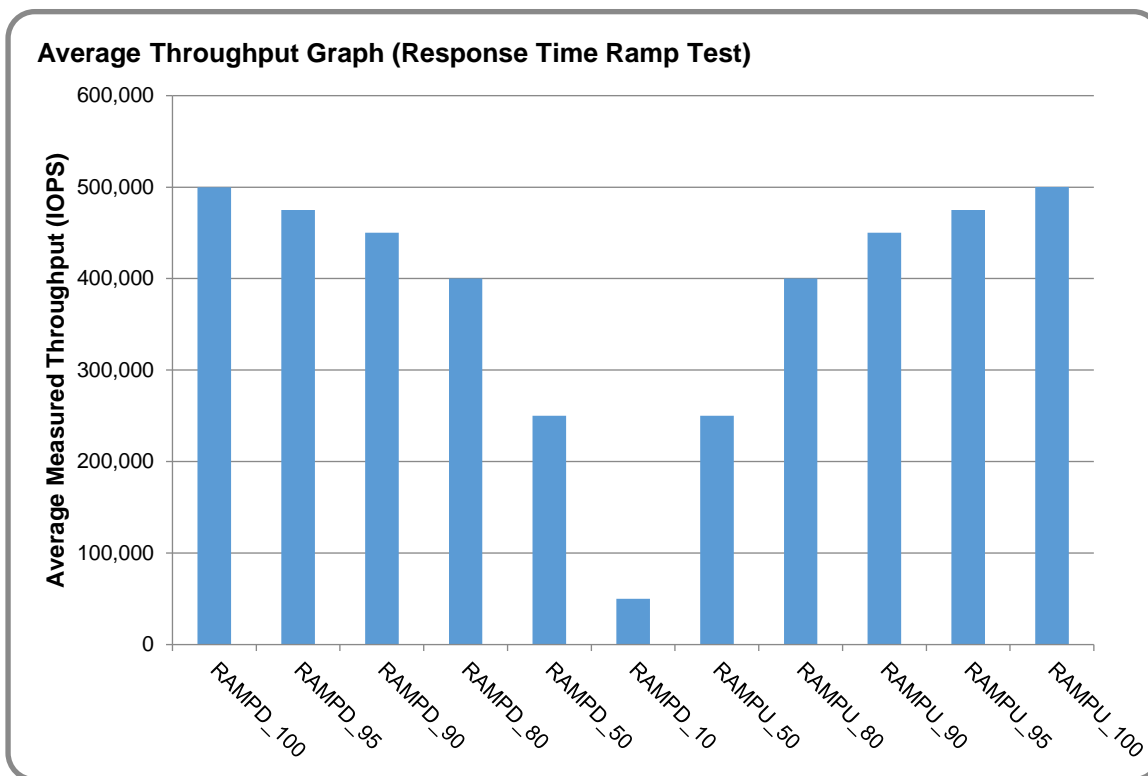
The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1\_METRICS\_0\_Raw\_Results.xlsx**

### Response Time Ramp Test – Phases

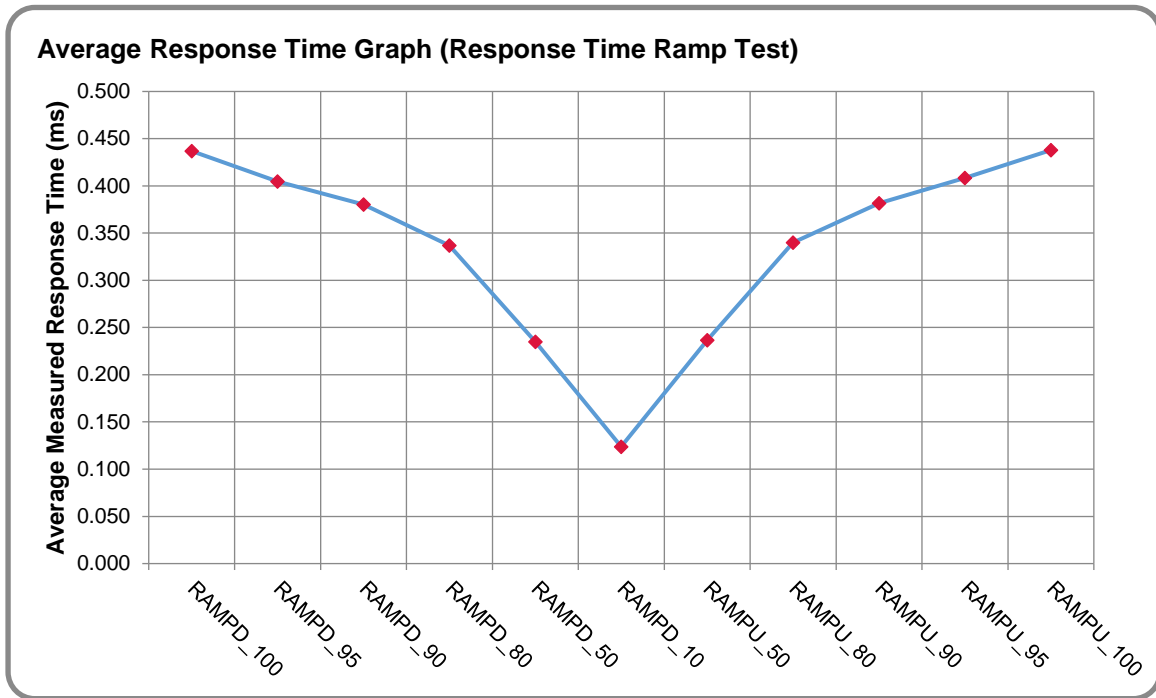
The Response Time Ramp Test is comprised of 11 Test Phases, including six Ramp-Down Phases (executed at 100%, 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit) and five Ramp-Up Phases (executed at 50%, 80%, 90%, 95%, and 100% of the Business Scaling Unit).

### Response Time Ramp Test – Average Throughput Graph

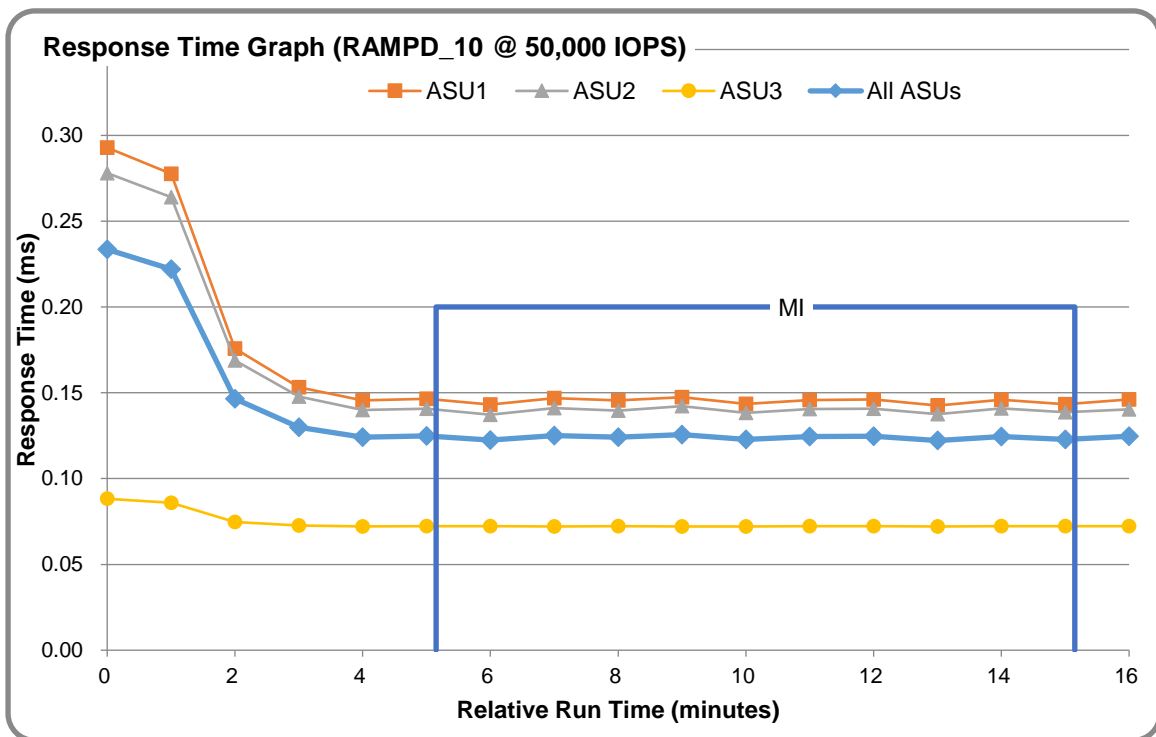




**Response Time Ramp Test – Average Response Time Graph**



**Response Time Ramp Test – RAMPD 10 Response Time Graph**



## Repeatability Test

### Repeatability Test Results File

The results file generated during the execution of the Repeatability Test is included in the Supporting Files (see Appendix A) as follows:

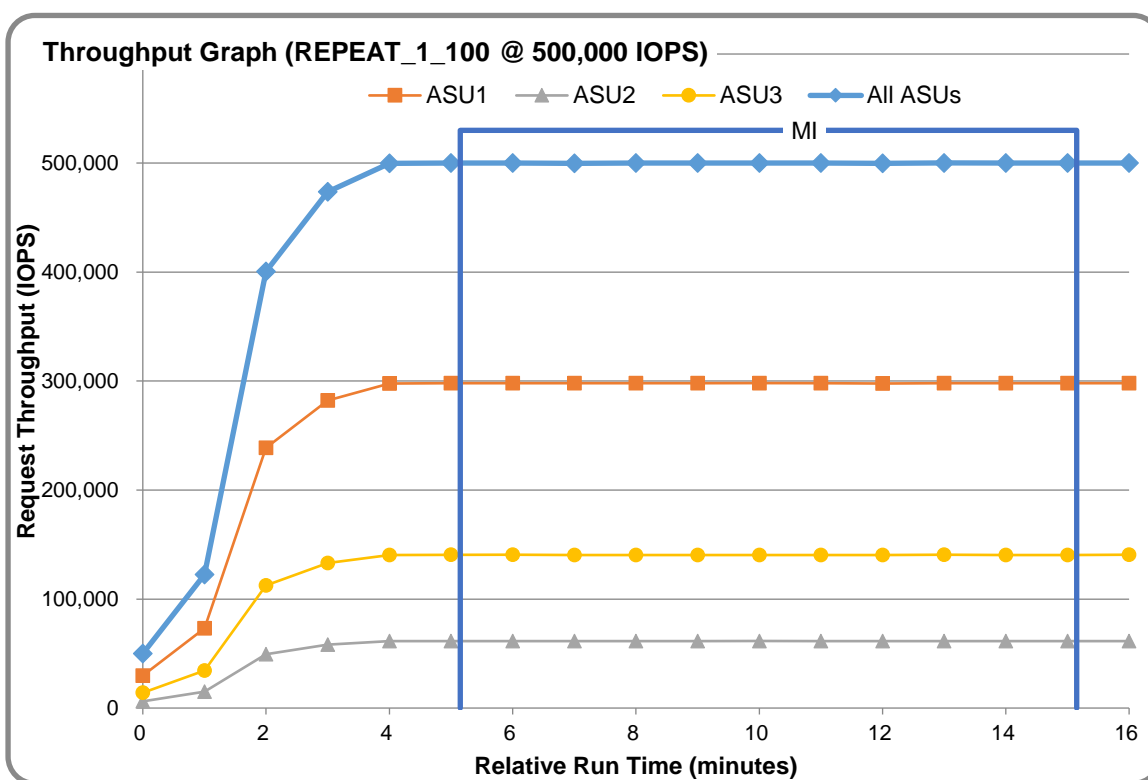
- SPC1\_METRICS\_0\_Raw\_Results.xlsx

### Repeatability Test Results

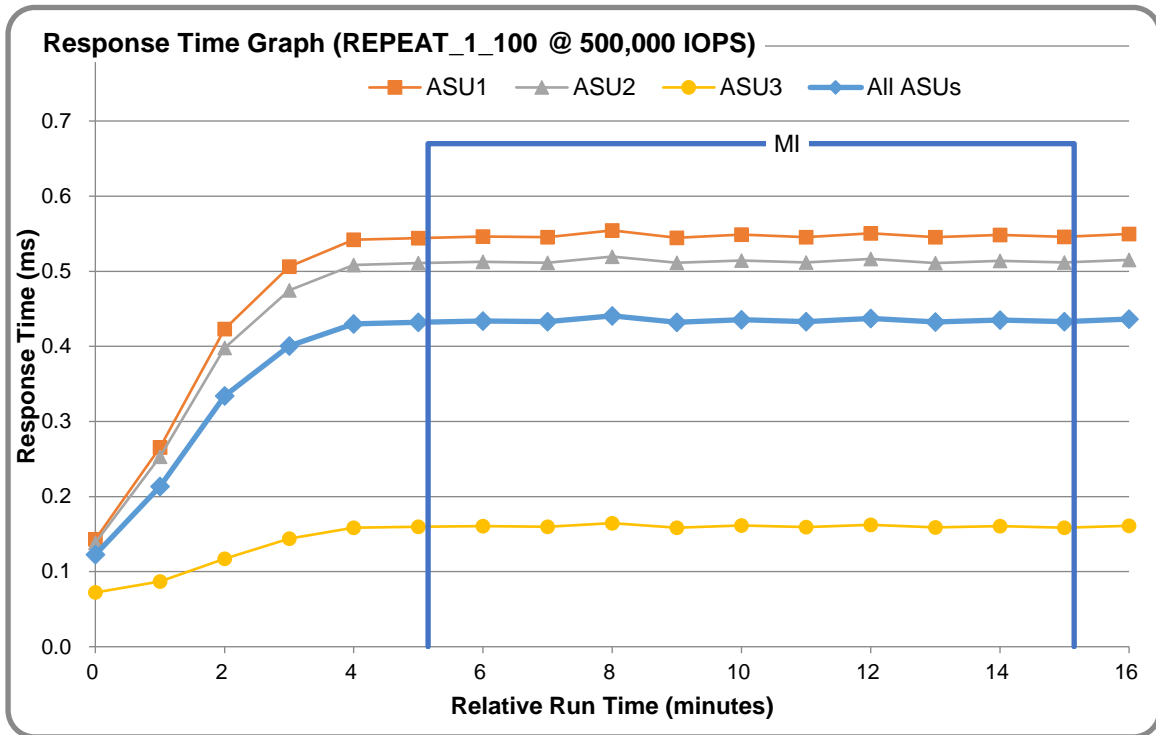
The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT\_1 and REPEAT\_2) are listed in the tables below.

Test Phase	100% IOPS	10% IOPS
RAMPD	500,022.9	50,017.5
REPEAT_1	499,995.3	49,994.5
REPEAT_2	500,022.0	49,992.6

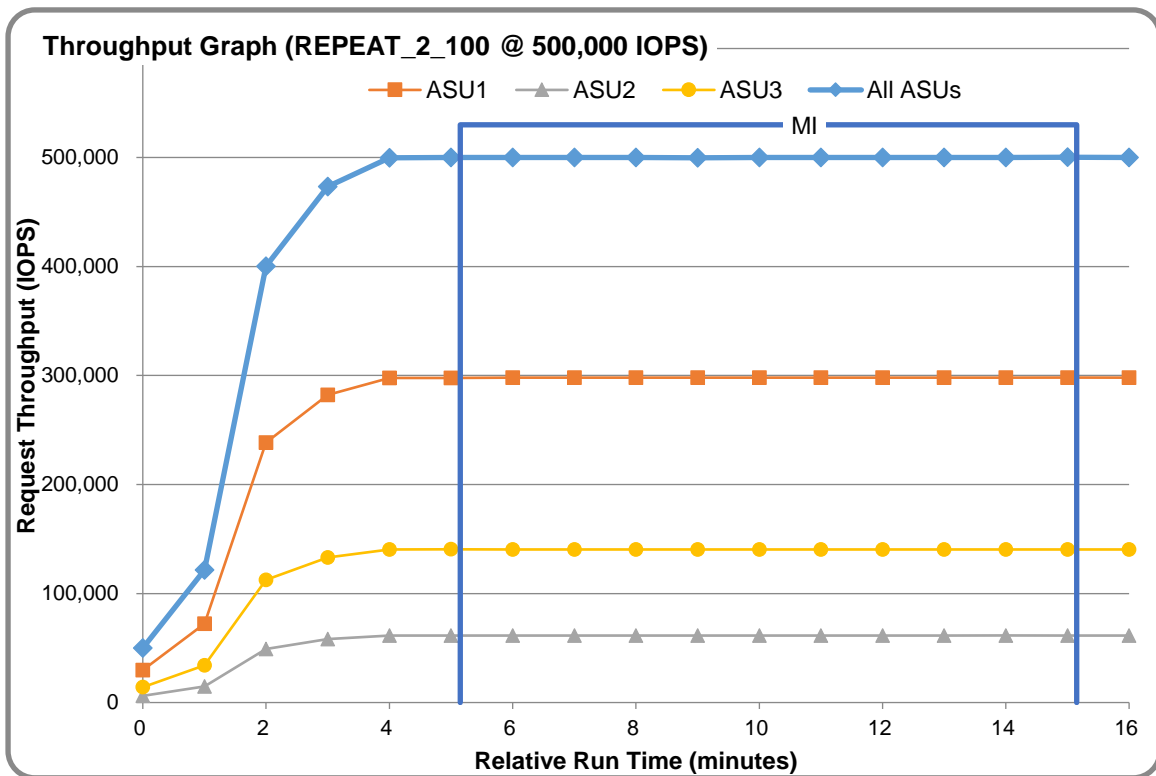
### REPEAT 1 100 – Throughput Graph



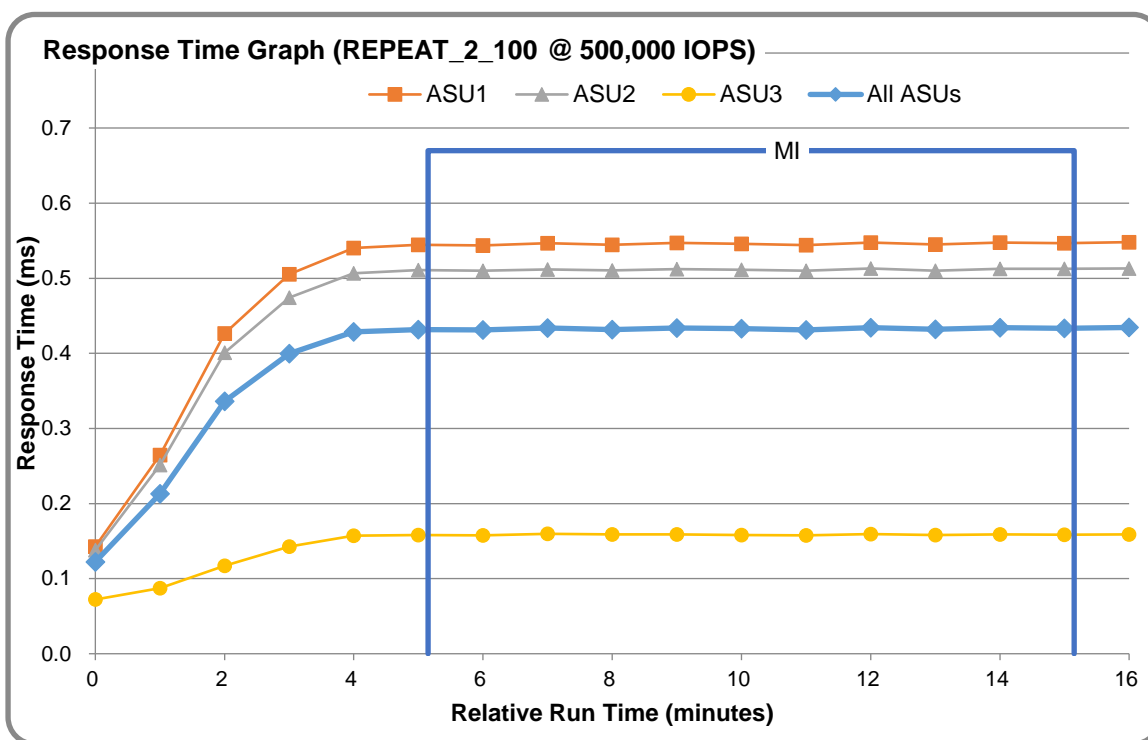
**REPEAT 1 100 – Response Time Graph**



**REPEAT 2 100 – Throughput Graph**



### REPEAT 2 100 – Response Time Graph



### Repeatability Test – Intensity Multiplier

The following tables lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percent of difference (Difference) between Target and Measured.

#### **REPEAT\_1\_100 Test Phase**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>Defined</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Measured</b>	0.0350	0.2811	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Variation</b>	0.0010	0.0002	0.0008	0.0003	0.0013	0.0005	0.0011	0.0004
<b>Difference</b>	0.017%	0.018%	0.038%	0.009%	0.003%	0.026%	0.004%	0.011%

#### **REPEAT\_2\_100 Test Phase**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>Defined</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Measured</b>	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
<b>Variation</b>	0.0008	0.0004	0.0008	0.0005	0.0008	0.0007	0.0008	0.0002
<b>Difference</b>	0.030%	0.011%	0.041%	0.016%	0.054%	0.014%	0.008%	0.006%

## Data Persistence Test

### Data Persistence Test Result files

The results files generated during the execution of the Data Persistence Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1\_PERSIST\_1\_0\_Raw\_Results.xlsx**
- **SPC1\_PERSIST\_2\_0\_Raw\_Results.xlsx**

### Data Persistence Test Execution

The Data Persistence Test was executed using the following sequence of steps:

- The PERSIST\_1\_0 Test Phase was executed to completion.
- The Benchmark Configuration was taken through an orderly shutdown process and powered off.
- The Benchmark Configuration was powered on and taken through an orderly startup process.
- The PERSIST\_2\_0 Test Phase was executed to completion.

### Data Persistence Test Results

<b>Data Persistence Test Phase: Persist1</b>	
<b>Total Number of Logical Blocks Written</b>	102,743,669
<b>Total Number of Logical Blocks Verified</b>	98,109,313
<b>Total Number of Logical Blocks Overwritten</b>	4,634,356
<b>Total Number of Logical Blocks that Failed Verification</b>	0
<b>Time Duration for Writing Test Logical Blocks (sec.)</b>	601
<b>Size in Bytes of each Logical Block</b>	8,192
<b>Number of Failed I/O Requests During the Test</b>	0

### Committed Data Persistence Implementation

Each controller's write cache is mirrored to the other controller. The mirroring operation must succeed before a write complete status is returned to the host. In the event of a power loss, batteries keep the controllers up until their cache can be written to the NVRAM located on each controller.

## **APPENDIX A: SUPPORTING FILES**

The following table details the content of the Supporting Files provided as part of this Full Disclosure Report.

<b>File Name</b>	<b>Description</b>	<b>Location</b>
<b>/SPC1_RESULTS</b>	<b>Data reduction worksheets</b>	<b>root</b>
SPC1_INIT_0_Raw_Results.xlsx	Raw results for INIT Test Phase	/SPC1_RESULTS
SPC1_METRICS_0_Quick_Look.xlsx	Quick Look Test Run Overview	/SPC1_RESULTS
SPC1_METRICS_0_Raw_Results.xlsx	Raw results for Primary Metrics Test	/SPC1_RESULTS
SPC1_METRICS_0_Summary_Results.xlsx	Primary Metrics Summary	/SPC1_RESULTS
SPC1_PERSIST_1_0_Raw_Results.xlsx	Raw results for PERSIST1 Test Phase	/SPC1_RESULTS
SPC1_PERSIST_2_0_Raw_Results.xlsx	Raw results for PERSIST2 Test Phase	/SPC1_RESULTS
SPC1_Run_Set_Overview.xlsx	Run Set Overview Worksheet	/SPC1_RESULTS
SPC1_VERIFY_0_Raw_Results.xlsx	Raw results for first VERIFY Test Phase	/SPC1_RESULTS
SPC1_VERIFY_1_Raw_Results.xlsx	Raw results for second VERIFY Test Phase	/SPC1_RESULTS
<b>/C_Tuning</b>	<b>Tuning parameters and options</b>	<b>root</b>
<i>No file in folder</i>	See /D_Creation	
<b>/D_Creation</b>	<b>Storage configuration creation</b>	<b>root</b>
SPC1_SH_RAID_Config.script	TSC creation script	/D_Creation
<b>/E_Inventory</b>	<b>Configuration inventory</b>	<b>root</b>
config_at_start.txt	Storage inventory at start of test	/E_Inventory
config_at_mid.txt	Storage inventory before system shutdown	/E_Inventory
config_at_end.txt	Storage inventory after Persistence test	/E_Inventory
<b>/F_Generator</b>	<b>Workload generator</b>	<b>root</b>
SPC1.asu	Defining LUNs hosting the ASUs	/F_generator
10slave_auto.hst	Host configuration file	/F_generator
Phase1.cmd	Execute all test phases until shutdown	/F_generator
Phase2.cmd	Execute final test phases after restart	/F_generator

## APPENDIX B: THIRD PARTY QUOTATION

### Source 2 – CDW

Checkout: Order Review
8/15/17, 12:39 PM

[My Account](#) [Cart \(12\) - \\$2,359.88](#)

# CHECKOUT: ORDER REVIEW

LOG ON    [SHIPPING ADDRESS](#)    [SHIPPING METHOD](#)    [BILLING & PAYMENT](#)    [REVIEW & PLACE ORDER](#)

[Place Order](#)

**Review your order**

Shipping Address	Shipping Method	Billing Address	Payment Method
<a href="#">Edit</a> NetApp Corporation Attn To: Mark Regester 3718 North Rock Road Wichita, KS - 67226	<a href="#">Edit</a> <b>Carrier</b> UPS Ground	<a href="#">Edit</a> NetApp Corporation 3718 North Rock Road Wichita, KS - 67226	<a href="#">Edit</a> Phone In

**For Your Reference**

P.O. Number/Description

Cost Center Code

Customer Notes 250 characters remaining

Notes will appear on invoice(s) for your reference only and will not be read by your account manager. CDW is not responsible for comments entered in this field.

Product	CDW Part #	Availability	Qty	Unit Price	Extended Price
LSI SAS 9300-8e SGL - storage controller - SATA 6Gb/s / SAS 12Gb/s - PCIe 3	3818102	2-4 days	4	\$449.99	\$1,799.96
Supermicro SAS external cable - 6.6 ft	3877041	In Stock	8	\$69.99	\$559.92
<b>Subtotal</b>					\$2,359.88
<b>Shipping</b>					\$23.43
<b>Sales Tax</b>					\$178.74
<b>Grand Total</b>					\$2,562.05

[Place Order](#)

<https://www.cdw.com/shop/checkout/review.aspx?Standard=1&>
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## APPENDIX C: TUNING PARAMETERS AND OPTIONS

### Storage Array Parameters

The following storage array parameters were changed from their default values by the TSC creation and configuration script, *SPC1\_SH\_RAID\_Config.script*, documented in “Appendix D: Storage Configuration Creation”:

- **CacheBlockSize** – the disk array controller cache allocation unit was set to 16.
- **CacheFlushStart** – the percentage of cache fill at which to start flushing was set to 50.
- **autoLoadBalancingEnable** – the monitoring of IO load across volumes with migration of volumes across controllers when imbalance occurs was disabled.

### HBA Parameters

The following Avago/LSI parameters were changed from their default values with the utility *lsiutil.exe* included with the HBA driver package.

Parameter	Default Value	New Value
IOC Settings (#10):		
Interrupt Coalescing	Enable	Disable
SAS IO Unit Settings (#13):		
SATA Max Queue Depth	32	255
SAS max queue depth, narrow	0	65535
SAS max queue depth, wide	0	65535
Device missing report delay	0	144
Device missing IO delay	0	8
Modify All Phys (#8):		
MinRate (Gbps)	1.5	12.0
MaxRate (Gbps)	6.0	12.0
Port configuration	Auto	Wide



## **APPENDIX D: STORAGE CONFIGURATION CREATION**

### **Step 1 - Storage Array Volume Creation**

The storage management utility, **SANtricity**, was installed on both Host System. It is a required software package that provides configuration, monitoring, and failover path management. The software is installed as a Windows installable package. After installation, it can be found in `\Program Files\StorageManager\client` and is started with the desktop shortcut **SANtricity Storage Manager Client**, or can be run using **Start→Search→SANtricity Storage Manager Client**.

**SANtricity Storage Manager** was used to create three volume groups on the NetApp EF570 All-Flash Array. Each volume group contains two RAID 1 (mirrored) volumes. All six RAID 1 volumes were visible by each Host System.

The physical storage volumes were created on the EF570 using the **Launch SANtricity Storage Manger** script editor, as follows:

- From the “Enterprise Management” window, right-click the name of the storage array on which volumes will be created;
- Select **Execute Script** from the pop-up menu;
- In the script editor window, load the script **SPC1\_SH\_RAID\_Config.script**; and
- Select **Execute** from the “Tools” menu.

### **Step 2 - Logical Volume Creation**

The following steps were executed on a single Host System to define the Windows partitions, volumes, and stripe sets that comprise the SPC-1 Logical Volumes used to host the Application Storage Units (ASUs).

1. Start the **Windows Disk Administrator** to discover the six RAID volumes, then exit the Disk Administrator.
2. Use **diskpar.exe** to set the starting offset for each of the storage system volumes. Starting offset is 65536 sectors (512 bytes per sector). Use all of the remaining capacity to create a single volume in each partition.
3. Start the **Disk Management** utility under **Computer Management**.
4. Convert all of the storage system volumes to Dynamic Disks.
5. Create a “Windows Striped” (RAID 0) volume using all six 32MB partitions.
6. Delete the remaining large volume on each of the Dynamic Disks.
7. Create a “Windows Striped” (RAID 0) volume for ASU-3.
  - a. Select all six volumes.
  - b. Set capacity to 143,150 MB.
  - c. Assign drive letter “T” to the volume. Do not format the volume.
8. Create a “Windows Striped” (RAID 0) volume for ASU-1.
  - a. Select all six volumes.

- b. Set capacity to 644,175 MB.
  - c. Assign drive letter “R” to the volume. Do not format the volume.
9. Create a “Windows Striped” (RAID 0) volume for ASU-2.
- a. Select all six volumes.
  - b. Set capacity to 644,175 MB.
  - c. Assign drive letter “S” to the volume. Do not format the volume.
10. Reboot the Host Systems.
11. After each reboot completes, start the *Disk Administrator* utility on each of the Host Systems.
12. On each Host System, select either the “import foreign disk” or the “reactivate Windows stripe sets” option, as necessary, then assign drive letters to the stripe sets as they were assigned in steps 7-9 above.

The above script is included in the Supporting Files (see Appendix A) and listed below.

***SPC1\_SH\_RAID\_Config.script***

```
/* SPC-1 v3 RAID Volume Configuration Script */

create volume drives[ 0,0 0,1 0,2 0,3 0,4 0,5 0,6 0,7 ]
RAIDLevel=1
segmentSize=64
userLabel="LUN_0"
volumeGroupUserLabel="VG_0"
capacity=1398 gb
owner = A;

create volume volumeGroup["VG_0"] RAIDLevel=1 segmentSize=64 userLabel="LUN_1"
    capacity=1398 gb owner = b;

create volume drives[ 0,8 0,9 0,10 0,11 0,12 0,13 0,14 0,15 ]
RAIDLevel=1
segmentSize=64
userLabel="LUN_2"
volumeGroupUserLabel="VG_1"
capacity=1398 gb
owner = b;

create volume volumeGroup["VG_1"] RAIDLevel=1 segmentSize=64 userLabel="LUN_3"
    capacity=1398 gb owner = A;

create volume drives[ 0,16 0,17 0,18 0,19 0,20 0,21 0,22 0,23 ]
RAIDLevel=1
segmentSize=64
userLabel="LUN_4"
volumeGroupUserLabel="VG_2"
capacity=1398 gb
owner = A;

create volume volumeGroup["VG_2"] RAIDLevel=1 segmentSize=64 userLabel="LUN_5"
    capacity=1398 gb owner = b;
```

```
/* define host mappings */
set volume["LUN_0"] logicalUnitNumber=0 hostGroup=defaultGroup;
set volume["LUN_1"] logicalUnitNumber=1 hostGroup=defaultGroup;
set volume["LUN_2"] logicalUnitNumber=2 hostGroup=defaultGroup;
set volume["LUN_3"] logicalUnitNumber=3 hostGroup=defaultGroup;
set volume["LUN_4"] logicalUnitNumber=4 hostGroup=defaultGroup;
set volume["LUN_5"] logicalUnitNumber=5 hostGroup=defaultGroup;

set allVolumes mirrorEnabled = True writeCacheEnabled = True
  cacheWithoutBatteryEnabled = False cacheReadPrefetch = False;

set storageArray cacheBlockSize = 16;
set storageArray cacheFlushStart = 50;
set storageArray autoLoadBalancingEnable = false;
```

## **APPENDIX E: CONFIGURATION INVENTORY**

An inventory of the Tested Storage Configuration was collected by the script ***phase1.cmd*** before the test execution, as well as before the Persistence test shutdown. A third inventory of the Tested Storage Configuration was collected by the script ***phase2.cmd*** after the end of the test execution. These scripts are documented in “Appendix D: Storage Configuration Creation”.

The following log files were generated and are included in the Supporting Files (see Appendix A):

- ***config\_at\_start.txt*** List of configured storage and logical volumes before test execution.
- ***config\_at\_mid.txt*** List of configured storage and logical volumes before TSC shutdown.
- ***config\_at\_end.txt*** List of configured storage and logical volumes after TSC restart.

## **APPENDIX F: WORKLOAD GENERATOR**

The host parameters for the SPC-1 workload generator were defined using the script ***10slave\_auto.hst***.

The ASUs accessed by the SPC-1 workload generator are defined using the script ***SPC1.asu***.

The initial test phases of the benchmark were invoked using the script ***phase1.cmd***, which executed steps up to the Persistence Test shutdown. Once the TSC had been restarted, the PERSIST\_2 test phase was invoked using the script ***phase2.cmd***.

The above scripts are included in the Supporting Files (see Appendix A) and listed below.

### ***10slave\_auto.hst***

```
-- 8slave_auto.hst
--
PORT=1001
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost
--
PORT=1002
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost
--
PORT=1003
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost
--
PORT=1004
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost
--
PORT=1005
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost
--
LOGIN=bench
PASSWORD=SPCSpecial1
EXEC=spc1.exe
CONFIG=c:\bench\spc1\v302
OUTPUT=c:\bench\spc1\v302
WINDOWS=Y
PORT=2004
WEIGHT=1
STORAGE=SPC1.asu
HOST=bmr730ab
--
LOGIN=bench
PASSWORD=SPCSpecial1
EXEC=spc1.exe
CONFIG=c:\bench\spc1\v302
```

```
OUTPUT=c:\bench\spc1\v302
WINDOWS=Y
PORT=2005
WEIGHT=1
STORAGE=SPC1.asu
HOST=bmr730ab
--
LOGIN=bench
PASSWORD=SPCSpecial1
EXEC=spc1.exe
CONFIG=c:\bench\spc1\v302
OUTPUT=c:\bench\spc1\v302
WINDOWS=Y
PORT=2006
WEIGHT=1
STORAGE=SPC1.asu
HOST=bmr730ab
--
LOGIN=bench
PASSWORD=SPCSpecial1
EXEC=spc1.exe
CONFIG=c:\bench\spc1\v302
OUTPUT=c:\bench\spc1\v302
WINDOWS=Y
PORT=2007
WEIGHT=1
STORAGE=SPC1.asu
HOST=bmr730ab
--
LOGIN=bench
PASSWORD=SPCSpecial1
EXEC=spc1.exe
CONFIG=c:\bench\spc1\v302
OUTPUT=c:\bench\spc1\v302
WINDOWS=Y
PORT=2008
WEIGHT=1
STORAGE=SPC1.asu
HOST=bmr730ab
```

### ***SPC1.asu***

```
ASU=1
OFFSET=0
SIZE=0
DEVICE=\\.\R:
--
ASU=2
OFFSET=0
SIZE=0
DEVICE=\\.\S:
--
ASU=3
OFFSET=0
SIZE=0
DEVICE=\\.\T:
```

### ***Phase1.cmd***

```
echo "Capture a storage profile at the start of the run....."
pushd "\Program Files\StorageManager\client"
smcli 10.113.120.33 10.113.120.34 -c "show storageArray time; show storageArray
  profile; show storageArray time;" -o \bench\spc1\v302\config_at_start.txt -
  quick
popd

spc1 -run SPC1_INIT -iops 3000 -output output091417 -queues 2
spc1 -run SPC1_VERIFY -iops 100 -output output091417

spc1 -run SPC1_METRICS -iops 500000 -master 10slave_auto.hst -output output091417
spc1 -run SPC1_VERIFY -iops 100 -output output091417

spc1 -run SPC1_PERSIST_1 -iops 125000 -output output091417

echo "Capture a storage profile at the end of Persist1....."
pushd "\Program Files\StorageManager\client"
smcli 10.113.120.33 10.113.120.34 -c "show storageArray time; show storageArray
  profile; show storageArray time;" -o \bench\spc1\v302\config_at_mid.txt -quick
popd
```

### ***Phase2.cmd***

```
spc1 -run SPC1_PERSIST_2 -iops 125000 -output output091417

echo "Capture a storage profile at the end of the run....."
pushd "\Program Files\StorageManager\client"
smcli 10.113.120.33 10.113.120.34 -c "show storageArray time; show storageArray
  profile; show storageArray time;" -o \bench\spc1\v302\config_at_end.txt -quick
popd
```