



**SPC BENCHMARK 1™  
FULL DISCLOSURE REPORT**

**LENOVO GROUP LTD.  
LENOVO STORAGE S2200**

**SPC-1 V1.14**

**Submitted for Review: June 30, 2016  
Submission Identifier: A00181**

**First Edition – June 2016**

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## AUDIT CERTIFICATION



Shawn Andrews  
Lenovo Group Ltd.  
7001 Development Drive  
Morrisville, NC 27560

June 29, 2016

The SPC Benchmark 1™ Reported Data listed below for the Lenovo Storage S2200 was produced in compliance with the SPC Benchmark 1™ v1.14 Onsite Audit requirements.

SPC Benchmark 1™ v1.14 Reported Data	
Tested Storage Product (TSP) Name: Lenovo Storage S2200	
Metric	Reported Result
SPC-1 IOPS™	41,046.45
SPC-1 Price-Performance	\$0.23/SPC-1 IOPS™
Total ASU Capacity	755.971 GB
Data Protection Level	Protected 1 ( <i>mirroring</i> )
Total Price (including three-year maintenance)	\$9,508.40
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

The following SPC Benchmark 1™ Onsite Audit requirements were reviewed and found compliant with 1.14 of the SPC Benchmark 1™ specification:

- A Letter of Good Faith, signed by a senior executive.
- The following Data Repository storage items were verified by physical inspection and information supplied by Lenovo Group Ltd.:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- The total Application Storage Unit (ASU) Capacity was filled with random data, using an auditor approved tool, prior to execution of the SPC-1 Tests.

Gradient Systems, Inc.  
643 Bair Island Road, Suite 103  
Redwood City, CA 94062  
[AuditService@storageperformance.org](mailto:AuditService@storageperformance.org)  
650.556.9380

## AUDIT CERTIFICATION (CONT.)

Lenovo Storage S2200  
SPC-1 Audit Certification

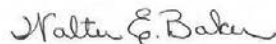
Page 2

- An appropriate diagram of both the Priced Storage Configuration and the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Physical verification of the components to match the above diagram.
- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.
- The following Host System requirements were verified by physical inspection and information supplied by Lenovo Group Ltd.:
  - ✓ The type and number of Host Systems including the number of processors and main memory.
  - ✓ The presence and version number of the SPC-1 Workload Generator on each Host System.
  - ✓ The TSC boundary within each Host System.
- The execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.
- The Test Results Files and resultant Summary Results Files received from Lenovo Group Ltd. for each of following were authentic, accurate, and compliant with all of the requirements and constraints of Clauses 4 and 5 of the SPC-1 Benchmark Specification:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test
- There was no difference between the Tested Storage Configuration (TSC) and Priced Storage Configuration.
- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.
- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.
- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

**Audit Notes:**

There are no audit notes.

Respectfully,



Walter E. Baker  
SPC Auditor

Gradient Systems, Inc.  
643 Bair Island Road, Suite 103  
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## LETTER OF GOOD FAITH

\_\_\_\_\_  
Lenovo.com

\_\_\_\_\_  
7001 Development Drive  
Morrisville, NC 27560



May 26, 2016

From: Gregory Moore, ED WW Datacenter Storage Dev, Lenovo

**Subject: SPC-1 Letter of Good Faith for the Lenovo Storage S2200**

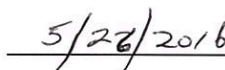
Lenovo is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with the 1.14 of the SPC-1 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Sincerely,

Date:

  
\_\_\_\_\_

  
\_\_\_\_\_

Gregory Moore

ED WW Storage Development  
Lenovo  
Tel: 919-237-8415  
Email: gmoore@lenovo.com

**EXECUTIVE SUMMARY****Test Sponsor and Contact Information**

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<b>Auditor</b>	Storage Performance Council – <a href="http://www.storageperformance.org">http://www.storageperformance.org</a> Walter E. Baker – <a href="mailto:AuditService@StoragePerformance.org">AuditService@StoragePerformance.org</a> Gradient Systems, Inc. 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9380 FAX: (650) 556-9385

**Revision Information and Key Dates**

<b>Revision Information and Key Dates</b>	
<b>SPC-1 Specification revision number</b>	V1.14
<b>SPC-1 Workload Generator revision number</b>	V2.3.0
<b>Date Results were first used publicly</b>	June 30, 2016
<b>Date the FDR was submitted to the SPC</b>	June 30, 2016
<b>Date the Priced Storage Configuration is available for shipment to customers</b>	currently available
<b>Date the TSC completed audit certification</b>	June 29, 2016

## Tested Storage Product (TSP) Description

The Lenovo Storage S Series Portfolio of SAN Storage is designed for simplicity, speed, scalability and availability. Known for providing customer value, Lenovo delivers enterprise class SAN offerings loaded with proven storage innovations at an affordable price point without sacrificing performance. These feature-rich arrays can be easily integrated into your network environment and supports a variety of workloads ranging from general purpose web serving and data management/analytics that require high IOPs, to streaming workloads that need high throughput. Every Lenovo Storage S2200 comes with Lenovo SAN Manager. This intuitive GUI enables many advanced features:

- Thin Provisioning – helps customers purchase only the storage needed for operations
- SSD Read Caching – enables priority access to “hot” data accelerating read performance
- Rapid RAID Rebuild - minimizes recovery time and risk factors with rapid data restoration
- Snapshot - provides point-in-time copies of live data, eliminating the need for restore and performance hits
- Storage Pooling – virtualizes storage across multiple drive types improving IO by up to 2.5x without impacting applications

Each S Series S2200 supports 12 x 3.5" or 24 x 2.5" SSD and HDD, for a total of 96 drives. If additional capacity, Snapshots, Users, and Performance are required, then just swap out the controllers with no data migration. With this upgrade, the system can support up to 192 drives. With S Series, Lenovo delivers storage that is simple to deploy, easy to manage, and accessible to businesses and budgets of all sizes.

## Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Lenovo Storage S2200	
Metric	Reported Result
SPC-1 IOPS™	41,046.45
SPC-1 Price-Performance™	\$0.23/SPC-1 IOPS™
Total ASU Capacity	755.971 GB
Data Protection Level	Protected 1 ( <i>Mirroring</i> )
Total Price	\$9,508.40
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

SPC-1 Price-Performance™ is the ratio of **Total Price** to SPC-1 IOPS™.

**Total ASU** (Application Storage Unit) **Capacity** represents the total storage capacity available to be read and written in the course of executing the SPC-1 benchmark.

A **Data Protection Level** of **Protected 1** using *Mirroring* configures two or more identical copies of user data.

***Protected 1:** The single point of failure of any **storage device** in the configuration will not result in permanent loss of access to or integrity of the SPC-1 Data Repository.*

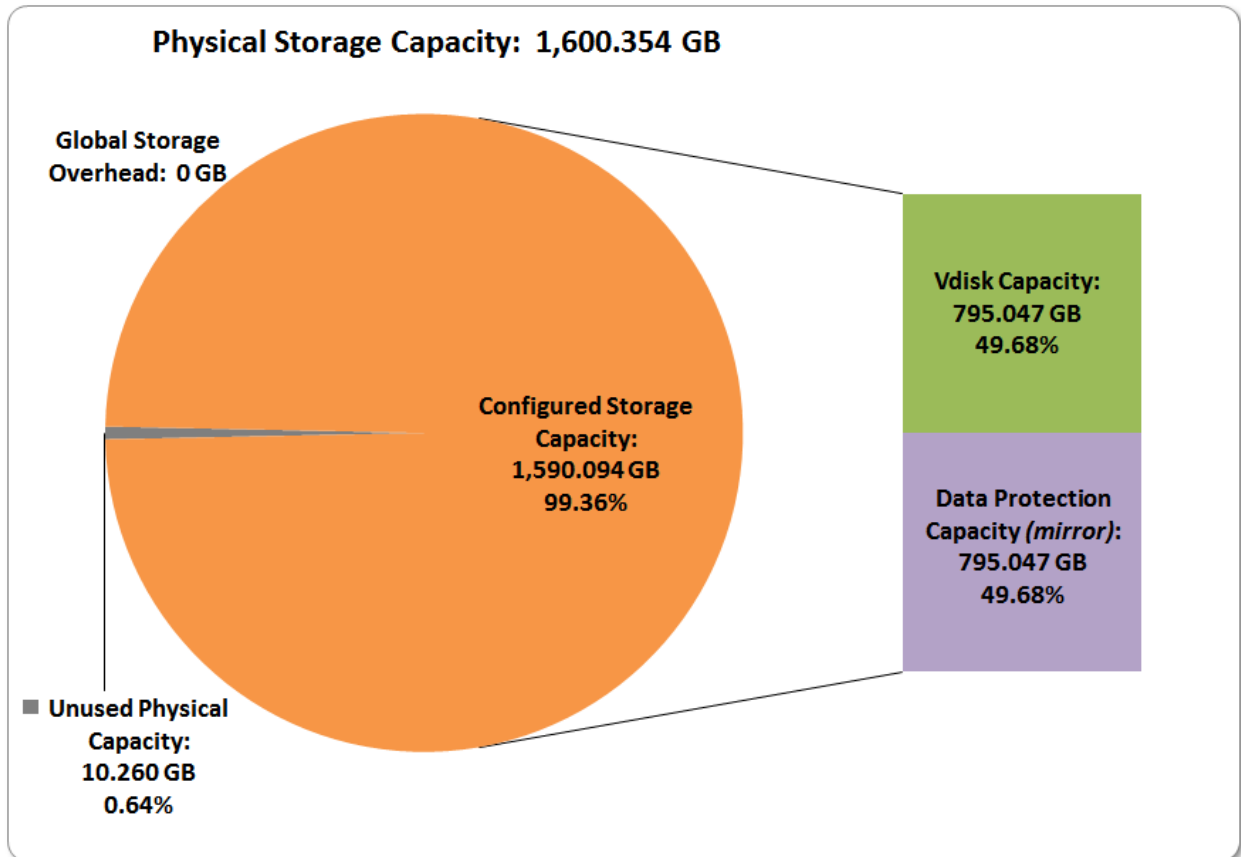
**Total Price** includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 17.

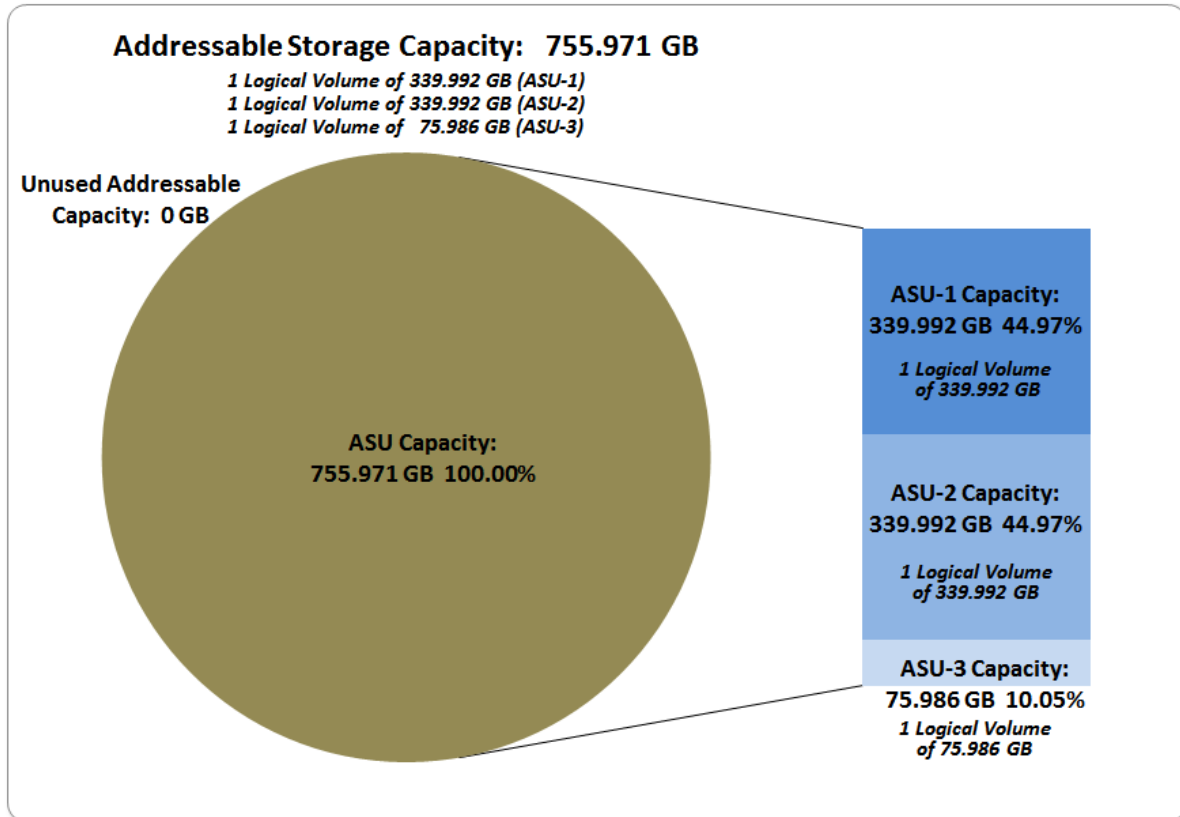
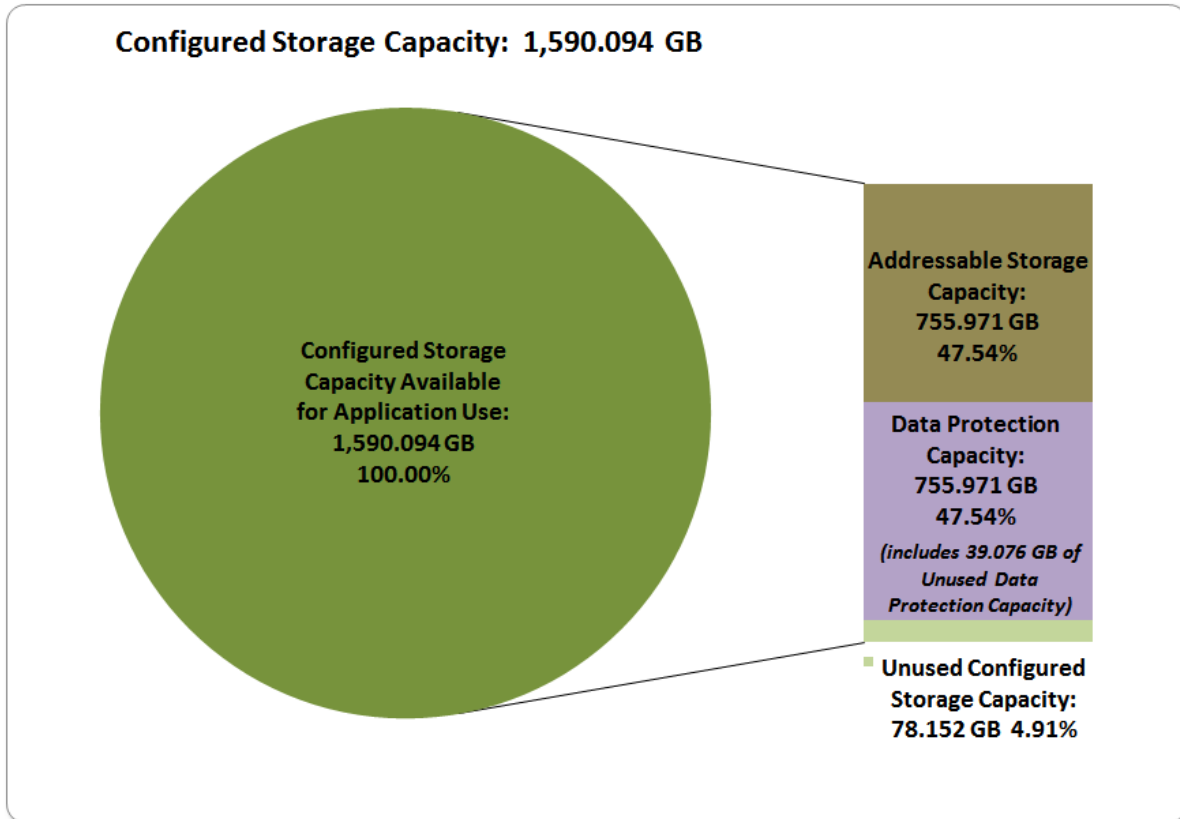
**Currency Used** is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country (*non-local currency*).

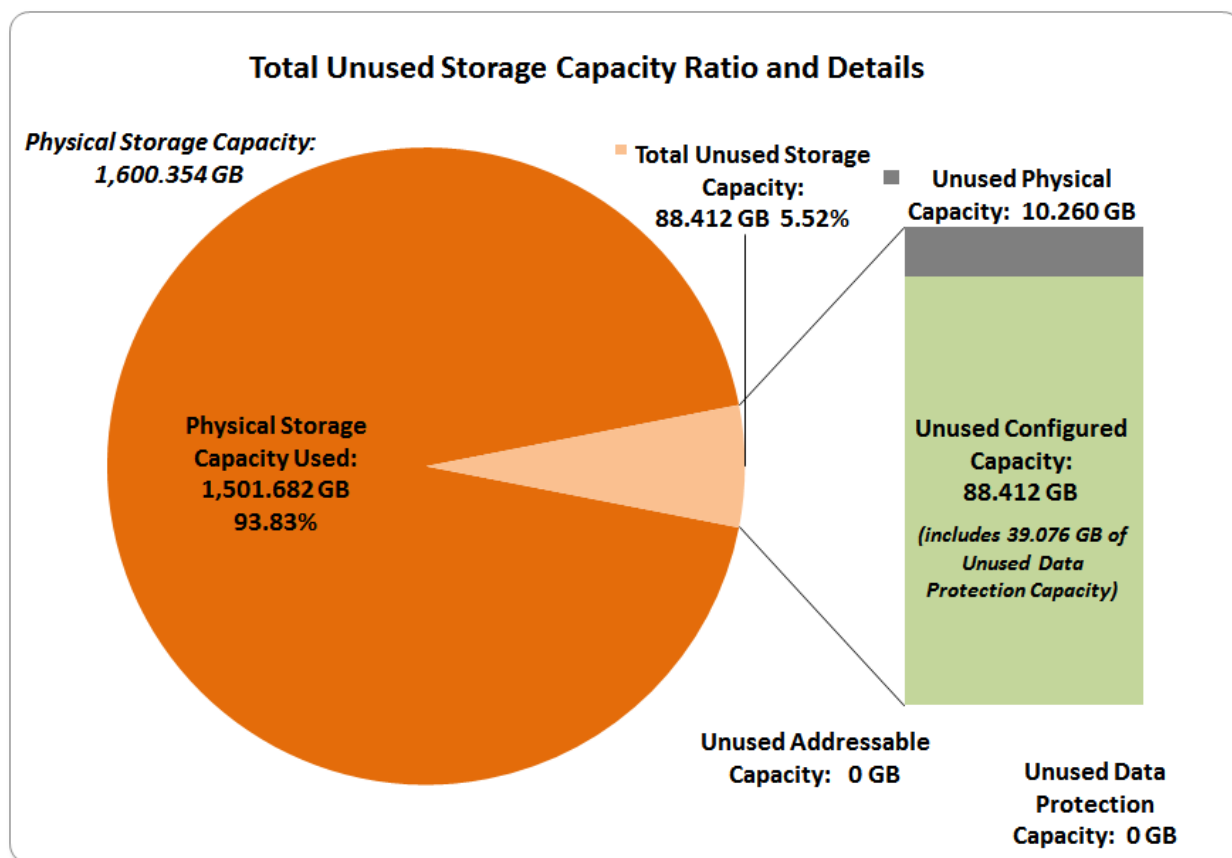
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

### Storage Capacities, Relationships, and Utilization

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.







SPC-1 Storage Capacity Utilization	
Application Utilization	47.24%
Protected Application Utilization	94.48%
Unused Storage Ratio	5.52%

**Application Utilization:** Total ASU Capacity (755.971 GB) divided by Physical Storage Capacity (1,600.354 GB).

**Protected Application Utilization:** (Total ASU Capacity (755.971 GB) plus total Data Protection Capacity (795.047 GB) minus unused Data Protection Capacity (39.076 GB)) divided by Physical Storage Capacity (1,600.354 GB).

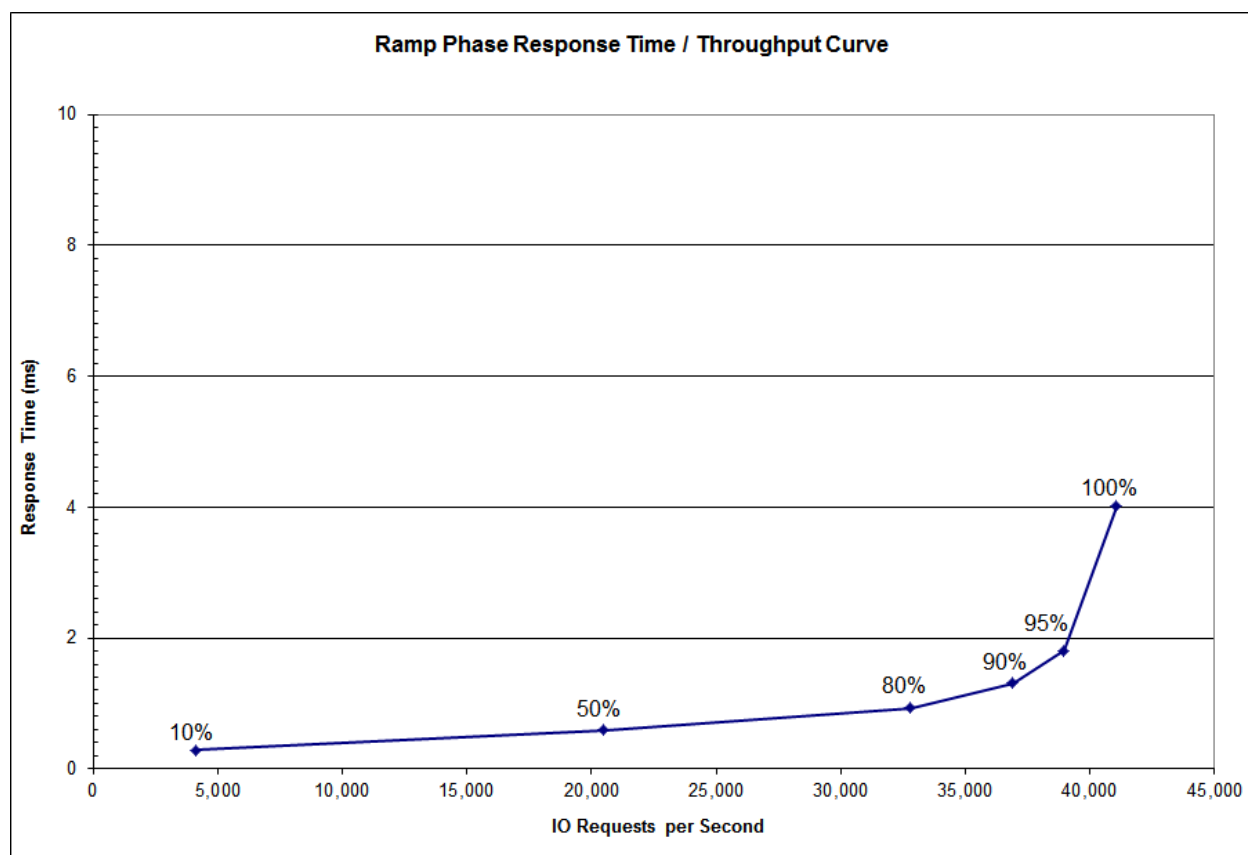
**Unused Storage Ratio:** Total Unused Capacity (88.412 GB) divided by Physical Storage Capacity (1,600.354 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 23-24.

## Response Time – Throughput Curve

The Response Time-Throughput Curve illustrates the Average Response Time (milliseconds) and I/O Request Throughput at 100%, 95%, 90%, 80%, 50%, and 10% of the workload level used to generate the SPC-1 IOPS™ metric.

The Average Response Time measured at any of the above load points cannot exceed 30 milliseconds or the benchmark measurement is invalid.



## Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
<b>I/O Request Throughput</b>	4,098.13	20,496.21	32,803.21	36,906.24	38,940.86	41,046.45
<b>Average Response Time (ms):</b>						
<b>All ASUs</b>	0.29	0.59	0.94	1.31	1.81	4.02
<b>ASU-1</b>	0.31	0.61	0.95	1.32	1.84	4.71
<b>ASU-2</b>	0.30	0.62	0.96	1.30	1.69	2.72
<b>ASU-3</b>	0.24	0.54	0.89	1.29	1.80	3.12
<b>Reads</b>	0.38	0.68	1.03	1.35	1.78	4.18
<b>Writes</b>	0.23	0.53	0.88	1.28	1.83	3.91



## Priced Storage Configuration Pricing

Description	Part Number	Quantity	List Price	Total Price
Lenovo Storage S2200 SFF SAS Dual Controller	6411-2B4	1	5,499.00	5,499.00
3 Year 24 x 7 4-Hour Response	00WX793	1	1,196.00	1,196.00
Lenovo Storage 2.5" 400GB SSD (SAS)	00MM720	4	2,499.00	9,996.00
External MiniSAS HD 8644/Mini SAS HD 8644 1m cable	00WE748	2	149.00	298.00
N2225 SAS/SATA HBA	00AE912	1	299.00	299.00

<b>Total List Price</b>	<b>17,288.00</b>
Discount	45%
<b>Total Discounted Price</b>	<b>9,508.40</b>

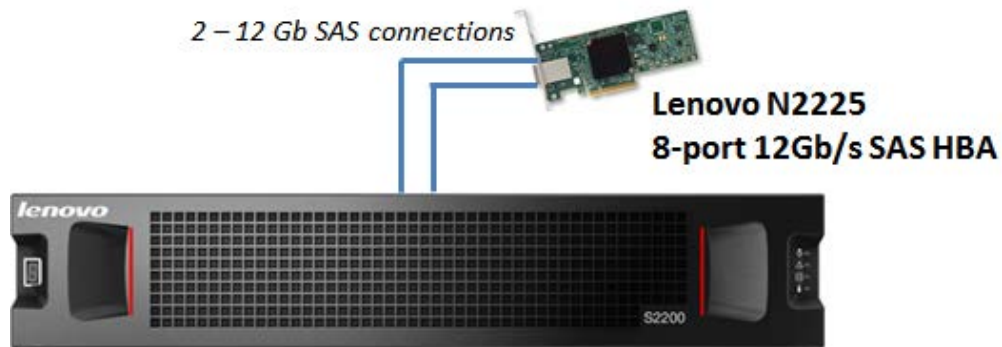
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- Acknowledgement of new and existing problems within four (4) hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative Price Storage Configuration that can be remedied by the repair or replacement of a 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



### Lenovo Storage S2200

Dual-Active Controllers with:  
 8GB cache, 4GB per controller  
 4 – 400GB 2.5" SSD SAS disk drives

### Priced Storage Configuration Components

Priced Storage Configuration
1 – Lenovo N2225 8-port, 12 Gb SAS HBA
<b>Lenovo Storage S2200</b> 2U24 Controller Enclosure Dual-Active Controllers each controller includes: 4 GB cache (8 GB total) 2 – 12 Gb SAS host ports (4 ports total and 2 ports used/1 port per controller) 1 – 6 Gb SAS connection (4 lanes) (2 total, none used) 4 – 400 GB SSDs

In each of the following sections of this document, the appropriate Full Disclosure Report requirement, from the SPC-1 benchmark specification, is stated in italics followed by the information to fulfill the stated requirement.

## **CONFIGURATION INFORMATION**

### **Benchmark Configuration (BC)/Tested Storage Configuration (TSC) Diagram**

#### *Clause 9.4.3.4.1*

*A one page Benchmark Configuration (BC)/Tested Storage Configuration (TSC) diagram shall be included in the FDR...*

The Benchmark Configuration (BC)/Tested Storage Configuration (TSC) is illustrated on page [20 \(Benchmark Configuration/Tested Storage Configuration Diagram\)](#).

### **Storage Network Configuration**

#### *Clause 9.4.3.4.1*

...

5. *If the TSC contains network storage, the diagram will include the network configuration. If a single diagram is not sufficient to illustrate both the Benchmark Configuration and network configuration in sufficient detail, the Benchmark Configuration diagram will include a high-level network illustration as shown in Figure 9-8. In that case, a separate, detailed network configuration diagram will also be included as described in Clause 9.4.3.4.2.*

#### *Clause 9.4.3.4.2*

*If a storage network was configured as a part of the Tested Storage Configuration and the Benchmark Configuration diagram described in Clause 9.4.3.4.1 contains a high-level illustration of the network configuration, the Executive Summary will contain a one page topology diagram of the storage network as illustrated in Figure 9-9.*

The Tested Storage Configuration only utilized direct-attached storage and, as such, did not utilize a storage network.

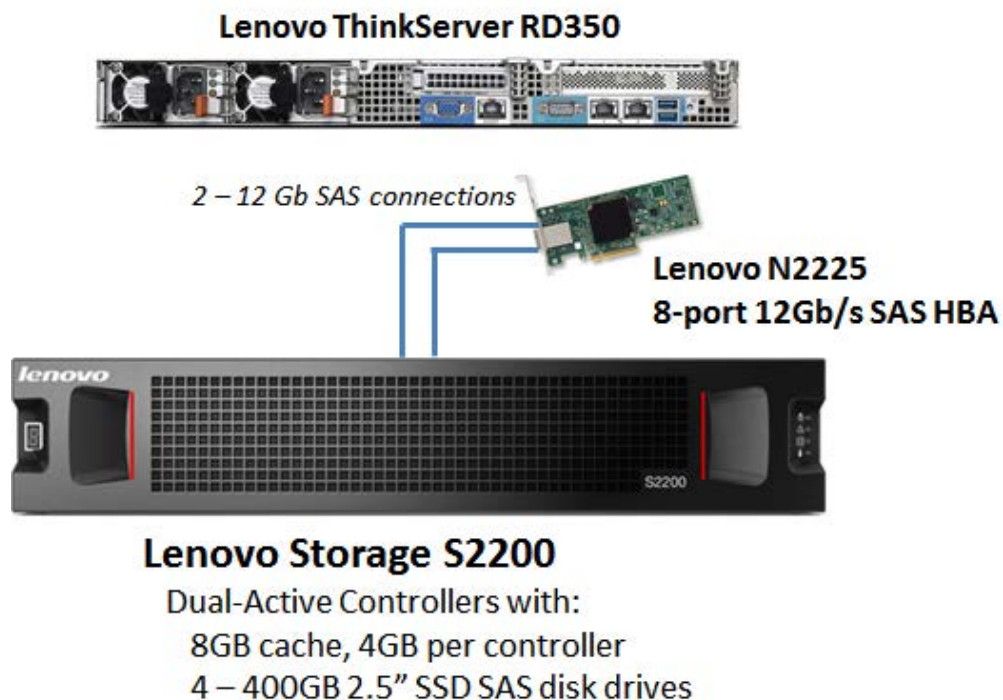
### **Host System(s) and Tested Storage Configuration (TSC) Table of Components**

#### *Clause 9.4.3.4.3*

*The FDR will contain a table that lists the major components of each Host System and the Tested Storage Configuration (TSC).*

The Host System(s) and TSC table of components may be found on page [20 \(Host System and Tested Storage Configuration Components\)](#).

### Benchmark Configuration/Tested Storage Configuration Diagram



### Host System and Tested Storage Configuration Components

<b>Host System</b>
<p><b>1 – Lenovo ThinkServer RD350</b>, each with:</p> <ul style="list-style-type: none"> <li>2 – Intel® Xeon® 2.4 GHz processor E5-2620 v3 each with 6 cores, 15 MB SmartCache</li> <li>64 GB main memory</li> <li>Windows Server 2008R2 SP1</li> <li>PCIe</li> </ul>
<b>Tested Storage Configuration</b>
<p>1 – Lenovo N2225 8-port, 12 Gb SAS HBA</p> <p><b>Lenovo Storage S2200</b></p> <ul style="list-style-type: none"> <li>2U24 Controller Enclosure</li> <li>Dual-Active Controllers</li> <li>each controller includes: <ul style="list-style-type: none"> <li>4 GB cache (8 GB total)</li> <li>2 – 12 Gb SAS host ports (4 ports total and 2 ports used/1 port per controller)</li> <li>1 – 6 Gb SAS connection (4 lanes) (2 total, none used)</li> </ul> </li> <li>4 – 400 GB SSDs</li> </ul>

## Customer Tunable Parameters and Options

### Clause 9.4.3.5.1

All Benchmark Configuration (BC) components with customer tunable parameter and options that have been altered from their default values must be listed in the FDR. The FDR entry for each of those components must include both the name of the component and the altered value of the parameter or option. If the parameter name is not self-explanatory to a knowledgeable practitioner, a brief description of the parameter's use must also be included in the FDR entry.

[Appendix B: Customer Tunable Parameters and Options](#) on page 66 contains the customer tunable parameters and options that have been altered from their default values for this benchmark.

## Tested Storage Configuration (TSC) Description

### Clause 9.4.3.5.2

The FDR must include sufficient information to recreate the logical representation of the TSC. In addition to customer tunable parameters and options (Clause 4.2.4.5.3), that information must include, at a minimum:

- A diagram and/or description of the following:
  - All physical components that comprise the TSC. Those components are also illustrated in the BC Configuration Diagram in Clause 9.2.4.4.1 and/or the Storage Network Configuration Diagram in Clause 9.2.4.4.2.
  - The logical representation of the TSC, configured from the above components that will be presented to the Workload Generator.
- Listings of scripts used to create the logical representation of the TSC.
- If scripts were not used, a description of the process used with sufficient detail to recreate the logical representation of the TSC.

[Appendix C: Tested Storage Configuration \(TSC\) Creation](#) on page 67 contains the detailed information that describes how to create and configure the logical TSC.

## SPC-1 Workload Generator Storage Configuration

### Clause 9.4.3.5.3

The FDR must include all SPC-1 Workload Generator storage configuration commands and parameters.

The SPC-1 Workload Generator storage configuration commands and parameters for this measurement appear in [Appendix D: SPC-1 Workload Generator Storage Commands and Parameters](#) on page 74.

## ASU Pre-Fill

### Clause 5.3.3

*Each of the three SPC-1 ASUs (ASU-1, ASU-2 and ASU-3) is required to be completely filled with specified content prior to the execution of audited SPC-1 Tests. The content is required to consist of random data pattern such as that produced by an SPC recommended tool.*

The configuration file used to complete the required ASU pre-fill appears in [Appendix D: SPC-1 Workload Generator Storage Commands and Parameters](#) on page 74.

## SPC-1 DATA REPOSITORY

This portion of the Full Disclosure Report presents the detailed information that fully documents the various SPC-1 storage capacities and mappings used in the Tested Storage Configuration. [SPC-1 Data Repository Definitions](#) on page [62](#) contains definitions of terms specific to the SPC-1 Data Repository.

### Storage Capacities and Relationships

#### Clause 9.4.3.6.1

*Two tables and four charts documenting the storage capacities and relationships of the SPC-1 Storage Hierarchy (Clause 2.1) shall be included in the FDR. ... The capacity value in each chart may be listed as an integer value, for readability, rather than the decimal value listed in the table below.*

#### SPC-1 Storage Capacities

The Physical Storage Capacity consisted of 1,600.354 GB distributed over 4 solid state drives (SSDs) each with a formatted capacity of 400.088 GB. There was 10.260 GB (0.64%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 0,000 GB (0.00%) of the Physical Storage Capacity. There was 78.152 GB (4.91%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100.00% of the Addressable Storage Capacity resulting in 0.000 GB (0.00%) of Unused Storage within the Addressable Storage Capacity. The Data Protection (*Mirroring*) capacity was 795.047 GB of which 755.971 GB was utilized. The total Unused Storage capacity was 88.412 GB.

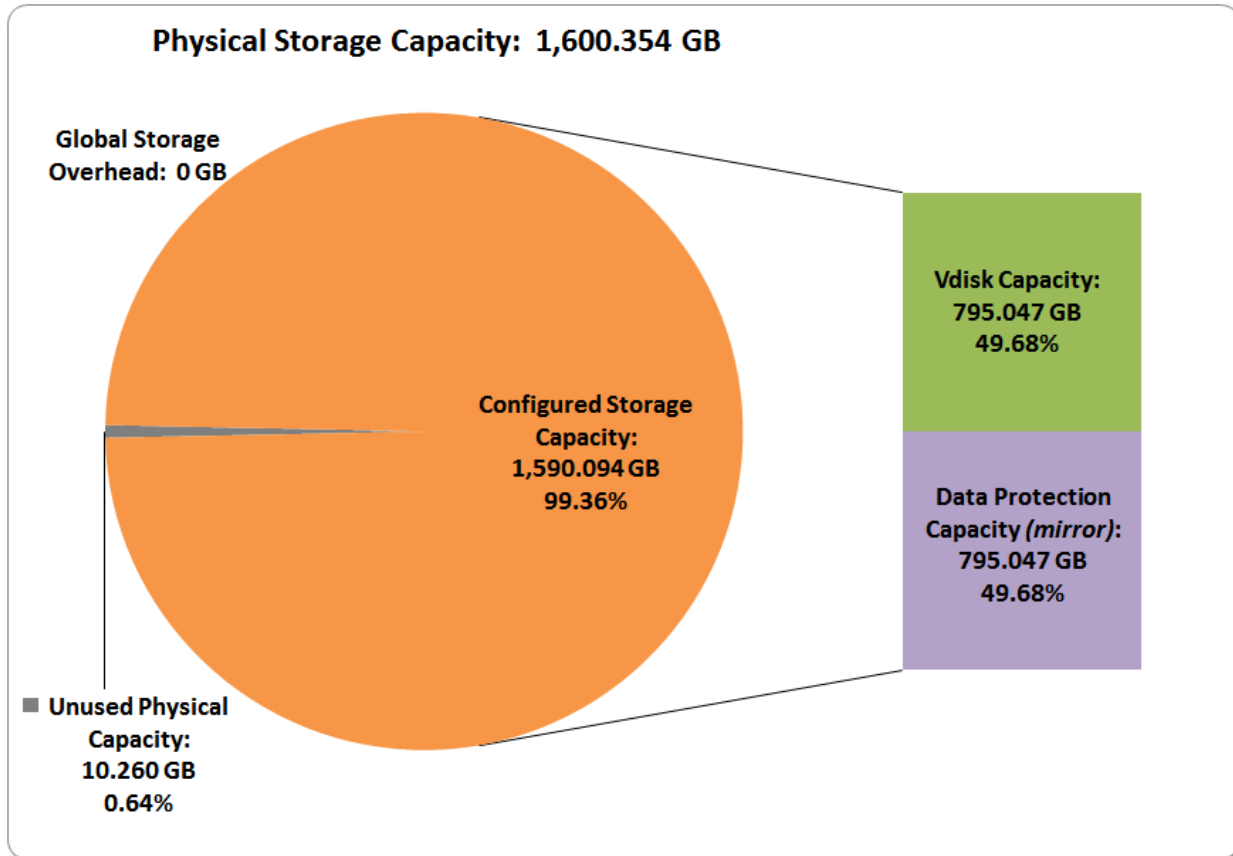
*Note: The configured Storage Devices may include additional storage capacity reserved for system overhead, which is not accessible for application use. That storage capacity may not be included in the value presented for Physical Storage Capacity.*

SPC-1 Storage Capacities		
Storage Hierarchy Component	Units	Capacity
Total ASU Capacity	Gigabytes (GB)	755.971
Addressable Storage Capacity	Gigabytes (GB)	755.971
Configured Storage Capacity	Gigabytes (GB)	1,590.094
Physical Storage Capacity	Gigabytes (GB)	1,600.354
Data Protection ( <i>Mirroring</i> )	Gigabytes (GB)	795.047
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	0.000
Total Unused Storage	Gigabytes (GB)	88.412

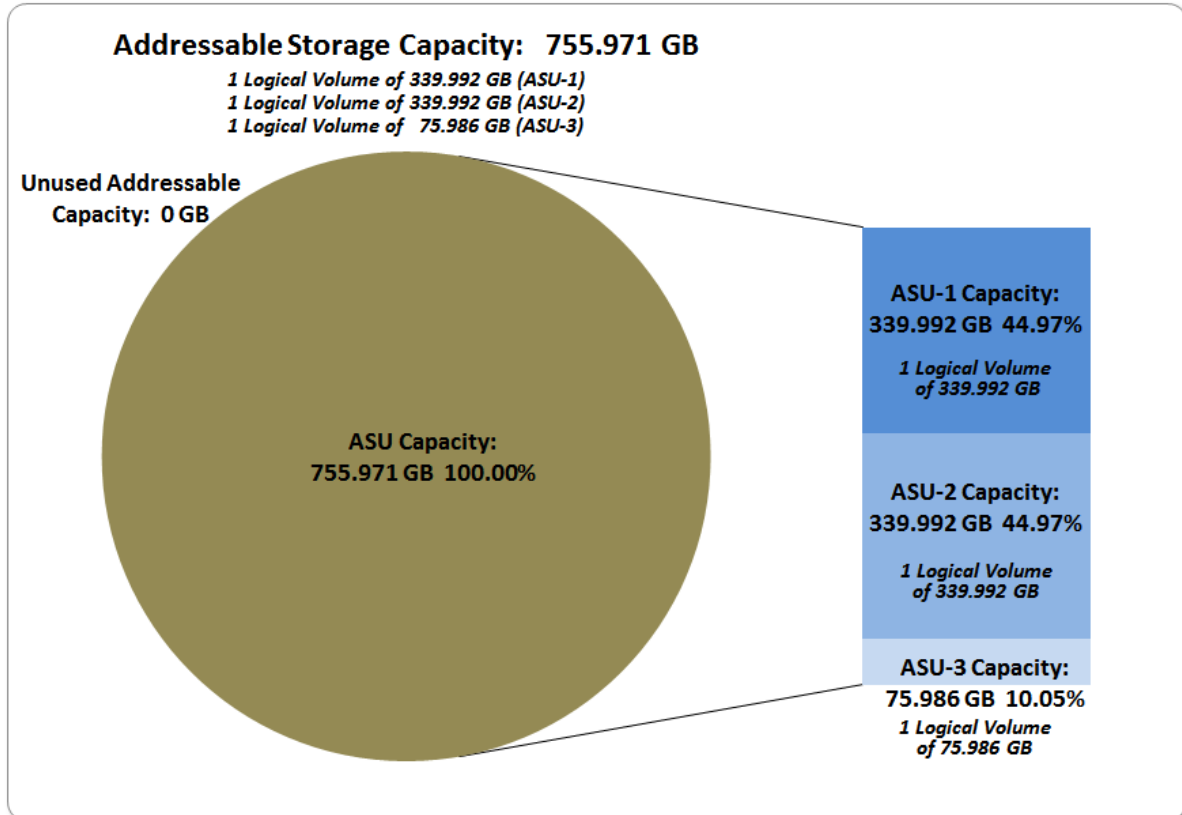
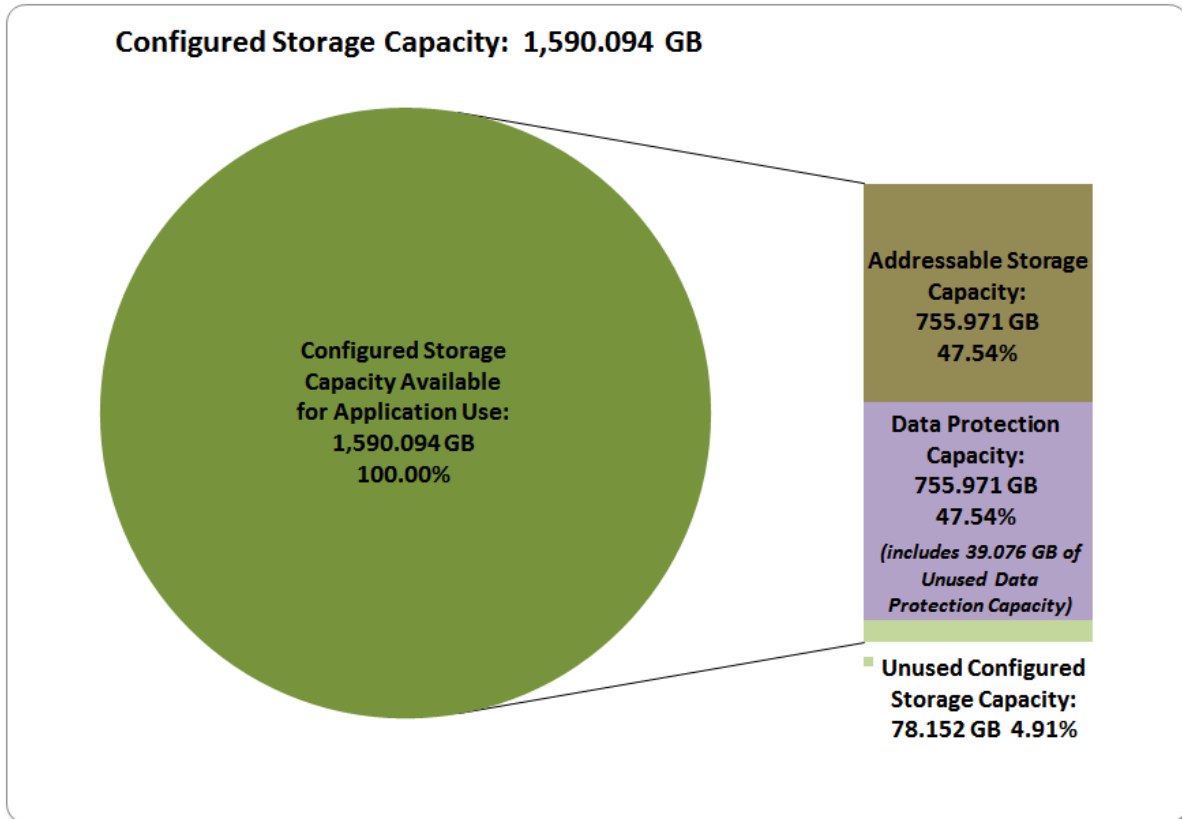
**SPC-1 Storage Hierarchy Ratios**

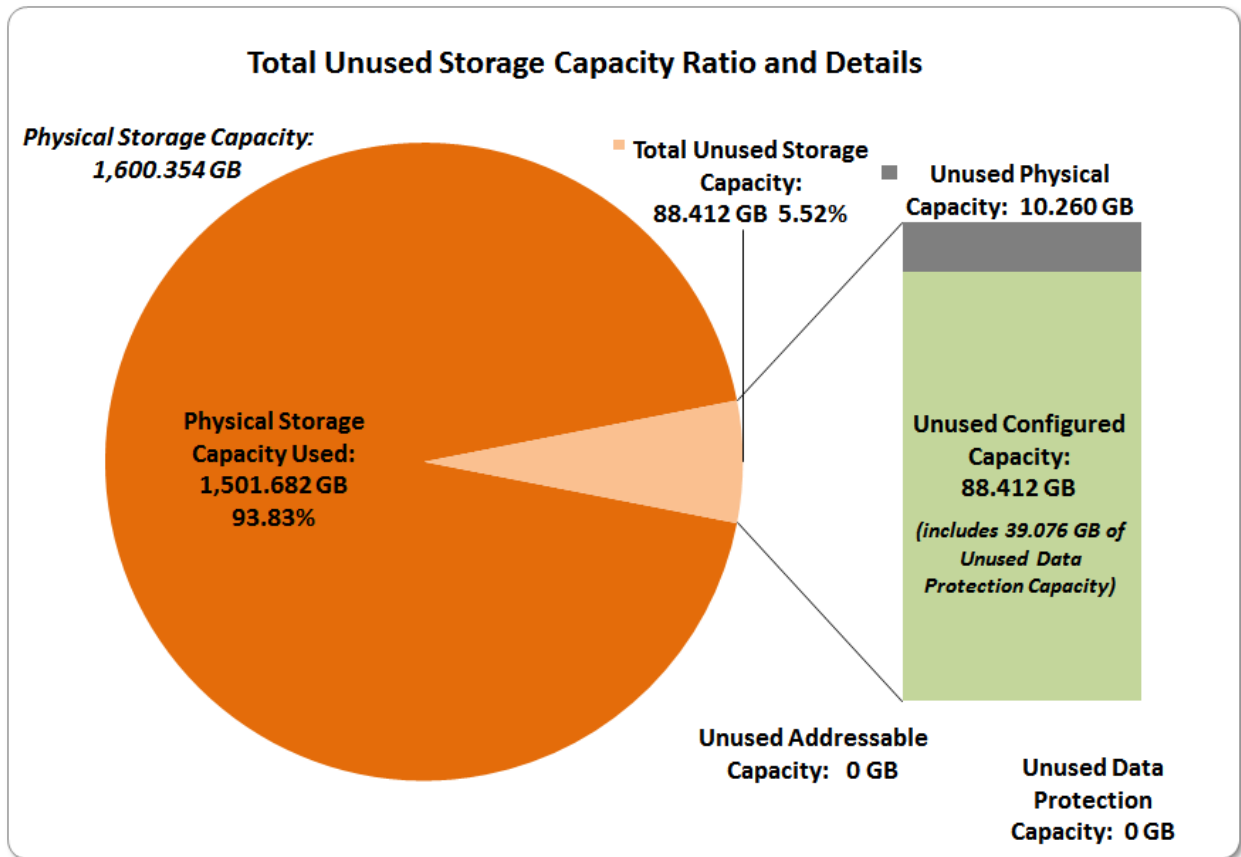
	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	47.54%	47.25%
Required for Data Protection ( <i>Mirroring</i> )		50.00%	49.68%
Addressable Storage Capacity		47.54%	47.24%
Required Storage		0.00%	0.00%
Configured Storage Capacity			99.36%
Global Storage Overhead			0.00%
Unused Storage:			
Addressable	0.00%		
Configured		4.91%	
Physical			0.64%

**SPC-1 Storage Capacity Charts**









## Storage Capacity Utilization

### Clause 9.4.3.6.2

The FDR will include a table illustrating the storage capacity utilization values defined for Application Utilization (Clause 2.8.1), Protected Application Utilization (Clause 2.8.2), and Unused Storage Ratio (Clause 2.8.3).

### Clause 2.8.1

Application Utilization is defined as Total ASU Capacity divided by Physical Storage Capacity.

### Clause 2.8.2

Protected Application Utilization is defined as (Total ASU Capacity plus total Data Protection Capacity minus unused Data Protection Capacity) divided by Physical Storage Capacity.

### Clause 2.8.3

Unused Storage Ratio is defined as Total Unused Capacity divided by Physical Storage Capacity and may not exceed 45%.

SPC-1 Storage Capacity Utilization	
Application Utilization	47.24%
Protected Application Utilization	94.48%
Unused Storage Ratio	5.52%

## Logical Volume Capacity and ASU Mapping

### Clause 9.4.3.6.3

A table illustrating the capacity of each ASU and the mapping of Logical Volumes to ASUs shall be provided in the FDR. ... Logical Volumes shall be sequenced in the table from top to bottom per its position in the contiguous address space of each ASU. The capacity of each Logical Volume shall be stated. ... In conjunction with this table, the Test Sponsor shall provide a complete description of the type of data protection (see Clause 2.4.5) used on each Logical Volume.

<b>Logical Volume Capacity and Mapping</b>
<b>ASU-1 (339.992 GB)</b>
1 Logical Volume 339.992 GB per Logical Volume (339.992 GB used per Logical Volume)
<b>ASU-2 (339.992 GB)</b>
1 Logical Volume 339.992 GB per Logical Volume (339.992 GB used per Logical Volume)
<b>ASU-3 (75.986 GB)</b>
1 Logical Volume 75.986 GB per Logical Volume (75.986 GB used per Logical Volume)

The Data Protection Level used for all Logical Volumes was [Protected 1](#) using *Mirroring* as described on page [12](#). See “ASU Configuration” in the [IOPS Test Results File](#) for more detailed configuration information.

## **SPC-1 BENCHMARK EXECUTION RESULTS**

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs. An [SPC-1 glossary](#) on page 62 contains definitions of terms specific to the SPC-1 Tests, Test Phases, and Test Runs.

### *Clause 5.4.3*

*The Tests must be executed in the following sequence: Primary Metrics, Repeatability, and Data Persistence. That required sequence must be uninterrupted from the start of Primary Metrics to the completion of Persistence Test Run 1. Uninterrupted means the Benchmark Configuration shall not be power cycled, restarted, disturbed, altered, or adjusted during the above measurement sequence. If the required sequence is interrupted other than for the Host System/TSC power cycle between the two Persistence Test Runs, the measurement is invalid.*

## **SPC-1 Tests, Test Phases, and Test Runs**

The SPC-1 benchmark consists of the following Tests, Test Phases, and Test Runs:

- **Primary Metrics Test**
  - Sustainability Test Phase and Test Run
  - IOPS Test Phase and Test Run
  - Response Time Ramp Test Phase
    - 95% of IOPS Test Run
    - 90% of IOPS Test Run
    - 80% of IOPS Test Run
    - 50% of IOPS Test Run
    - 10% of IOPS Test Run (LRT)
- **Repeatability Test**
  - Repeatability Test Phase 1
    - 10% of IOPS Test Run (LRT)
    - IOPS Test Run
  - Repeatability Test Phase 2
    - 10% of IOPS Test Run (LRT)
    - IOPS Test Run
- **Data Persistence Test**
  - Data Persistence Test Run 1
  - Data Persistence Test Run 2

Each Test is an atomic unit that must be executed from start to finish before any other Test, Test Phase, or Test Run may be executed.

The results from each Test, Test Phase, and Test Run are listed below along with a more detailed explanation of each component.

## “Ramp-Up” Test Runs

### Clause 5.3.13

*In order to warm-up caches or perform the initial ASU data migration in a multi-tier configuration, a Test Sponsor may perform a series of “Ramp-Up” Test Runs as a substitute for an initial, gradual Ramp-Up.*

### Clause 5.3.13.3

*The “Ramp-Up” Test Runs will immediately precede the Primary Metrics Test as part of the uninterrupted SPC-1 measurement sequence.*

### Clause 9.4.3.7.1

*If a series of “Ramp-Up” Test Runs were included in the SPC-1 measurement sequence, the FDR shall report the duration (ramp-up and measurement interval), BSU level, SPC-1 IOPS and average response time for each “Ramp-Up” Test Run in an appropriate table.*

There were no “Ramp-Up” Test Runs executed.

## Primary Metrics Test – Sustainability Test Phase

### Clause 5.4.4.1.1

*The Sustainability Test Phase has exactly one Test Run and shall demonstrate the maximum sustainable I/O Request Throughput within at least a continuous eight (8) hour Measurement Interval. This Test Phase also serves to insure that the TSC has reached Steady State prior to reporting the final maximum I/O Request Throughput result (SPC-1 IOPS™).*

### Clause 5.4.4.1.2

*The computed I/O Request Throughput of the Sustainability Test must be within 5% of the reported SPC-1 IOPS™ result.*

### Clause 5.4.4.1.4

*The Average Response Time, as defined in Clause 5.1.1, will be computed and reported for the Sustainability Test Run and cannot exceed 30 milliseconds. If the Average Response time exceeds that 30-milliseconds constraint, the measurement is invalid.*

### Clause 9.4.3.7.2

*For the Sustainability Test Phase the FDR shall contain:*

- 1. A Data Rate Distribution graph and data table.*
- 2. I/O Request Throughput Distribution graph and data table.*
- 3. A Response Time Frequency Distribution graph and table.*
- 4. An Average Response Time Distribution graph and table.*
- 5. The human readable Test Run Results File produced by the Workload Generator (may be included in an appendix).*
- 6. A listing or screen image of all input parameters supplied to the Workload Generator (may be included in an appendix).*
- 7. The Measured Intensity Multiplier for each I/O stream.*
- 8. The variability of the Measured Intensity Multiplier, as defined in Clause 5.3.13.3.*

### SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page 75.

### Sustainability Test Results File

A link to the test results file generated from the Sustainability Test Run is listed below.

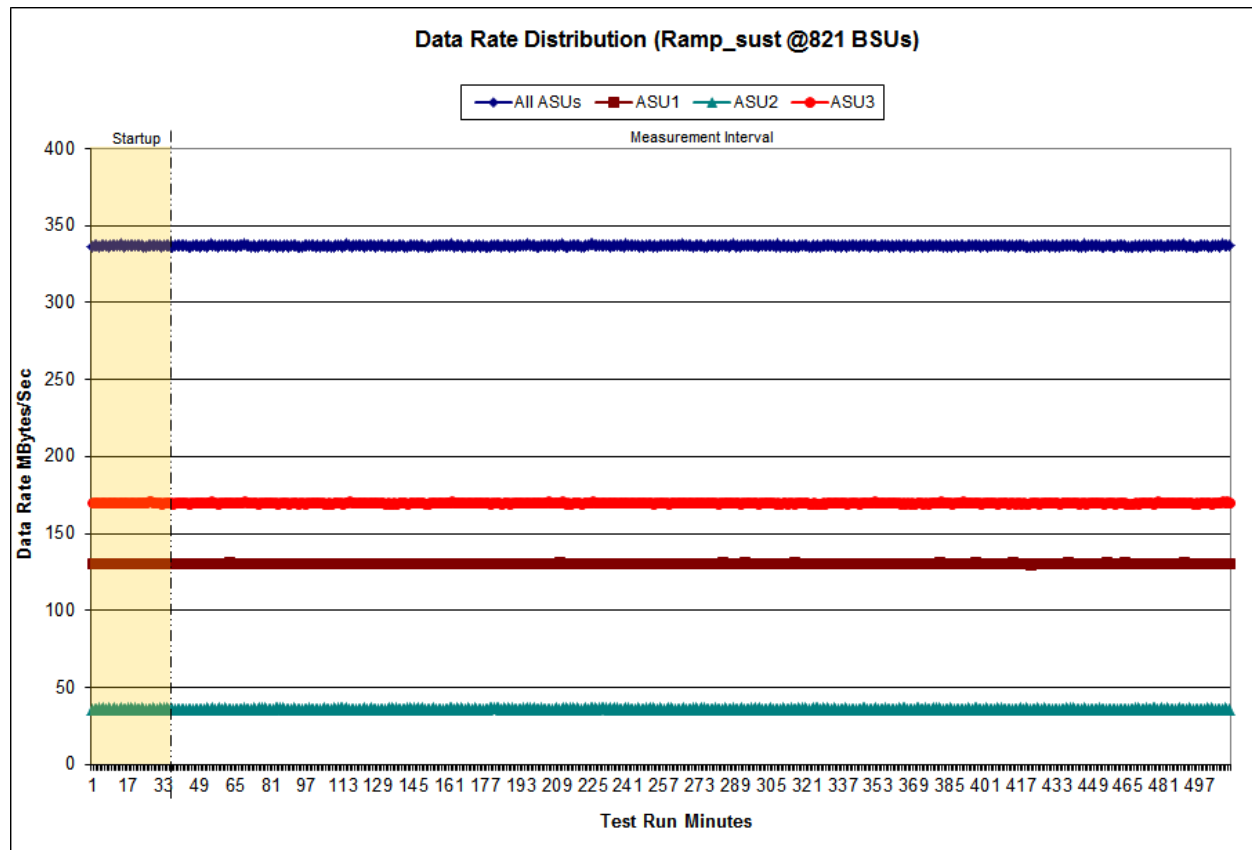
[Sustainability Test Results File](#)

### Sustainability – Data Rate Distribution Data (MB/second)

The Sustainability Data Rate Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability Data Rate Distribution Data Table](#)

### Sustainability – Data Rate Distribution Graph

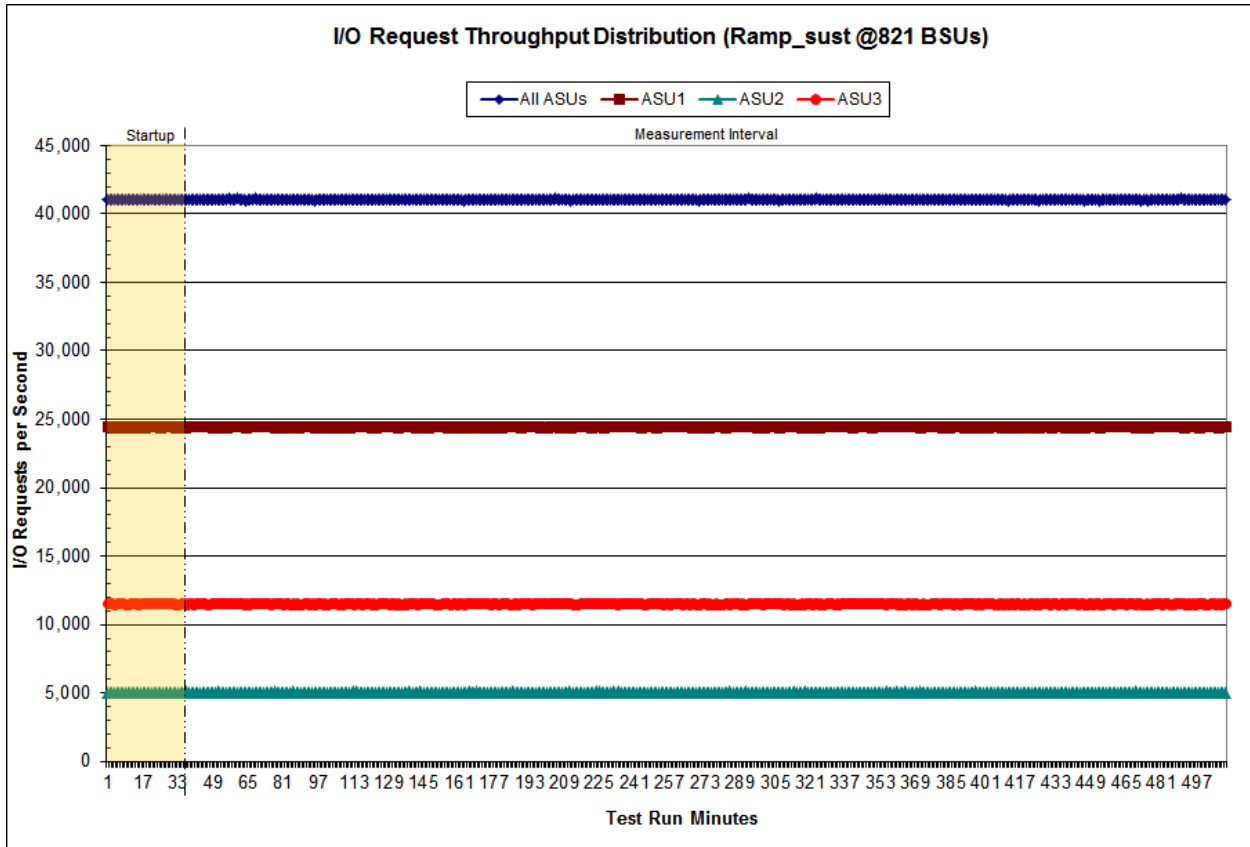


### Sustainability – I/O Request Throughput Distribution Data

The Sustainability I/O Request Throughput Data table is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability I/O Request Throughput Table](#)

### Sustainability – I/O Request Throughput Distribution Graph

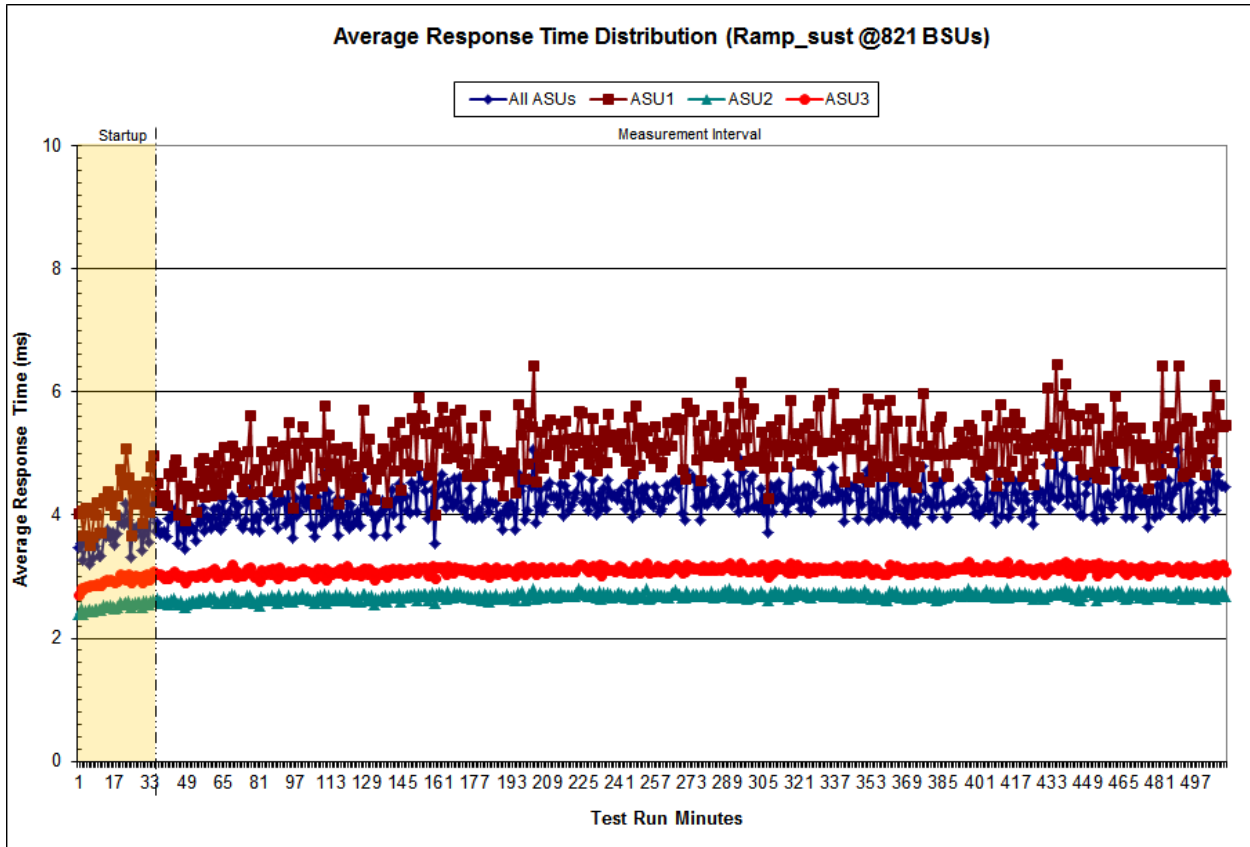


### Sustainability – Average Response Time (ms) Distribution Data

The Sustainability Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability Average Response Time Distribution Data Table](#)

### Sustainability – Average Response Time (ms) Distribution Graph



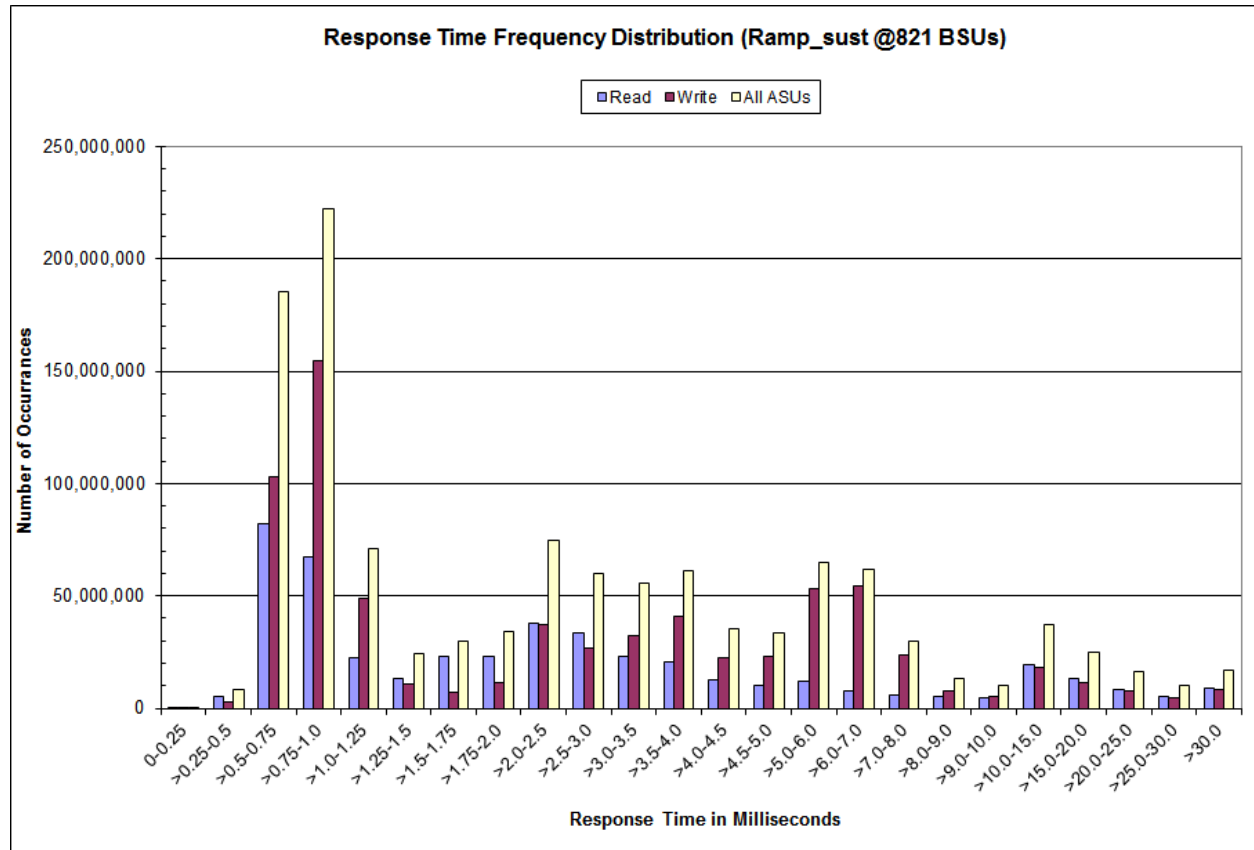


### Sustainability – Response Time Frequency Distribution Data

The Sustainability Response Time Frequency Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Sustainability Response Time Frequency Distribution Data Table](#)

### Sustainability – Response Time Frequency Distribution Graph



## Sustainability – Measured Intensity Multiplier and Coefficient of Variation

### Clause 3.4.3

**IM – Intensity Multiplier:** The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.

### Clauses 5.1.10 and 5.3.15.2

**MIM – Measured Intensity Multiplier:** The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.

### Clause 5.3.15.3

**COV – Coefficient of Variation:** This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.005	0.002	0.003	0.001

## Primary Metrics Test – IOPS Test Phase

### Clause 5.4.4.2

*The IOPS Test Phase consists of one Test Run at the 100% load point with a Measurement Interval of ten (10) minutes. The IOPS Test Phase immediately follows the Sustainability Test Phase without any interruption or manual intervention.*

*The IOPS Test Run generates the SPC-1 IOPS™ primary metric, which is computed as the I/O Request Throughput for the Measurement Interval of the IOPS Test Run.*

*The Average Response Time is computed for the IOPS Test Run and cannot exceed 30 milliseconds. If the Average Response Time exceeds the 30 millisecond constraint, the measurement is invalid.*

### Clause 9.4.3.7.3

*For the IOPS Test Phase the FDR shall contain:*

- 1. I/O Request Throughput Distribution (data and graph).*
- 2. A Response Time Frequency Distribution.*
- 3. An Average Response Time Distribution.*
- 4. The human readable Test Run Results File produced by the Workload Generator.*
- 5. A listing or screen image of all input parameters supplied to the Workload Generator.*
- 6. The total number of I/O Requests completed in the Measurement Interval as well as the number of I/O Requests with a Response Time less than or equal to 30 milliseconds and the number of I/O Requests with a Response Time greater than 30 milliseconds.*

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [75](#).

## IOPS Test Results File

A link to the test results file generated from the IOPS Test Run is listed below.

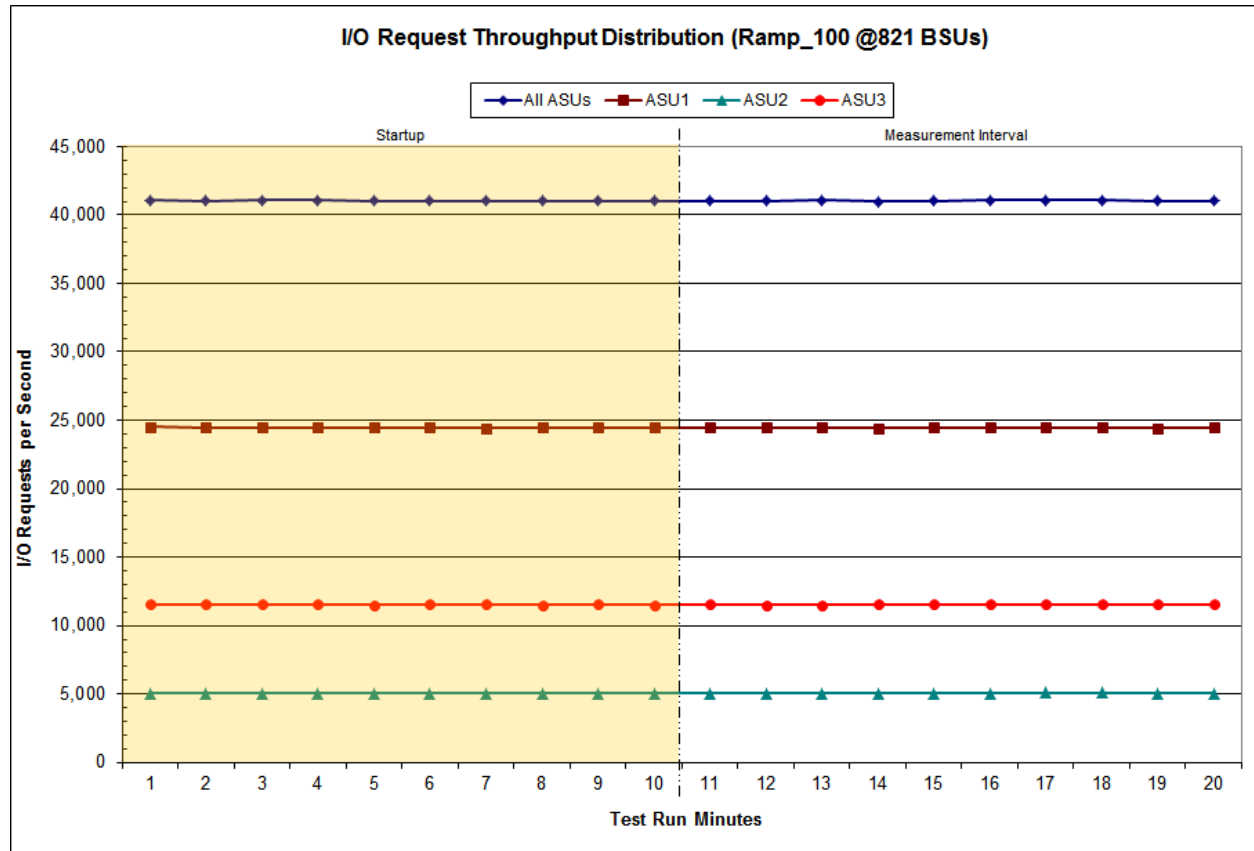
[IOPS Test Results File](#)

### IOPS Test Run – I/O Request Throughput Distribution Data

The I/O Request Throughput Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[I/O Request Throughput Distribution Data Table](#)

### IOPS Test Run – I/O Request Throughput Distribution Graph

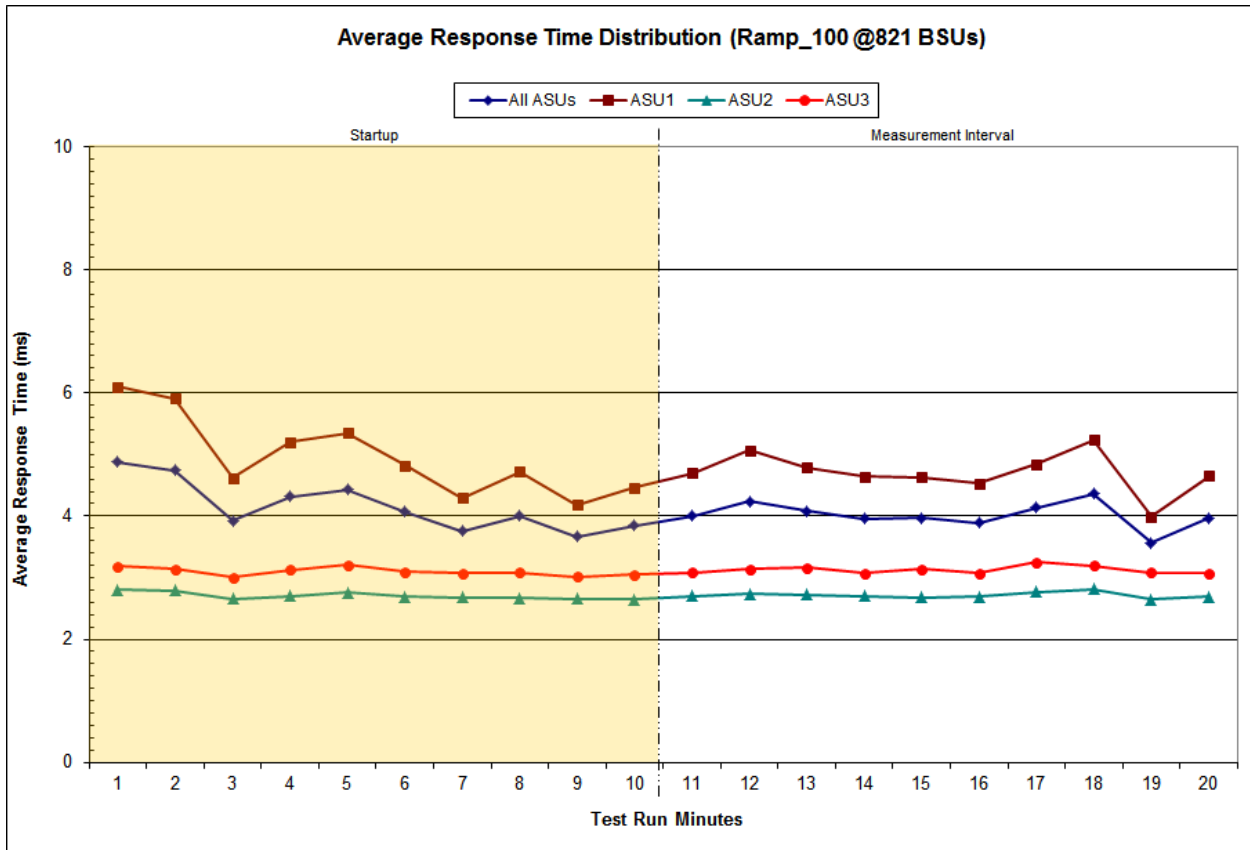


### IOPS Test Run – Average Response Time (ms) Distribution Data

The IOPS Test Run – Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[IOPS Test Run – Average Response Time \(ms\) Distribution Data Table](#)

### IOPS Test Run – Average Response Time (ms) Distribution Graph



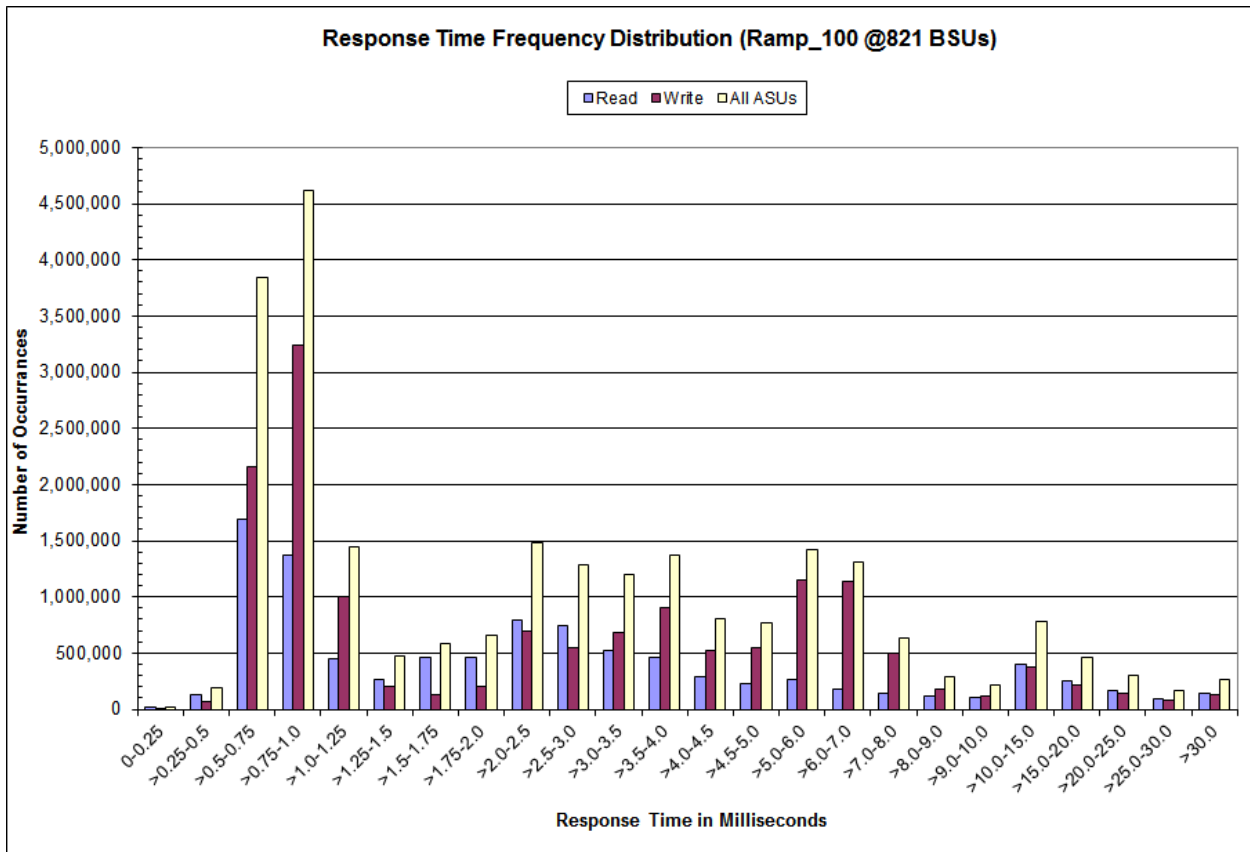
**IOPS Test Run –Response Time Frequency Distribution Data**

<b>Response Time (ms)</b>	<b>0-0.25</b>	<b>&gt;0.25-0.5</b>	<b>&gt;0.5-0.75</b>	<b>&gt;0.75-1.0</b>	<b>&gt;1.0-1.25</b>	<b>&gt;1.25-1.5</b>	<b>&gt;1.5-1.75</b>	<b>&gt;1.75-2.0</b>
Read	15,155	130,199	1,695,579	1,376,910	445,134	268,829	463,439	455,894
Write	424	63,924	2,152,248	3,245,796	1,005,703	206,860	125,833	201,690
All ASUs	15,579	194,123	3,847,827	4,622,706	1,450,837	475,689	589,272	657,584
ASU1	13,962	139,612	2,473,845	2,618,300	796,003	313,795	442,059	469,003
ASU2	1,312	23,711	480,906	553,890	167,190	61,980	87,119	92,517
ASU3	305	30,800	893,076	1,450,516	487,644	99,914	60,094	96,064
<b>Response Time (ms)</b>	<b>&gt;2.0-2.5</b>	<b>&gt;2.5-3.0</b>	<b>&gt;3.0-3.5</b>	<b>&gt;3.5-4.0</b>	<b>&gt;4.0-4.5</b>	<b>&gt;4.5-5.0</b>	<b>&gt;5.0-6.0</b>	<b>&gt;6.0-7.0</b>
Read	788,745	742,516	522,638	462,340	283,069	223,466	265,834	172,842
Write	695,041	542,721	680,891	905,117	523,713	541,214	1,151,727	1,142,617
All ASUs	1,483,786	1,285,237	1,203,529	1,367,457	806,782	764,680	1,417,561	1,315,459
ASU1	959,636	844,529	684,345	699,068	397,750	362,464	490,335	340,963
ASU2	194,944	183,731	191,267	223,787	152,996	131,817	209,125	177,105
ASU3	329,206	256,977	327,917	444,602	256,036	270,399	718,101	797,391
<b>Response Time (ms)</b>	<b>&gt;7.0-8.0</b>	<b>&gt;8.0-9.0</b>	<b>&gt;9.0-10.0</b>	<b>&gt;10.0-15.0</b>	<b>&gt;15.0-20.0</b>	<b>&gt;20.0-25.0</b>	<b>&gt;25.0-30.0</b>	<b>&gt;30.0</b>
Read	135,858	118,073	103,024	401,169	247,970	164,409	88,460	140,545
Write	499,379	175,254	117,574	373,747	216,086	139,103	82,930	126,139
All ASUs	635,237	293,327	220,598	774,916	464,056	303,512	171,390	266,684
ASU1	263,107	226,807	198,524	747,719	457,026	300,569	170,532	266,399
ASU2	66,515	12,276	3,968	7,356	4,314	2,876	842	285
ASU3	305,615	54,244	18,106	19,841	2,716	67	16	0

The IOPS Test Run –Response Time Frequency Distribution Data table is also available via the following URL:

[IOPS Test Run –Response Time Frequency Distribution Data Table](#)

**IOPS Test Run –Response Time Frequency Distribution Graph**



### IOPS Test Run – I/O Request Information

<b>I/O Requests Completed in the Measurement Interval</b>
24,627,828
<b>I/O Requests Completed with Response Time = or &lt; 30 ms</b>
24,361,144
<b>I/O Requests Completed with Response Time &gt; 30 ms</b>
266,684

### IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

Clause 3.4.3

**IM – Intensity Multiplier:** The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.

Clauses 5.1.10 and 5.3.15.2

**MIM – Measured Intensity Multiplier:** The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.

Clause 5.3.15.3

**COV – Coefficient of Variation:** This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2810	0.0700	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.005	0.002	0.003	0.001



## Primary Metrics Test – Response Time Ramp Test Phase

### Clause 5.4.4.3

*The Response Time Ramp Test Phase consists of five Test Runs, one each at 95%, 90%, 80%, 50%, and 10% of the load point (100%) used to generate the SPC-1 IOPS™ primary metric. Each of the five Test Runs has a Measurement Interval of ten (10) minutes. The Response Time Ramp Test Phase immediately follows the IOPS Test Phase without any interruption or manual intervention.*

*The five Response Time Ramp Test Runs, in conjunction with the IOPS Test Run (100%), demonstrate the relationship between Average Response Time and I/O Request Throughput for the Tested Storage Configuration (TSC) as illustrated in the response time/throughput curve on page 16.*

*In addition, the Average Response Time measured during the 10% Test Run is the value for the SPC-1 LRT™ metric. That value represents the Average Response Time of a lightly loaded TSC.*

### Clause 9.4.3.7.4

*The following content shall appear in the FDR for the Response Time Ramp Phase:*

- 1. A Response Time Ramp Distribution.*
- 2. The human readable Test Run Results File produced by the Workload Generator for each Test Run within the Response Time Ramp Test Phase.*
- 3. For the 10% Load Level Test Run (SPC-1 LRT™ metric) an Average Response Time Distribution.*
- 4. A listing or screen image of all input parameters supplied to the Workload Generator.*

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [75](#).

## Response Time Ramp Test Results File

A link to each test result file generated from each Response Time Ramp Test Run list listed below.

[95% Load Level](#)

[90% Load Level](#)

[80% Load Level](#)

[50% Load Level](#)

[10% Load Level](#)

### Response Time Ramp Distribution (IOPS) Data

The five Test Runs that comprise the Response Time Ramp Phase are executed at 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit (BSU) load level used to produce the SPC-1 IOPS™ primary metric. The 100% BSU load level is included in the following Response Time Ramp data table and graph for completeness.

100% Load Level:					95% Load Level:				
821 BSUs	Start	Stop	Interval	Duration	779 BSUs	Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	6:00:05	6:10:06	0-7	0:10:01	<b>Start-Up/Ramp-Up</b>	6:20:11	6:30:12	0-7	0:10:01
<b>Measurement Interval</b>	6:10:06	6:20:06	8-17	0:10:00	<b>Measurement Interval</b>	6:30:12	6:40:12	8-17	0:10:00
<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>
0	41,088.50	24,500.57	5,039.67	11,548.27	0	38,993.58	23,238.40	4,796.05	10,959.13
1	41,043.33	24,455.35	5,044.40	11,543.58	1	38,921.07	23,190.32	4,787.58	10,943.17
2	41,055.75	24,477.82	5,048.60	11,529.33	2	38,980.90	23,223.62	4,793.57	10,963.72
3	41,077.00	24,469.52	5,055.52	11,551.97	3	38,927.25	23,206.15	4,797.95	10,923.15
4	41,016.40	24,449.75	5,042.42	11,524.23	4	38,970.12	23,215.92	4,792.12	10,962.08
5	41,041.53	24,451.67	5,050.13	11,539.73	5	38,953.80	23,207.57	4,798.15	10,948.08
6	41,003.72	24,422.23	5,048.70	11,532.78	6	38,950.92	23,230.93	4,775.48	10,944.50
7	41,003.15	24,447.93	5,039.47	11,515.75	7	38,941.80	23,200.52	4,798.73	10,942.55
8	41,041.97	24,467.28	5,046.17	11,528.52	8	38,943.80	23,195.77	4,783.20	10,964.83
9	41,016.40	24,453.95	5,050.83	11,511.62	9	38,967.02	23,209.55	4,807.90	10,949.57
10	41,019.78	24,451.77	5,029.95	11,538.07	10	38,936.97	23,189.27	4,803.53	10,944.17
11	41,051.10	24,483.87	5,057.65	11,509.58	11	38,980.97	23,218.83	4,793.92	10,968.22
12	41,069.52	24,487.87	5,061.87	11,519.78	12	38,922.22	23,205.77	4,779.42	10,937.03
13	40,999.58	24,421.38	5,052.50	11,525.70	13	38,990.05	23,244.28	4,792.02	10,953.75
14	41,036.63	24,468.20	5,041.28	11,527.15	14	38,947.65	23,203.53	4,790.28	10,953.83
15	41,084.95	24,484.75	5,054.67	11,545.53	15	38,928.73	23,200.50	4,787.07	10,941.17
16	41,080.03	24,460.13	5,066.68	11,553.22	16	38,907.25	23,188.12	4,774.98	10,944.15
17	41,086.55	24,465.68	5,068.88	11,551.98	17	38,914.13	23,195.03	4,782.68	10,936.42
18	41,005.47	24,434.38	5,044.08	11,527.00	18	38,927.92	23,199.85	4,806.40	10,921.67
19	41,030.83	24,448.15	5,052.98	11,529.70	19	38,952.75	23,222.47	4,782.58	10,947.70
<b>Average</b>	<b>41,046.45</b>	<b>24,460.62</b>	<b>5,053.06</b>	<b>11,532.77</b>	<b>Average</b>	<b>38,940.86</b>	<b>23,206.77</b>	<b>4,789.29</b>	<b>10,944.81</b>
90% Load Level:					80% Load Level:				
738 BSUs	Start	Stop	Interval	Duration	656 BSUs	Start	Stop	Interval	Duration
<b>Start-Up/Ramp-Up</b>	6:40:16	23:13:21	0-7	16:33:05	<b>Start-Up/Ramp-Up</b>	7:00:21	7:10:22	0-7	0:10:01
<b>Measurement Interval</b>	23:13:21	23:13:21	8-17	0:00:00	<b>Measurement Interval</b>	7:10:22	7:20:22	8-17	0:10:00
<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>	<i>(60 second intervals)</i>	<b>All ASUs</b>	<b>ASU-1</b>	<b>ASU-2</b>	<b>ASU-3</b>
0	36,874.08	21,980.32	4,524.18	10,369.58	0	32,827.15	19,561.37	4,036.07	9,229.72
1	36,917.58	22,025.12	4,531.90	10,360.57	1	32,789.58	19,527.73	4,043.45	9,218.40
2	36,884.78	21,980.60	4,549.30	10,354.88	2	32,769.12	19,531.13	4,026.50	9,211.48
3	36,856.22	21,952.00	4,542.92	10,361.30	3	32,801.72	19,529.08	4,042.93	9,229.70
4	36,918.67	21,997.72	4,534.80	10,386.15	4	32,786.07	19,540.93	4,024.68	9,220.45
5	36,891.80	22,005.72	4,526.58	10,359.50	5	32,829.58	19,581.42	4,024.63	9,223.53
6	36,878.33	21,996.07	4,533.80	10,348.47	6	32,801.37	19,538.63	4,028.98	9,233.75
7	36,915.85	22,000.05	4,537.72	10,378.08	7	32,774.90	19,539.05	4,021.58	9,214.27
8	36,935.42	22,008.85	4,550.97	10,375.60	8	32,843.37	19,586.20	4,037.52	9,219.65
9	36,883.83	21,959.68	4,532.80	10,391.35	9	32,770.83	19,530.55	4,035.43	9,204.85
10	36,923.05	22,013.93	4,538.50	10,370.62	10	32,775.85	19,532.30	4,016.68	9,226.87
11	36,937.77	22,025.67	4,536.17	10,375.93	11	32,793.82	19,549.75	4,035.90	9,208.17
12	36,896.95	21,991.23	4,544.07	10,361.65	12	32,824.45	19,572.72	4,026.22	9,225.52
13	36,891.63	21,985.73	4,537.07	10,368.83	13	32,807.37	19,552.68	4,043.75	9,210.93
14	36,907.17	22,005.48	4,535.88	10,365.80	14	32,808.77	19,560.55	4,027.97	9,220.25
15	36,889.33	22,000.73	4,529.93	10,358.67	15	32,792.38	19,529.67	4,036.00	9,226.72
16	36,908.38	21,986.42	4,540.12	10,381.85	16	32,803.23	19,540.47	4,039.05	9,223.72
17	36,898.28	21,999.78	4,535.42	10,363.08	17	32,819.72	19,548.40	4,035.88	9,235.43
18	36,895.23	21,981.97	4,547.15	10,366.12	18	32,816.78	19,573.90	4,036.05	9,206.83
19	36,914.55	21,977.37	4,536.83	10,400.35	19	32,789.75	19,548.18	4,032.88	9,208.68
<b>Average</b>	<b>36,906.24</b>	<b>21,996.83</b>	<b>4,538.11</b>	<b>10,371.29</b>	<b>Average</b>	<b>32,803.21</b>	<b>19,550.86</b>	<b>4,033.04</b>	<b>9,219.31</b>

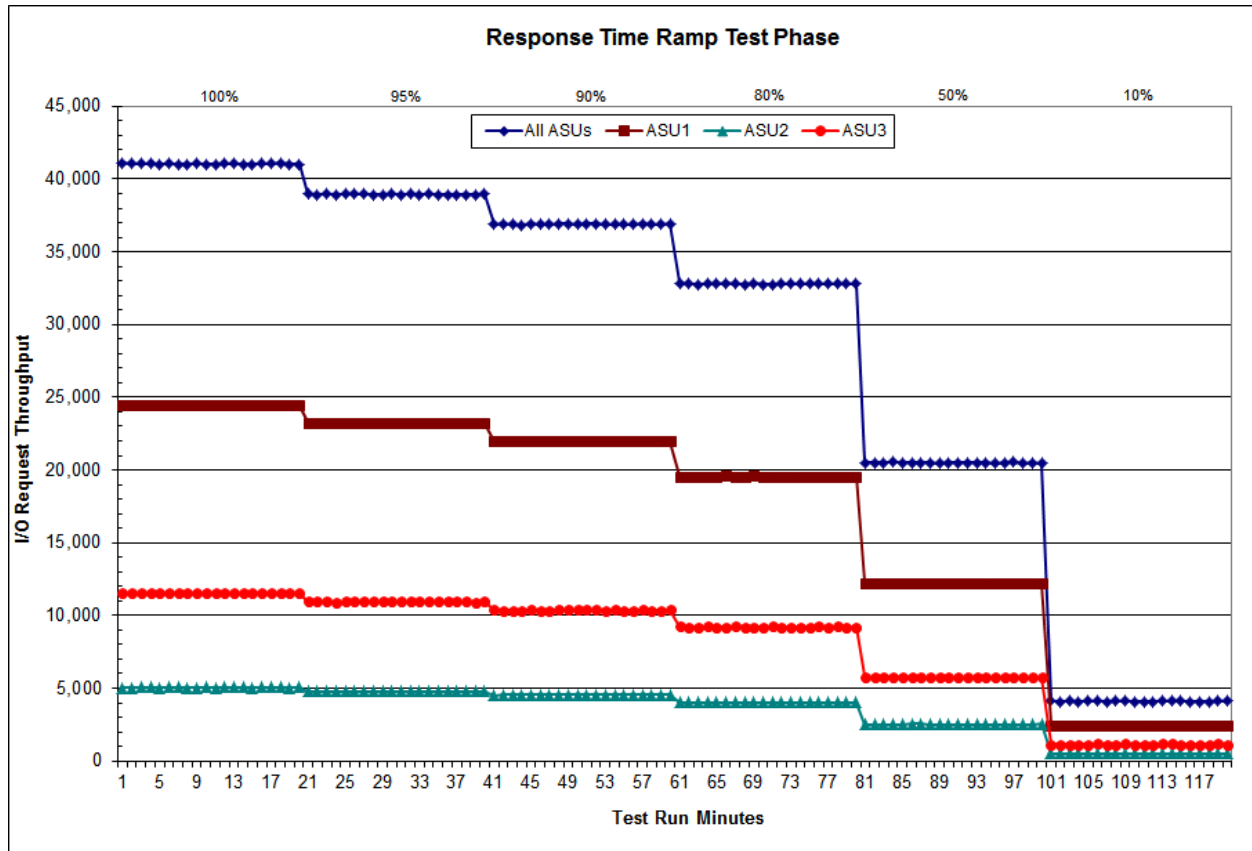
**Response Time Ramp Distribution (IOPS) Data (continued)**

50% Load Level: 410 BSUs					10% Load Level: 82 BSUs				
	Start	Stop	Interval	Duration		Start	Stop	Interval	Duration
Start-Up/Ramp-Up	7:20:26	7:30:27	0-7	0:10:01	Start-Up/Ramp-Up	7:40:30	7:50:31	0-7	0:10:01
Measurement Interval	7:30:27	7:40:27	8-17	0:10:00	Measurement Interval	7:50:31	8:00:31	8-17	0:10:00
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	20,521.38	12,228.32	2,523.50	5,769.57	0	4,099.17	2,439.98	509.78	1,149.40
1	20,509.82	12,228.93	2,530.85	5,750.03	1	4,094.55	2,437.17	505.22	1,152.17
2	20,518.65	12,218.08	2,519.92	5,780.65	2	4,113.72	2,453.10	507.02	1,153.60
3	20,553.98	12,257.30	2,521.88	5,774.80	3	4,097.88	2,442.18	505.80	1,149.90
4	20,498.65	12,209.63	2,518.38	5,770.63	4	4,105.35	2,452.82	506.15	1,146.38
5	20,520.23	12,220.97	2,534.80	5,764.47	5	4,111.85	2,451.35	505.20	1,155.30
6	20,515.65	12,226.88	2,533.75	5,755.02	6	4,094.83	2,442.50	505.25	1,147.08
7	20,511.65	12,229.08	2,522.62	5,759.95	7	4,104.32	2,444.43	505.58	1,154.30
8	20,469.53	12,211.38	2,514.17	5,743.98	8	4,106.82	2,443.25	502.63	1,160.93
9	20,489.57	12,210.75	2,527.32	5,751.50	9	4,085.82	2,428.67	506.78	1,150.37
10	20,526.78	12,246.50	2,520.65	5,759.63	10	4,094.38	2,436.23	508.43	1,149.72
11	20,499.30	12,224.27	2,523.33	5,751.70	11	4,078.92	2,432.08	503.50	1,143.33
12	20,500.33	12,213.33	2,522.53	5,764.47	12	4,102.45	2,437.47	506.08	1,158.90
13	20,513.17	12,226.33	2,525.18	5,761.65	13	4,110.63	2,449.85	505.90	1,154.88
14	20,470.35	12,193.30	2,520.45	5,756.60	14	4,102.32	2,449.90	502.47	1,149.95
15	20,488.70	12,208.42	2,518.67	5,761.62	15	4,097.73	2,446.63	504.35	1,146.75
16	20,536.52	12,249.83	2,520.10	5,766.58	16	4,091.08	2,439.77	503.15	1,148.17
17	20,466.83	12,191.32	2,516.08	5,759.43	17	4,091.58	2,433.72	509.05	1,148.82
18	20,486.78	12,211.50	2,515.38	5,759.90	18	4,099.35	2,437.22	503.02	1,159.12
19	20,473.28	12,191.73	2,534.05	5,747.50	19	4,112.85	2,454.82	506.08	1,151.95

In addition to appearing above, the Response Time Ramp Distribution (IOPS) Data table is available via the following URL.

[IOPS Test Run –Response Time Frequency Distribution Data Table](#)

### Response Time Ramp Distribution (IOPS) Graph

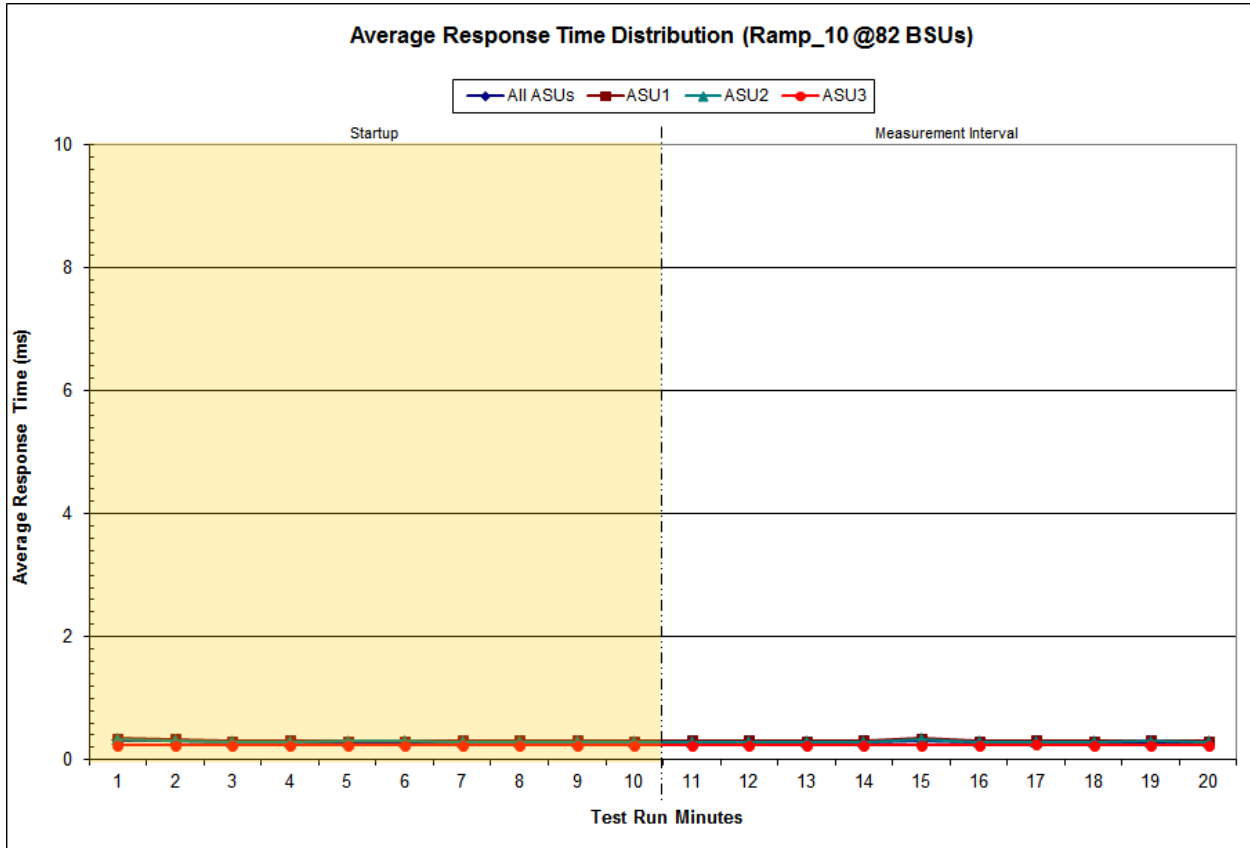


### SPC-1 LRT™ Average Response Time (ms) Distribution Data

The SPC-1 LRT™ Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[SPC-1 LRT™ Average Response Time Distribution Data Table](#)

### SPC-1 LRT™ Average Response Time (ms) Distribution Graph



**SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation**

Clause 3.4.3

**IM – Intensity Multiplier:** The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.

Clauses 5.1.10 and 5.3.15.2

**MIM – Measured Intensity Multiplier:** The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.

Clause 5.3.15.3

**COV – Coefficient of Variation:** This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
MIM	0.0349	0.2812	0.0698	0.2099	0.0180	0.0703	0.0349	0.2809
COV	0.012	0.004	0.006	0.003	0.014	0.004	0.011	0.003

## Repeatability Test

### Clause 5.4.5

*The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ primary metric and the SPC-1 LRT™ metric generated in earlier Test Runs.*

*There are two identical Repeatability Test Phases. Each Test Phase contains two Test Runs. Each of the Test Runs will have a Measurement Interval of no less than ten (10) minutes. The two Test Runs in each Test Phase will be executed without interruption or any type of manual intervention.*

*The first Test Run in each Test Phase is executed at the 10% load point. The Average Response Time from each of the Test Runs is compared to the SPC-1 LRT™ metric. Each Average Response Time value must be less than the SPC-1 LRT™ metric plus 5% or less than the SPC-1 LRT™ metric plus one (1) millisecond (ms).*

*The second Test Run in each Test Phase is executed at the 100% load point. The I/O Request Throughput from the Test Runs is compared to the SPC-1 IOPS™ primary metric. Each I/O Request Throughput value must be greater than the SPC-1 IOPS™ primary metric minus 5%. In addition, the Average Response Time for each Test Run cannot exceed 30 milliseconds.*

*If any of the above constraints are not met, the benchmark measurement is invalid.*

### Clause 9.4.3.7.5

*The following content shall appear in the FDR for each Test Run in the two Repeatability Test Phases:*

- 1. A table containing the results of the Repeatability Test.*
- 2. An I/O Request Throughput Distribution graph and table.*
- 3. An Average Response Time Distribution graph and table.*
- 4. The human readable Test Run Results File produced by the Workload Generator.*
- 5. A listing or screen image of all input parameters supplied to the Workload Generator.*

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [75](#).

### Repeatability Test Results File

The values for the SPC-1 IOPS™, SPC-1 LRT™, and the Repeatability Test measurements are listed in the tables below.

	SPC-1 IOPS™
<b>Primary Metrics</b>	<b>41,046.45</b>
<b>Repeatability Test Phase 1</b>	41,038.54
<b>Repeatability Test Phase 2</b>	41,052.58

The SPC-1 IOPS™ values in the above table were generated using 100% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 IOPS™ must be greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
<b>Primary Metrics</b>	<b>0.29</b>
<b>Repeatability Test Phase 1</b>	0.29
<b>Repeatability Test Phase 2</b>	0.29

The average response time values in the SPC-1 LRT™ column were generated using 10% of the specified Business Scaling Unit (BSU) load level. Each of the Repeatability Test Phase values for SPC-1 LRT™ must be less than 105% of the reported SPC-1 LRT™ Primary Metric or less than the reported SPC-1 LRT™ Primary Metric plus one (1) millisecond (ms).

A link to the test result file generated from each Repeatability Test Run is listed below.

[Repeatability Test Phase 1, Test Run 1 \(LRT\)](#)

[Repeatability Test Phase 1, Test Run 2 \(IOPS\)](#)

[Repeatability Test Phase 2, Test Run 1 \(LRT\)](#)

[Repeatability Test Phase 2, Test Run 2 \(IOPS\)](#)

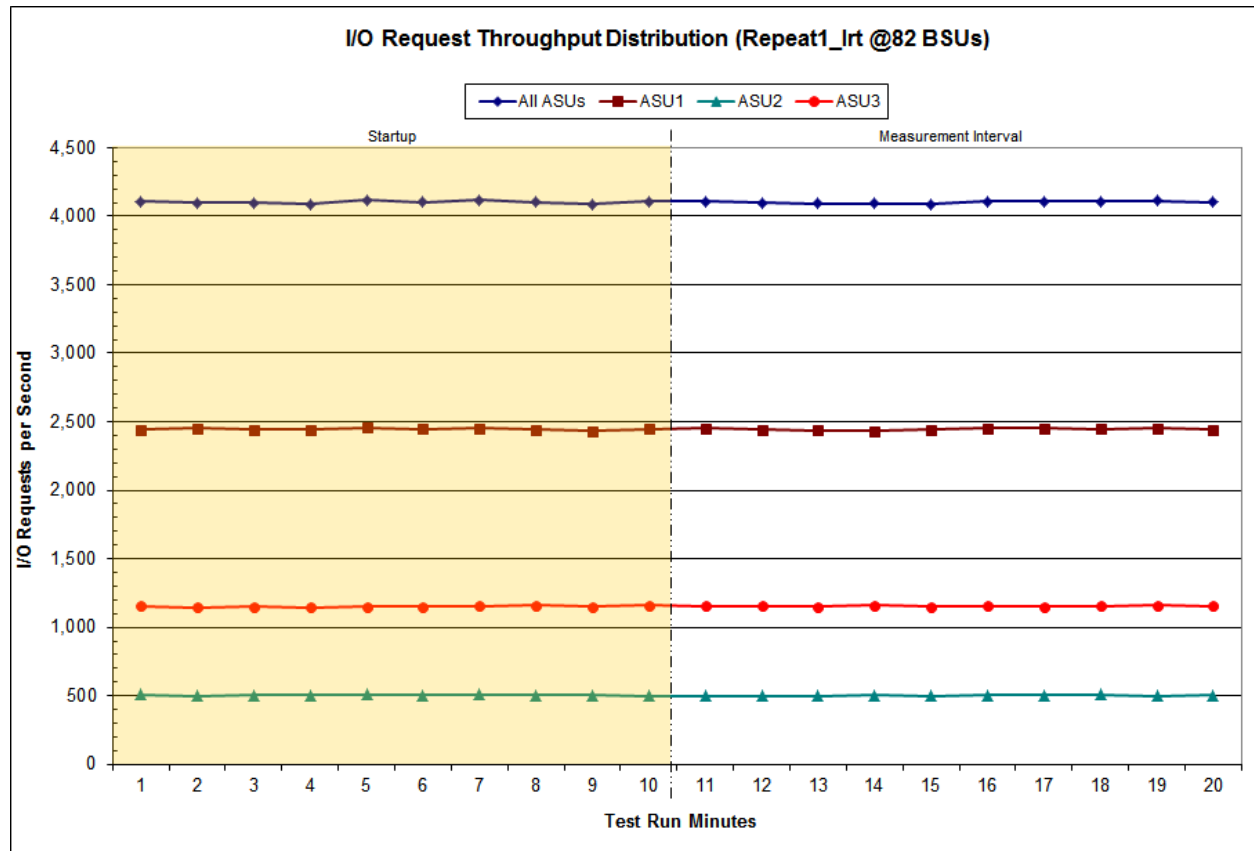


### Repeatability 1 LRT – I/O Request Throughput Distribution Data

The Repeatability 1 LRT – I/O Request Throughput Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 1 LRT – I/O Request Throughput Distribution Data Table](#)

### Repeatability 1 LRT – I/O Request Throughput Distribution Graph

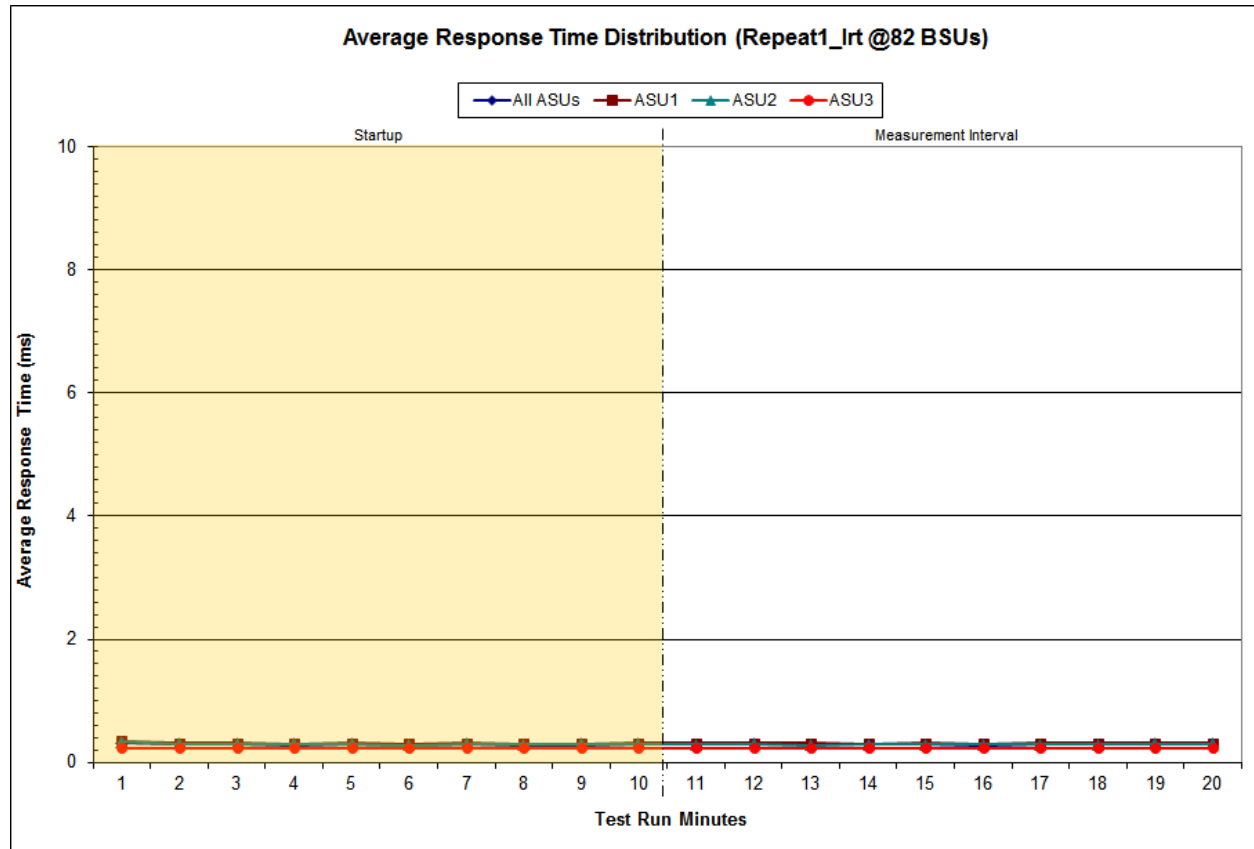


### Repeatability 1 LRT –Average Response Time (ms) Distribution Data

The Repeatability 1 LRT – Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 1 LRT – Average Response Time Distribution Data Table](#)

### Repeatability 1 LRT –Average Response Time (ms) Distribution Graph

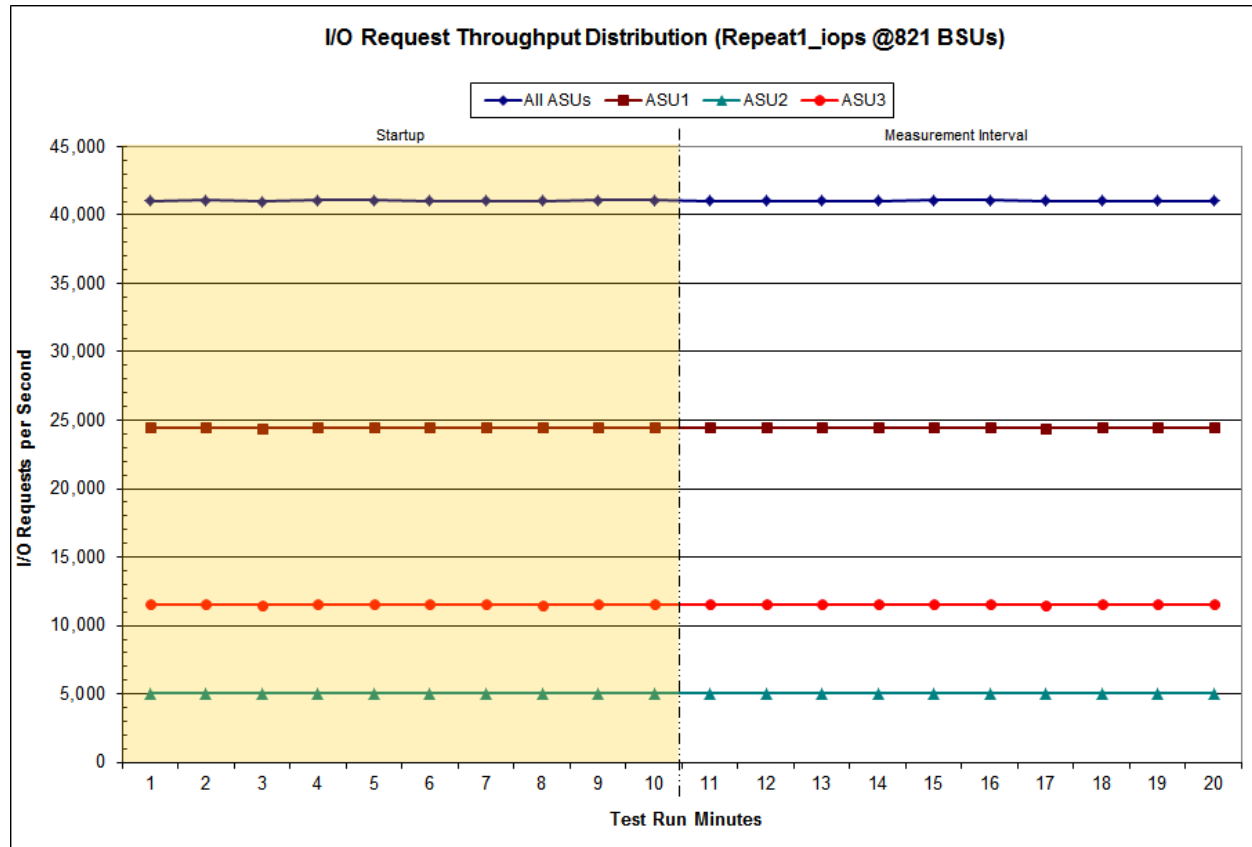


### Repeatability 1 IOPS – I/O Request Throughput Distribution Data

The Repeatability 1 IOPS – I/O Request Throughput Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 1 IOPS – I/O Request Throughput Distribution Data Table](#)

### Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

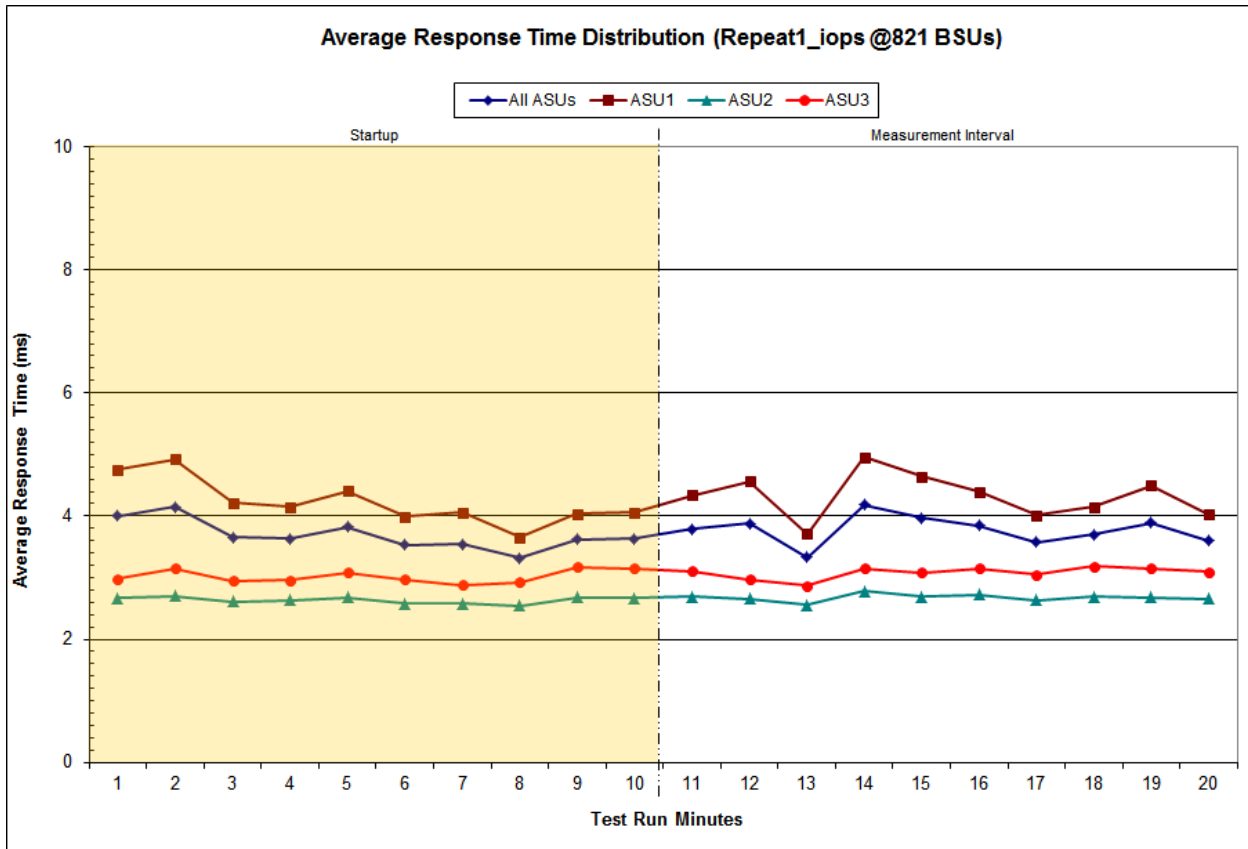


### Repeatability 1 IOPS –Average Response Time (ms) Distribution Data

The Repeatability 1 IOPS – Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 1 IOPS – Average Response Time Distribution Data Table](#)

### Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph

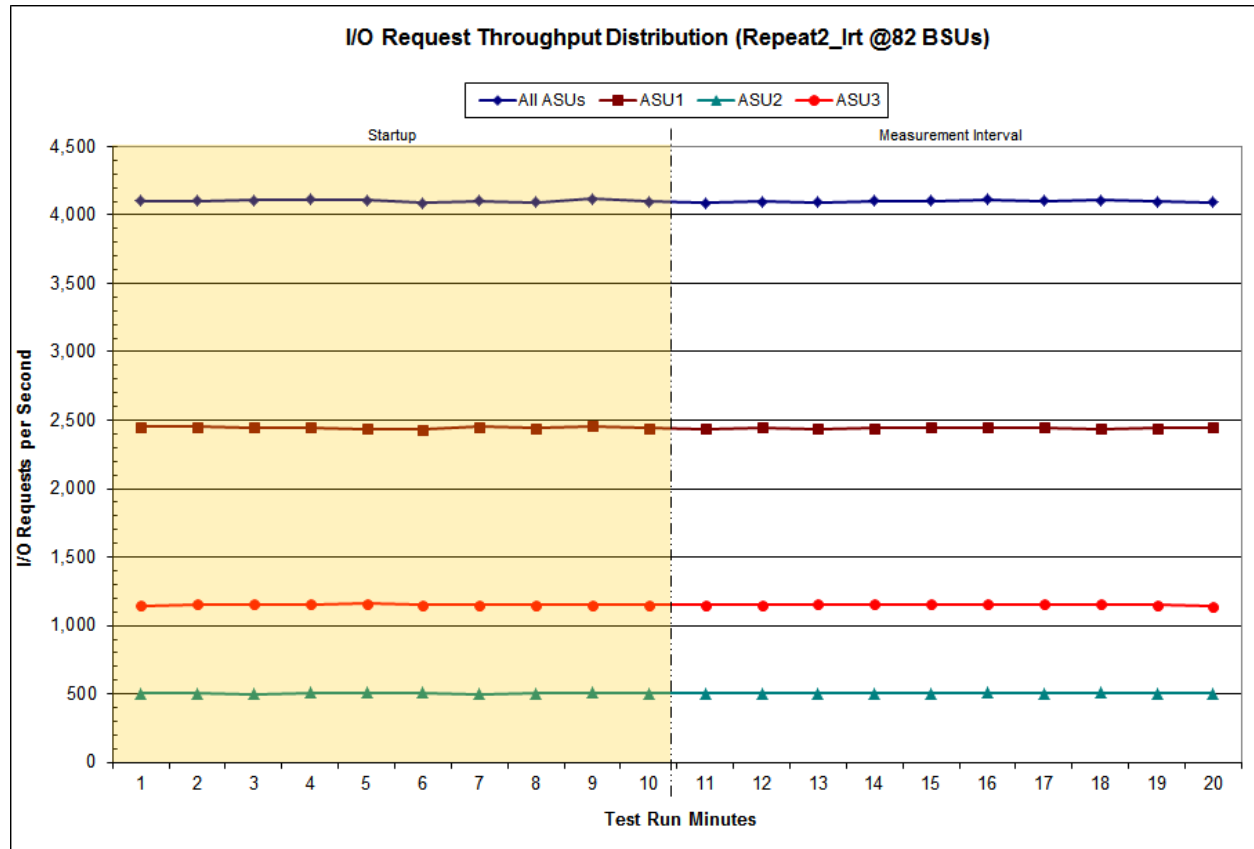


### Repeatability 2 LRT – I/O Request Throughput Distribution Data

The Repeatability 2 LRT – I/O Request Throughput Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 2 LRT – I/O Request Throughput Distribution Data Table](#)

### Repeatability 2 LRT – I/O Request Throughput Distribution Graph

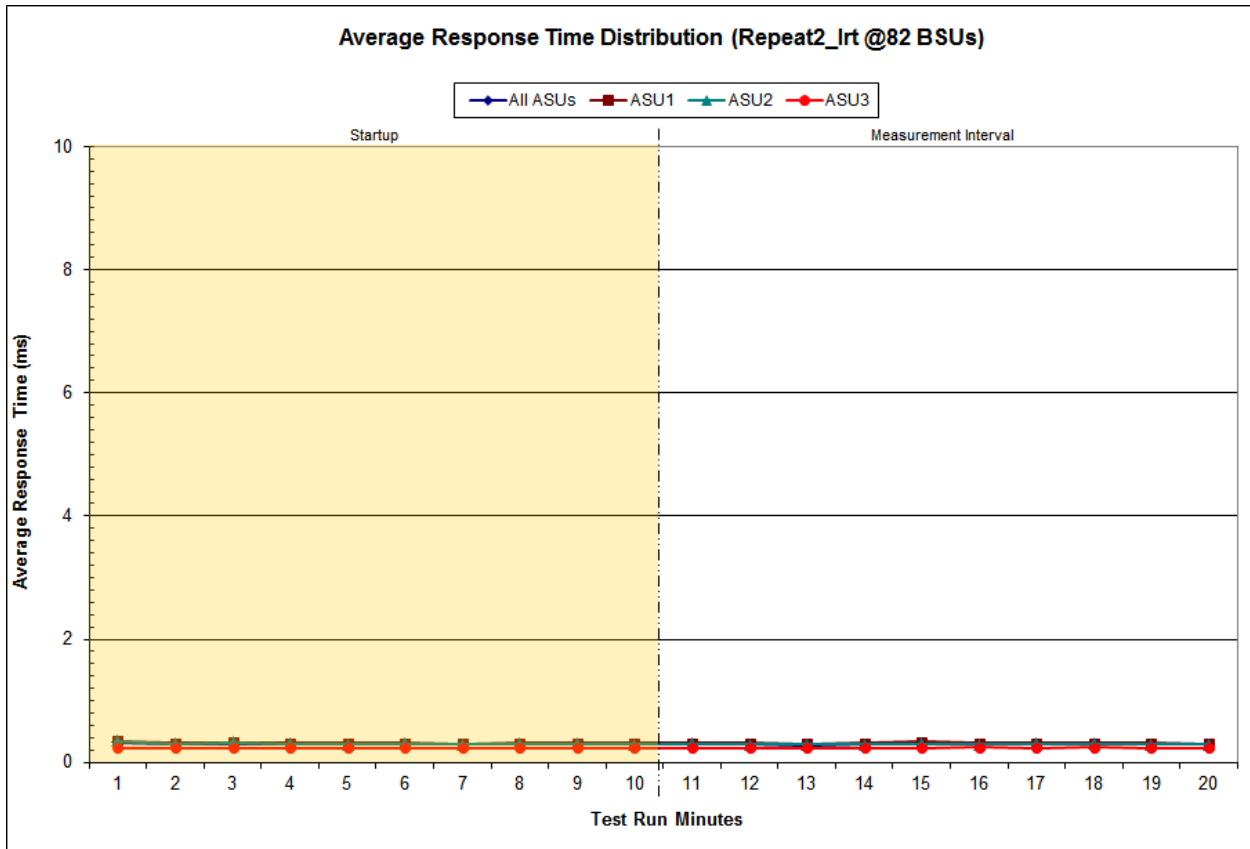


### Repeatability 2 LRT –Average Response Time (ms) Distribution Data

The Repeatability 2 LRT – Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 2 LRT – Average Response Time Distribution Data Table](#)

### Repeatability 2 LRT –Average Response Time (ms) Distribution Graph

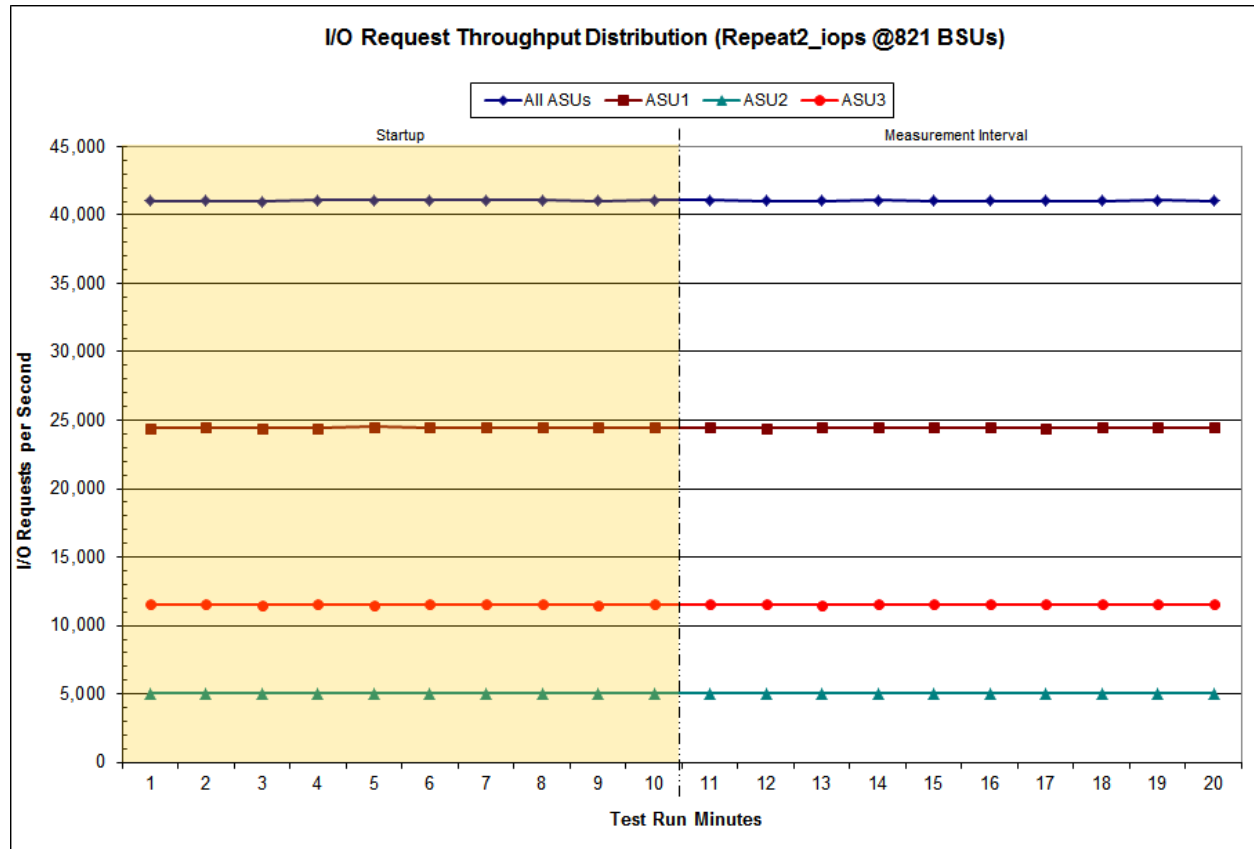


### Repeatability 2 IOPS – I/O Request Throughput Distribution Data

The Repeatability 2 IOPS – I/O Request Throughput Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 2 IOPS – I/O Request Throughput Distribution Data Table](#)

### Repeatability 2 IOPS – I/O Request Throughput Distribution Graph

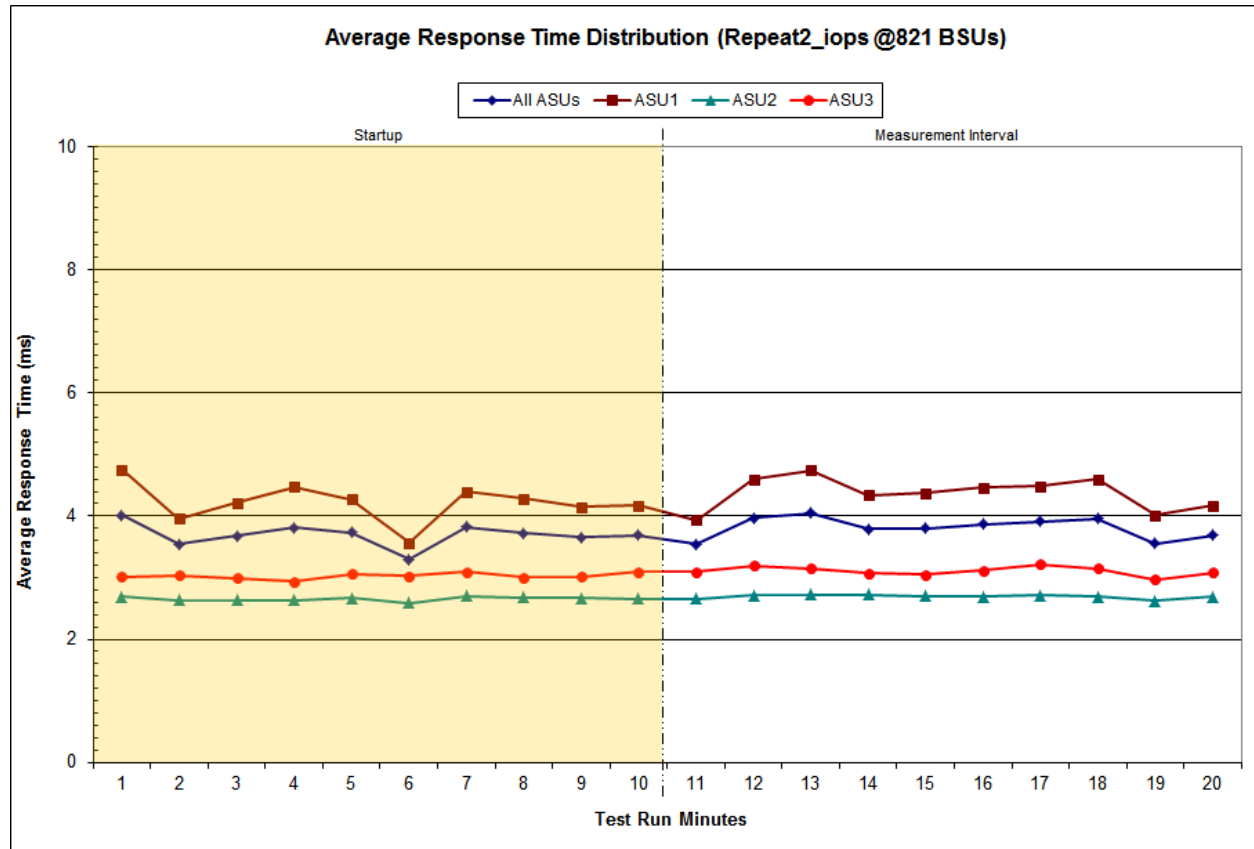


### Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

The Repeatability 2 IOPS – Average Response Time Distribution Data table is not embedded in this document due to its size. The table is available via the following URL:

[Repeatability 2 IOPS – Average Response Time Distribution Data Table](#)

### Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph





**Repeatability 1 (LRT)**  
**Measured Intensity Multiplier and Coefficient of Variation**

Clause 3.4.3

**IM – Intensity Multiplier:** The ratio of I/Os for each I/O stream relative to the total I/Os for all I/O streams (ASU1-1 – ASU3-1) as required by the benchmark specification.

Clauses 5.1.10 and 5.3.15.2

**MIM – Measured Intensity Multiplier:** The Measured Intensity Multiplier represents the ratio of measured I/Os for each I/O stream relative to the total I/Os measured for all I/O streams (ASU1-1 – ASU3-1). This value may differ from the corresponding Expected Intensity Multiplier by no more than 5%.

Clause 5.3.15.3

**COV – Coefficient of Variation:** This measure of variation for the Measured Intensity Multiplier cannot exceed 0.2.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2809	0.0699	0.2104	0.0178	0.0698	0.0348	0.2814
COV	0.009	0.004	0.005	0.003	0.008	0.006	0.011	0.003

**Repeatability 1 (IOPS)**  
**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0350	0.2809	0.0701	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.002	0.001	0.004	0.003	0.002	0.001

**Repeatability 2 (LRT)**  
**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<b>IM</b>	<b>0.0350</b>	<b>0.2810</b>	<b>0.0700</b>	<b>0.2100</b>	<b>0.0180</b>	<b>0.0700</b>	<b>0.0350</b>	<b>0.2810</b>
MIM	0.0347	0.2811	0.0702	0.2098	0.0180	0.0700	0.0351	0.2810
COV	0.010	0.004	0.008	0.004	0.009	0.007	0.010	0.003

**Repeatability 2 (IOPS)**  
**Measured Intensity Multiplier and Coefficient of Variation**

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
<i>IM</i>	<i>0.0350</i>	<i>0.2810</i>	<i>0.0700</i>	<i>0.2100</i>	<i>0.0180</i>	<i>0.0700</i>	<i>0.0350</i>	<i>0.2810</i>
MIM	0.0350	0.2810	0.0701	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.004	0.001	0.002	0.001	0.003	0.002	0.003	0.001

## Data Persistence Test

### Clause 6

*The Data Persistence Test demonstrates the Tested Storage Configuration (TSC):*

- *Is capable of maintain data integrity across a power cycle.*
- *Ensures the transfer of data between Logical Volumes and host systems occurs without corruption or loss.*

*The SPC-1 Workload Generator will write 16 block I/O requests at random over the total Addressable Storage Capacity of the TSC for ten (10) minutes at a minimum of 25% of the load used to generate the SPC-1 IOPS™ primary metric. The bit pattern selected to be written to each block as well as the address of the block will be retained in a log file.*

*The Tested Storage Configuration (TSC) will be shutdown and restarted using a power off/power on cycle at the end of the above sequence of write operations. In addition, any caches employing battery backup must be flushed/emptied.*

*The SPC-1 Workload Generator will then use the above log file to verify each block written contains the correct bit pattern.*

### Clause 9.4.3.8

*The following content shall appear in this section of the FDR:*

1. *A listing or screen image of all input parameters supplied to the Workload Generator.*
2. *For the successful Data Persistence Test Run, a table illustrating key results. The content, appearance, and format of this table are specified in Table 9-12. Information displayed in this table shall be obtained from the Test Run Results File referenced below in #3.*
3. *For the successful Data Persistence Test Run, the human readable Test Run Results file produced by the Workload Generator (may be contained in an appendix).*

## SPC-1 Workload Generator Input Parameters

The SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, Repeatability, and Persistence Test Runs are documented in [Appendix E: SPC-1 Workload Generator Input Parameters](#) on Page [75](#).

## Data Persistence Test Results File

A link to each test result file generated from each Data Persistence Test is listed below.

[Persistence 1 Test Results File](#)

[Persistence 2 Test Results File](#)

### Data Persistence Test Results

Data Persistence Test Results	
Data Persistence Test Run Number: 1	
Total Number of Logical Blocks Written	98,407,344
Total Number of Logical Blocks Verified	60,328,192
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10 minutes
Size in bytes of each Logical Block	512
Number of Failed I/O Requests in the process of the Test	0

In some cases the same address was the target of multiple writes, which resulted in more Logical Blocks Written than Logical Blocks Verified. In the case of multiple writes to the same address, the pattern written and verified must be associated with the last write to that address.

## **PRICED STORAGE CONFIGURATION AVAILABILITY DATE**

### **Clause 9.4.3.9**

*The committed delivery data for general availability (Availability Date) of all products that comprise the Priced Storage Configuration must be reported. When the Priced Storage Configuration includes products or components with different availability dates, the reported Availability Date for the Priced Storage Configuration must be the date at which all components are committed to be available.*

The entire Priced Storage Configuration, as documented in this Full Disclosure Report, is currently available for customer purchase and shipment.

## **PRICING INFORMATION**

### **Clause 9.4.3.3.6**

*The Executive Summary shall contain a pricing spreadsheet as documented in Clause 8.3.1.*

Pricing information may be found in the Priced Storage Configuration Pricing section on page [17](#).

## **TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES**

### **Clause 9.4.3.3.8**

*The Executive Summary shall contain a list of all differences between the Tested Storage Configuration (TSC) and the Priced Storage Configuration.*

A list of all differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration may be found in the Executive Summary portion of this document on page [17](#).

## **ANOMALIES OR IRREGULARITIES**

### **Clause 9.4.3.10**

*The FDR shall include a clear and complete description of any anomalies or irregularities encountered in the course of executing the SPC-1 benchmark that may in any way call into question the accuracy, verifiability, or authenticity of information published in this FDR.*

There were no anomalies or irregularities encountered during the SPC-1 Onsite Audit of the Lenovo Storage S2200.

## **APPENDIX A: SPC-1 GLOSSARY**

### “Decimal” (*powers of ten*) Measurement Units

In the storage industry, the terms “kilo”, “mega”, “giga”, “tera”, “peta”, and “exa” are commonly used prefixes for computing performance and capacity. For the purposes of the SPC workload definitions, all of the following terms are defined in “powers of ten” measurement units.

A kilobyte (KB) is equal to 1,000 ( $10^3$ ) bytes.

A megabyte (MB) is equal to 1,000,000 ( $10^6$ ) bytes.

A gigabyte (GB) is equal to 1,000,000,000 ( $10^9$ ) bytes.

A terabyte (TB) is equal to 1,000,000,000,000 ( $10^{12}$ ) bytes.

A petabyte (PB) is equal to 1,000,000,000,000,000 ( $10^{15}$ ) bytes

An exabyte (EB) is equal to 1,000,000,000,000,000,000 ( $10^{18}$ ) bytes

### “Binary” (*powers of two*) Measurement Units

The sizes reported by many operating system components use “powers of two” measurement units rather than “power of ten” units. The following standardized definitions and terms are also valid and may be used in this document.

A kibibyte (KiB) is equal to 1,024 ( $2^{10}$ ) bytes.

A mebibyte (MiB) is equal to 1,048,576 ( $2^{20}$ ) bytes.

A gibibyte (GiB) is equal to 1,073,741,824 ( $2^{30}$ ) bytes.

A tebibyte (TiB) is equal to 1,099,511,627,776 ( $2^{40}$ ) bytes.

A pebibyte (PiB) is equal to 1,125,899,906,842,624 ( $2^{50}$ ) bytes.

An exbibyte (EiB) is equal to 1,152,921,504,606,846,967 ( $2^{60}$ ) bytes.

## **SPC-1 Data Repository Definitions**

**Total ASU Capacity:** The total storage capacity read and written in the course of executing the SPC-1 benchmark.

**Application Storage Unit (ASU):** The logical interface between the storage and SPC-1 Workload Generator. The three ASUs (Data, User, and Log) are typically implemented on one or more Logical Volume.

**Logical Volume:** The division of Addressable Storage Capacity into individually addressable logical units of storage used in the SPC-1 benchmark. Each Logical Volume is implemented as a single, contiguous address space.

**Addressable Storage Capacity:** The total storage (sum of Logical Volumes) that can be read and written by application programs such as the SPC-1 Workload Generator.

**Configured Storage Capacity:** This capacity includes the Addressable Storage Capacity and any other storage (parity disks, hot spares, etc.) necessary to implement the Addressable Storage Capacity.

**Physical Storage Capacity:** The formatted capacity of all storage devices physically present in the Tested Storage Configuration (TSC).

**Data Protection Overhead:** The storage capacity required to implement the selected level of data protection.

**Required Storage:** The amount of Configured Storage Capacity required to implement the Addressable Storage Configuration, excluding the storage required for the three ASUs.

**Global Storage Overhead:** The amount of Physical Storage Capacity that is required for storage subsystem use and unavailable for use by application programs.

**Total Unused Storage:** The amount of storage capacity available for use by application programs but not included in the Total ASU Capacity.

## SPC-1 Data Protection Levels

**Protected 1:** The single point of failure of any *storage device* in the configuration will not result in permanent loss of access to or integrity of the SPC-1 Data Repository.

**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-1 Data Repository.

## SPC-1 Test Execution Definitions

**Average Response Time:** The sum of the Response Times for all Measured I/O Requests divided by the total number of Measured I/O Requests.

**Completed I/O Request:** An I/O Request with a Start Time and a Completion Time (see “I/O Completion Types” below).

**Completion Time:** The time recorded by the Workload Generator when an I/O Request is satisfied by the TSC as signaled by System Software.

**Data Rate:** The data transferred in all Measured I/O Requests in an SPC-1 Test Run divided by the length of the Test Run in seconds.

**Expected I/O Count:** For any given I/O Stream and Test Phase, the product of 50 times the BSU level, the duration of the Test Phase in seconds, and the Intensity Multiplier for that I/O Stream.

**Failed I/O Request:** Any I/O Request issued by the Workload Generator that could not be completed or was signaled as failed by System Software. A Failed I/O Request has no Completion Time (see “I/O Completion Types” below).

**I/O Request Throughput:** The total number of Measured I/O requests in an SPC-1 Test Run divided by the duration of the Measurement Interval in seconds.

**In-Flight I/O Request:** An I/O Request issued by the I/O Command Generator to the TSC that has a recorded Start Time, but does not complete within the Measurement Interval (see “I/O Completion Types” below).

**Measured I/O Request:** A Completed I/O Request with a Completion Time occurring within the Measurement Interval (see “I/O Completion Types” below).

**Measured Intensity Multiplier:** The percentage of all Measured I/O Requests that were issued by a given I/O Stream.

**Measurement Interval:** The finite and contiguous time period, after the TSC has reached Steady State, when data is collected by a Test Sponsor to generate an SPC-1 test result or support an SPC-1 test result.

**Ramp-Up:** The time required for the Benchmark Configuration (BC) to produce Steady State throughput after the Workload Generator begins submitting I/O Requests to the TSC for execution.

**Ramp-Down:** The time required for the BC to complete all I/O Requests issued by the Workload Generator. The Ramp-Down period begins when the Workload Generator ceases to issue new I/O Requests to the TSC.

**Response Time:** The Response Time of a Measured I/O Request is its Completion Time minus its Start Time.

**Start Time:** The time recorded by the Workload Generator when an I/O Request is submitted, by the Workload Generator, to the System Software for execution on the Tested Storage Configuration (TSC).

**Start-Up:** The period that begins after the Workload Generator starts to submit I/O requests to the TSC and ends at the beginning of the Measurement Interval.

**Shut-Down:** The period between the end of the Measurement Interval and the time when all I/O Requests issued by the Workload Generator have completed or failed.

**Steady State:** The consistent and sustainable throughput of the TSC. During this period the load presented to the TSC by the Workload Generator is constant.

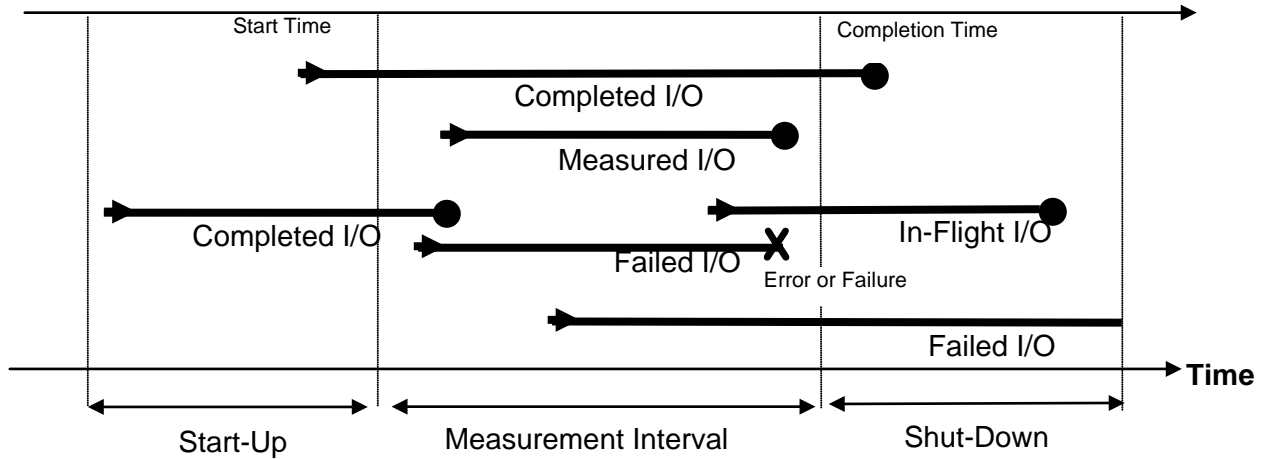
**Test:** A collection of Test Phases and or Test Runs sharing a common objective.

**Test Run:** The execution of SPC-1 for the purpose of producing or supporting an SPC-1 test result. SPC-1 Test Runs may have a finite and measured Ramp-Up period, Start-Up period, Shut-Down period, and Ramp-Down period as illustrated in the “SPC-1 Test Run Components” below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

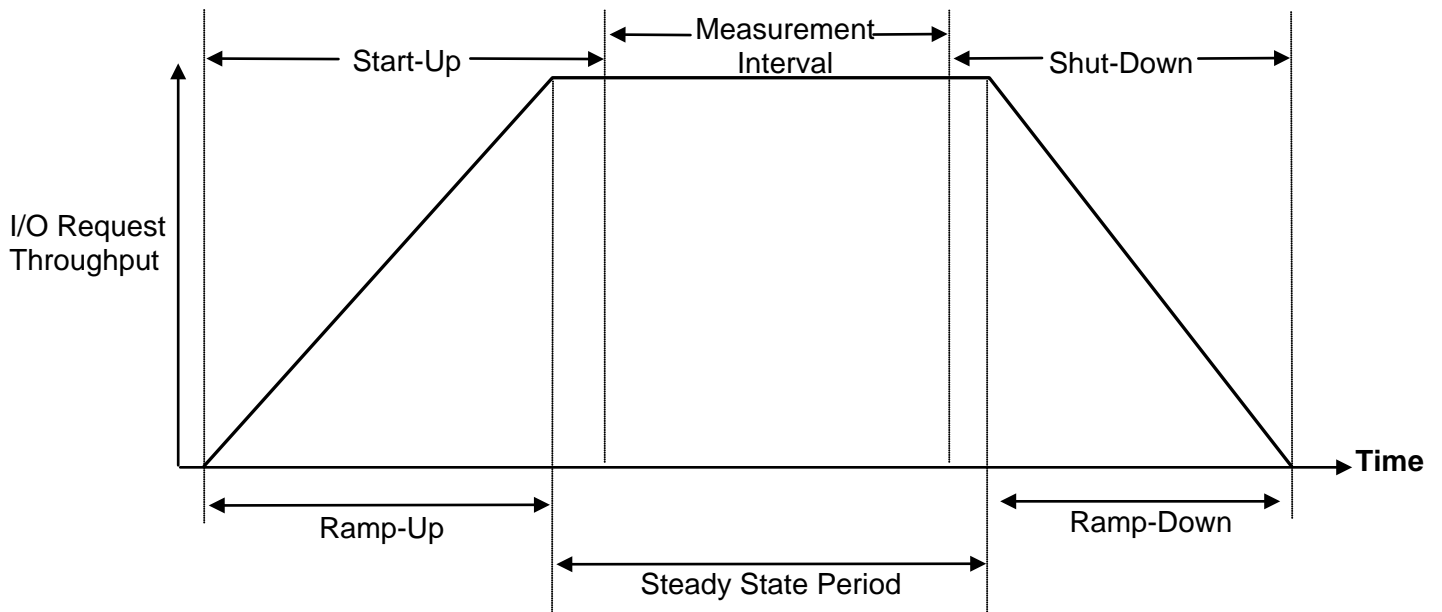


**Test Phase:** A collection of one or more SPC-1 Test Runs sharing a common objective and intended to be run in a specific sequence.

### I/O Completion Types



### SPC-1 Test Run Components



**APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS**

There were no customer tunable parameters or option changed from their default values for this set of audited benchmark measurements.

## **APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION**

### **Create Disk Groups, Pools, Volumes and LUNs**

The following commands were executed in a CLI session on a console connected the the TSC to create disk groups, pools, volumes and LUNs:

```
#
# Create Vdisks from SSD's in Enclosure 0
#
add disk-group type virtual disks 0.16,0.17 level r1 pool a name SSD-HGST-A1
add disk-group type virtual disks 0.18,0.19 level r1 pool b name SSD-HGST-B1
#
#
# for 400GB SSD R1 AFA in Pools
#
create volume pool A size 170GB ASU1-A1
create volume pool A size 170GB ASU2-A1
create volume pool A size 38GB ASU3-A1

create volume pool B size 170GB ASU1-B1
create volume pool B size 170GB ASU2-B1
create volume pool B size 38GB ASU3-B1
#
#
#
map volume lun 10 ports a0 ASU1-A1
map volume lun 12 ports a0 ASU2-A1
map volume lun 14 ports a0 ASU3-A1

map volume lun 11 ports b0 ASU1-B1
map volume lun 13 ports b0 ASU2-B1
map volume lun 15 ports b0 ASU3-B1
```

### **Create SPC-1 Logical Volumes**

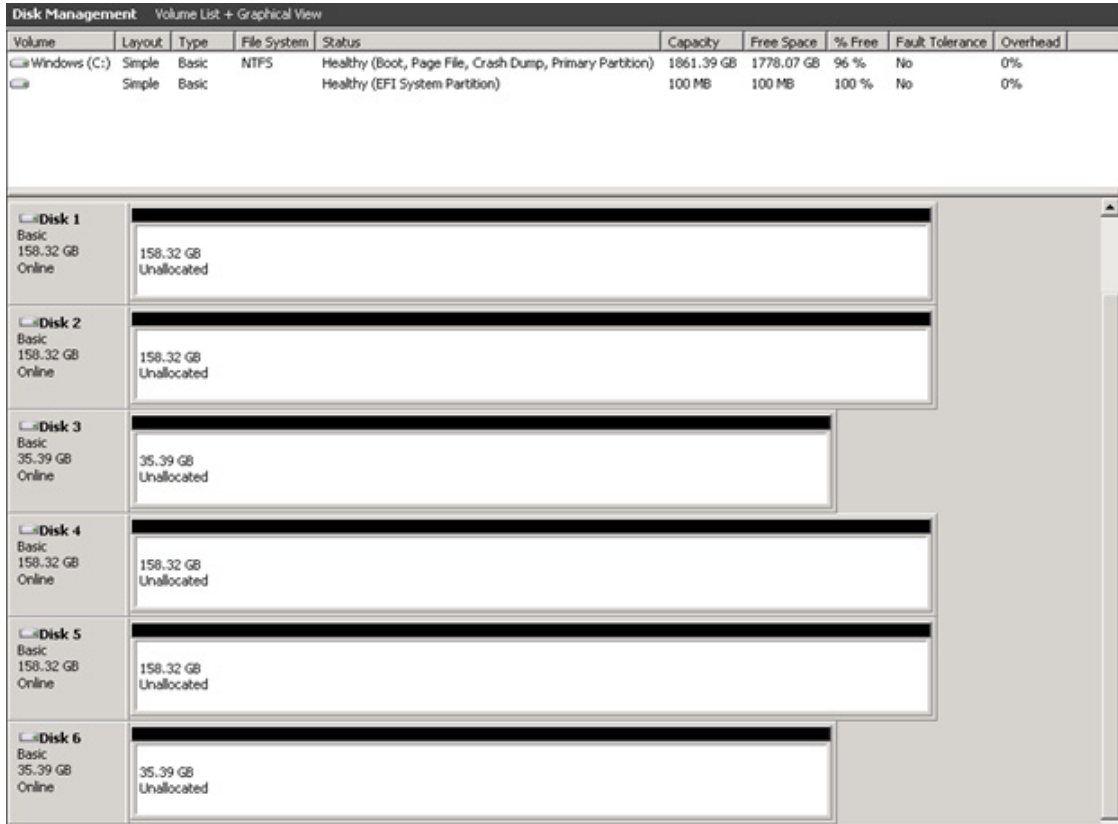
The Windows Disk Management utility was used to create three striped SPC-1 Logical Volumes from the six LUNs (*Windows "Physical Disks"*), which were created as documented above. The three logical volumes comprise the three SPC-1 ASUs.

Two "Physical Disks" were selected for each logical volume and drive letters assigned according to the following:

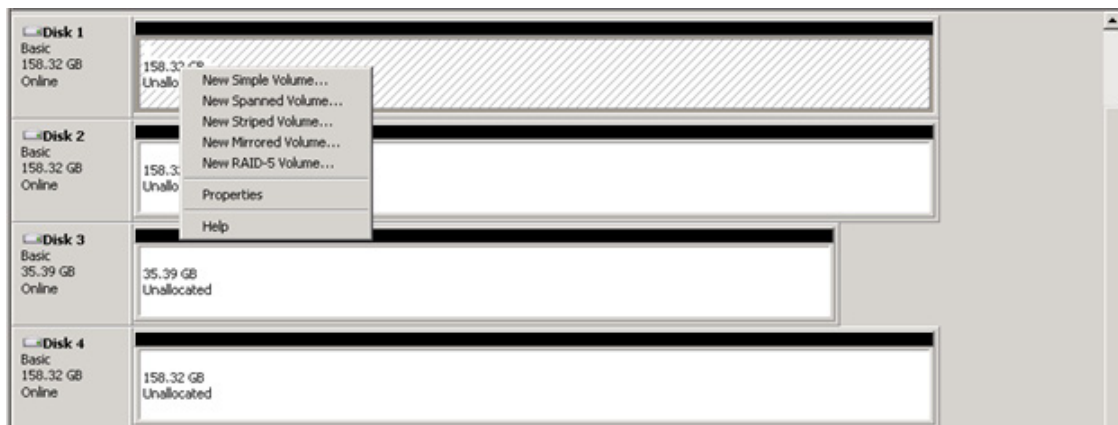
<b>"Physical Disk"</b>	<b>LUN #</b>	<b>ASU</b>	<b>Drive Letter</b>
1 and 4	10 and 11	ASU-1	I
2 and 5	12 and 13	ASU-2	J
3 and 6	14 and 15	ASU-3	K

The following process documents the creation of the SPC-1 Logical Volumes.

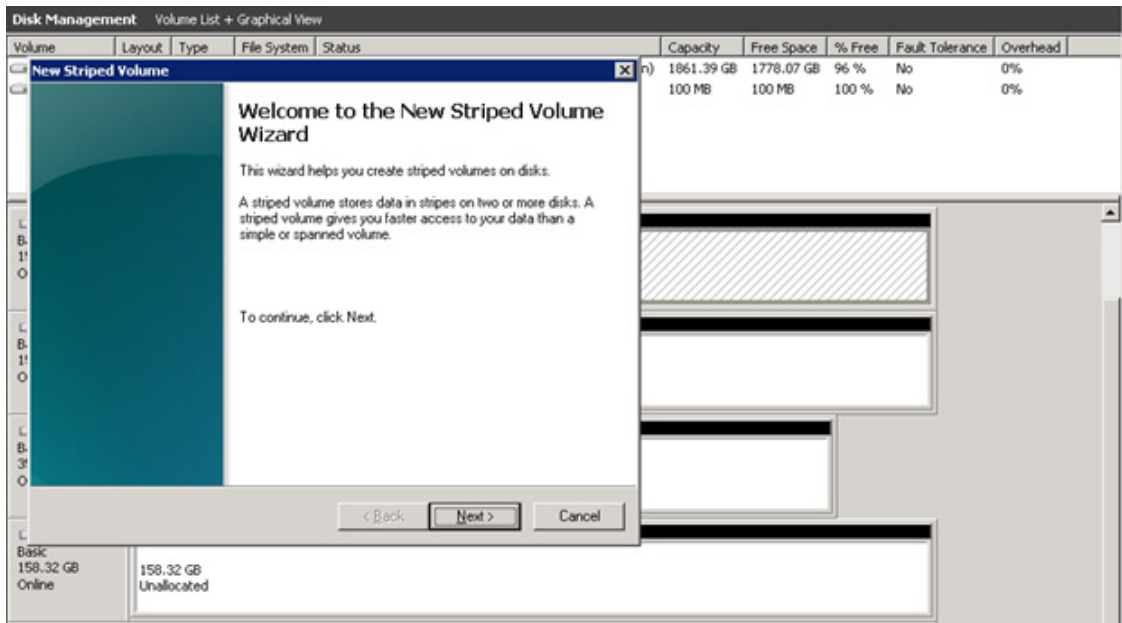
1. Start the Windows Disk Management utility on the Host System and the console will display the six LUNs (*Windows “Physical Disks”*) as follows:



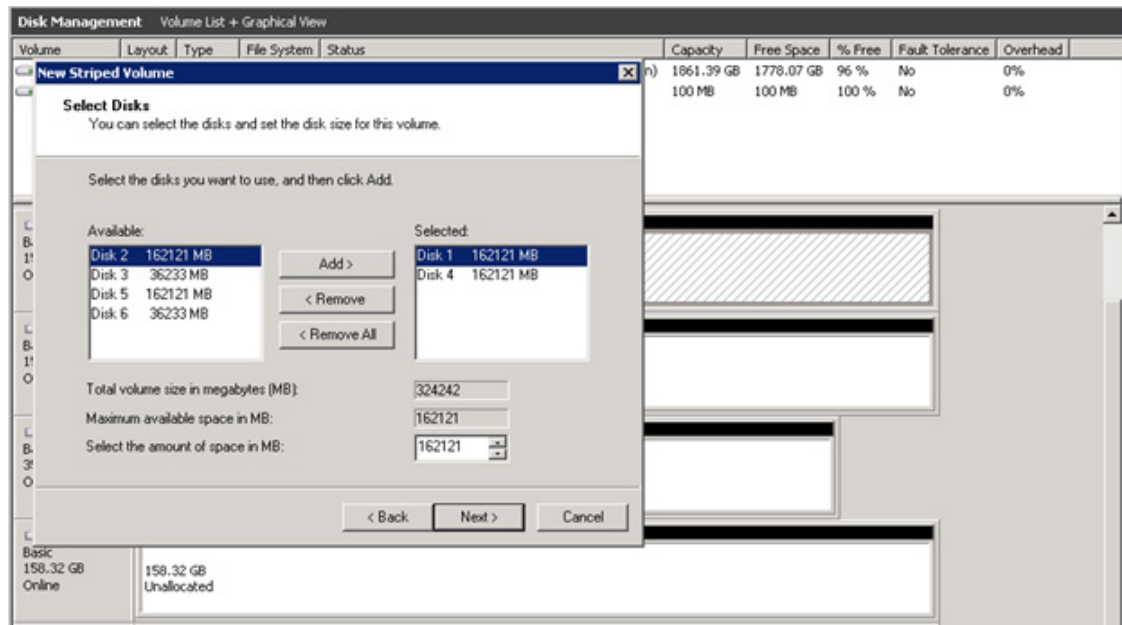
2. Highlight the volume space on **Disk 1** and right click, and the volume create window appears.  
Select **New Striped Volume...**



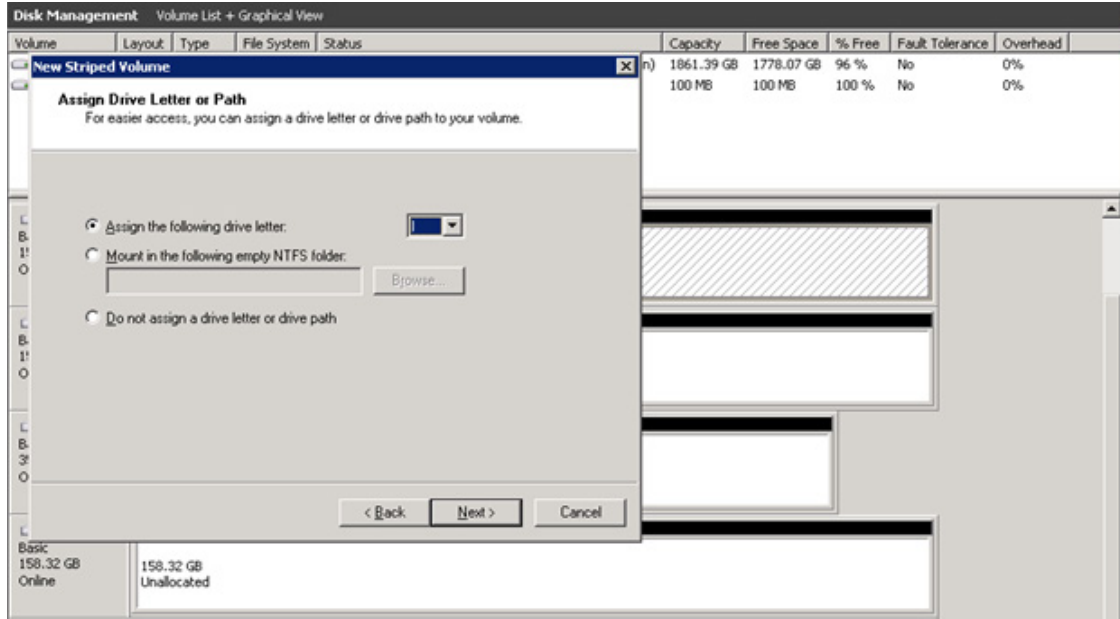
- The welcome banner appears.  
Select **Next**.



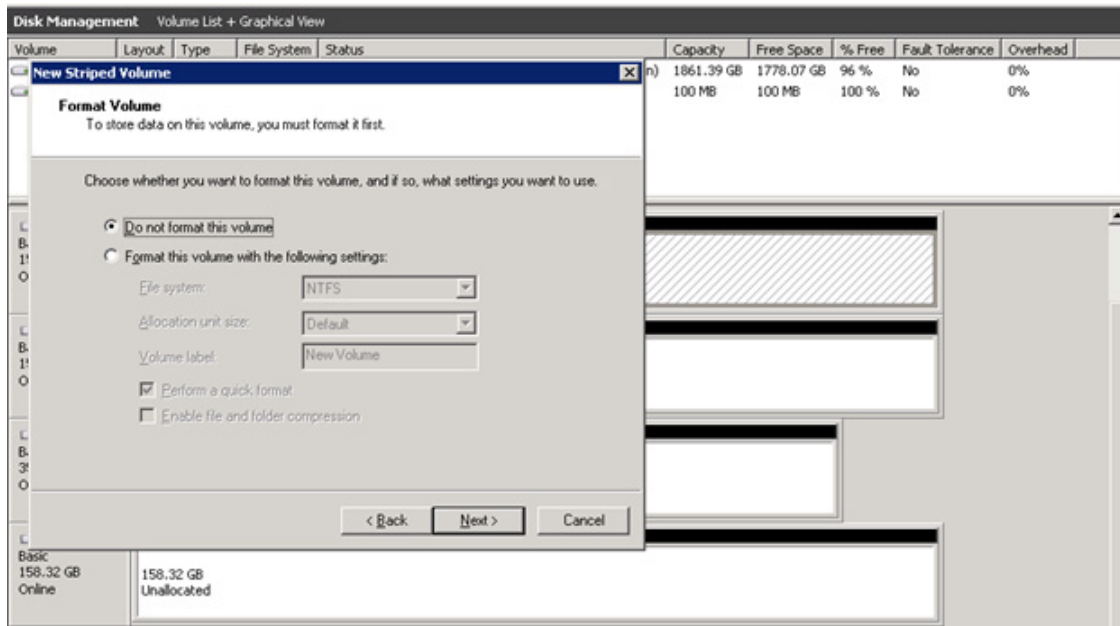
- The **New Striped Volume** window appears.  
Highlight **Disk 4**  
Click on **Add>**.  
**Disk 1** and **Disk 4** are now in the selected window.  
Click **Next >**.



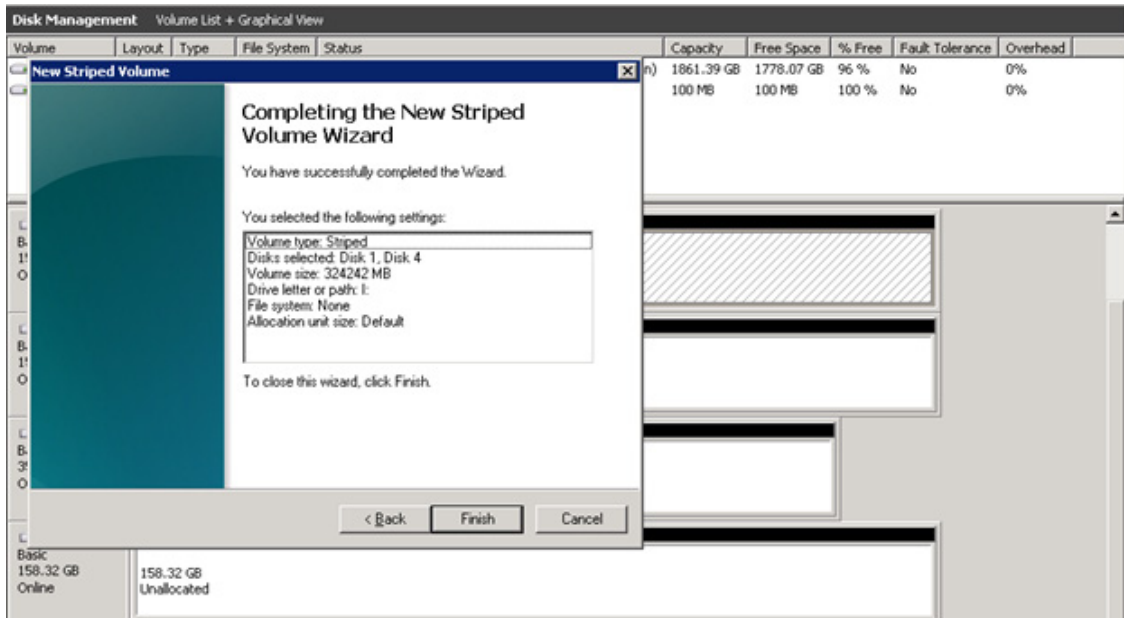
- The **Assign Drive Letter** window appears.  
Click the radio button **Assign the following drive letter**.  
Use the pull down arrow on drive letter and select **I**.  
Click **Next >**.



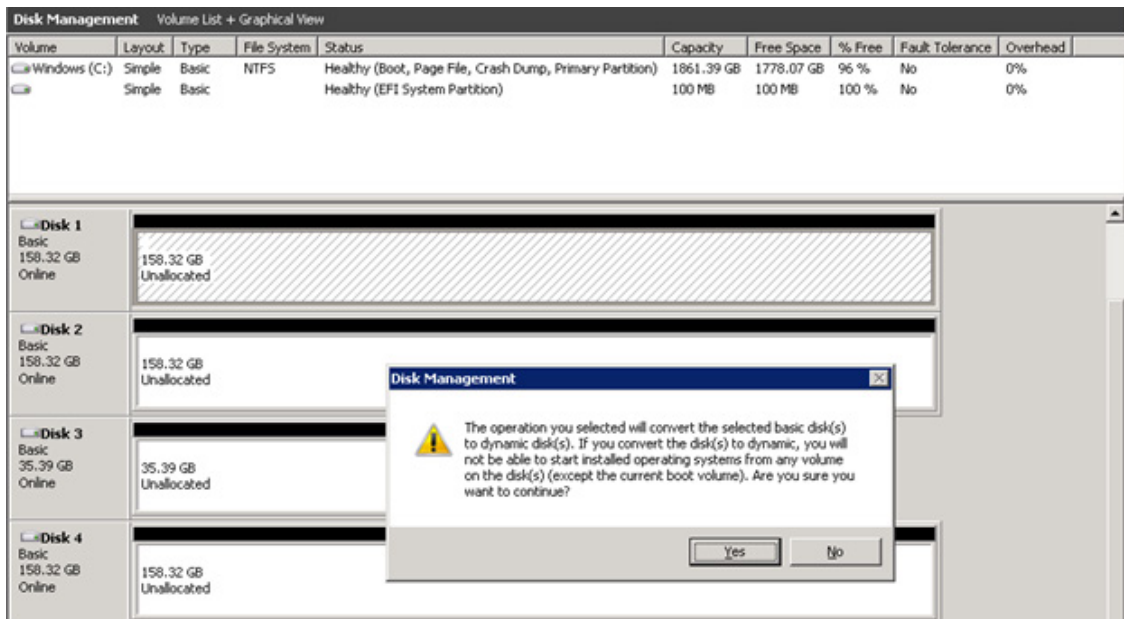
- The **Format Volume** window appears.  
Select **Do not format this volume**.  
Click **Next >**.



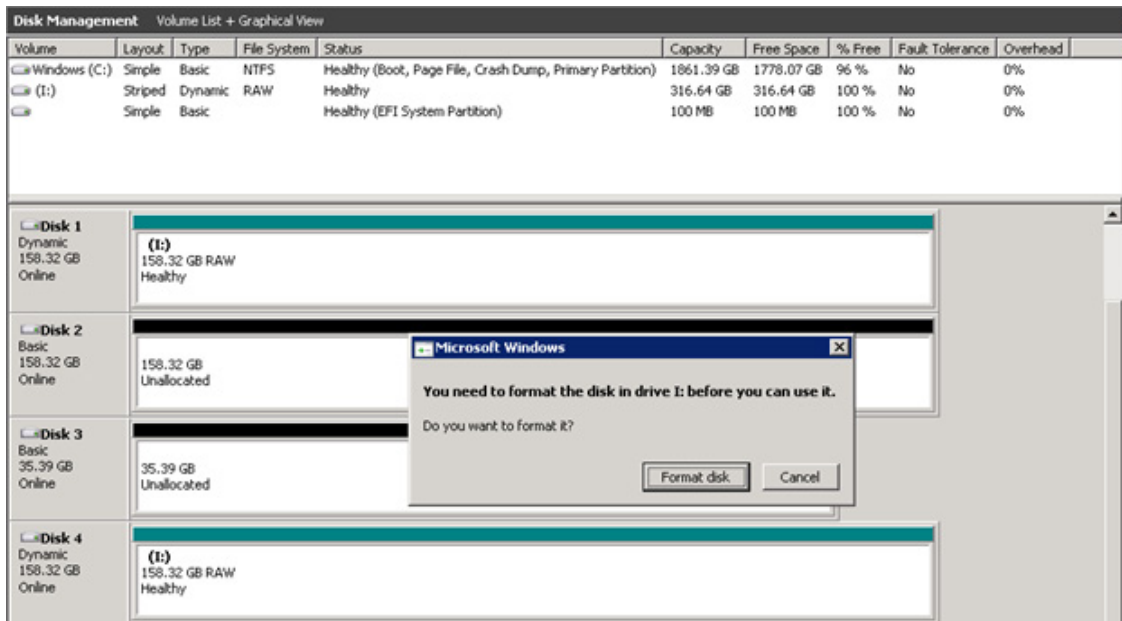
7. **Completing the New Striped Volume Wizard** window appears.  
Click **Finish**.



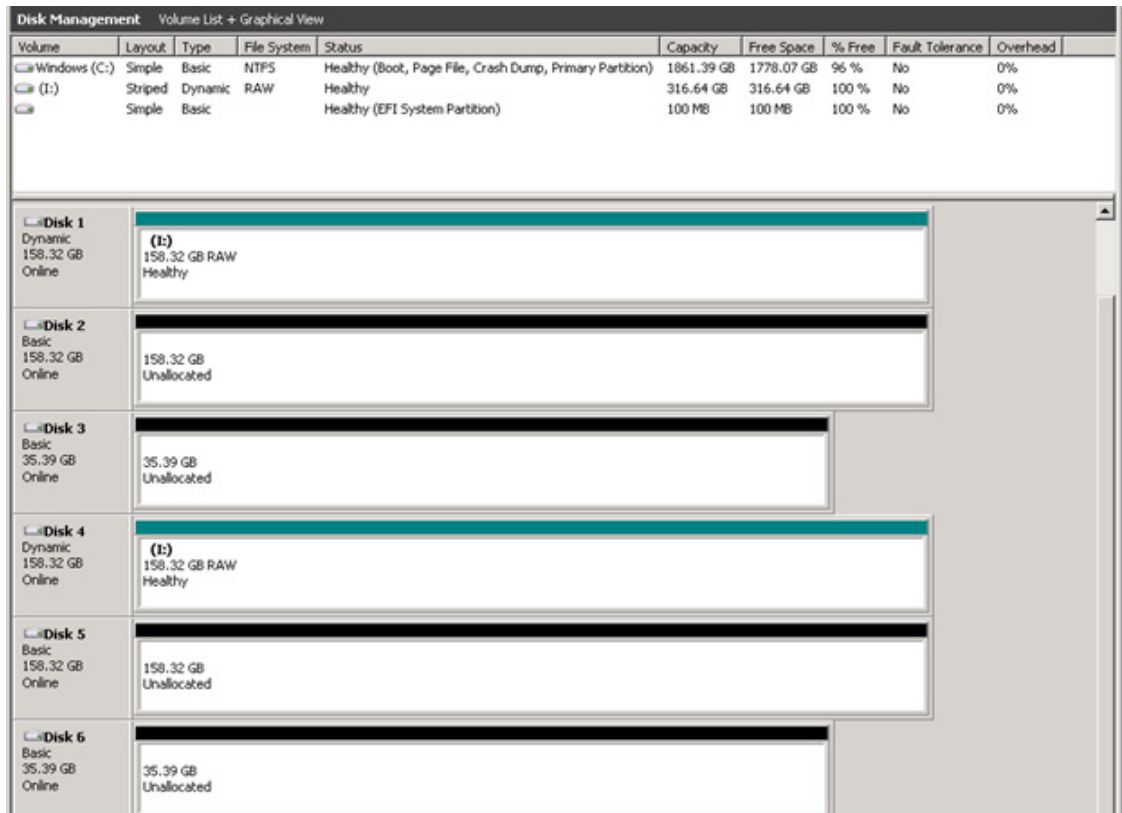
8. The **Disk Management** window appears, asking for confirmation to create the volume.  
Click **Yes**.



9. **Microsoft Windows** appears asking to format the Volume  
Click **Cancel**.

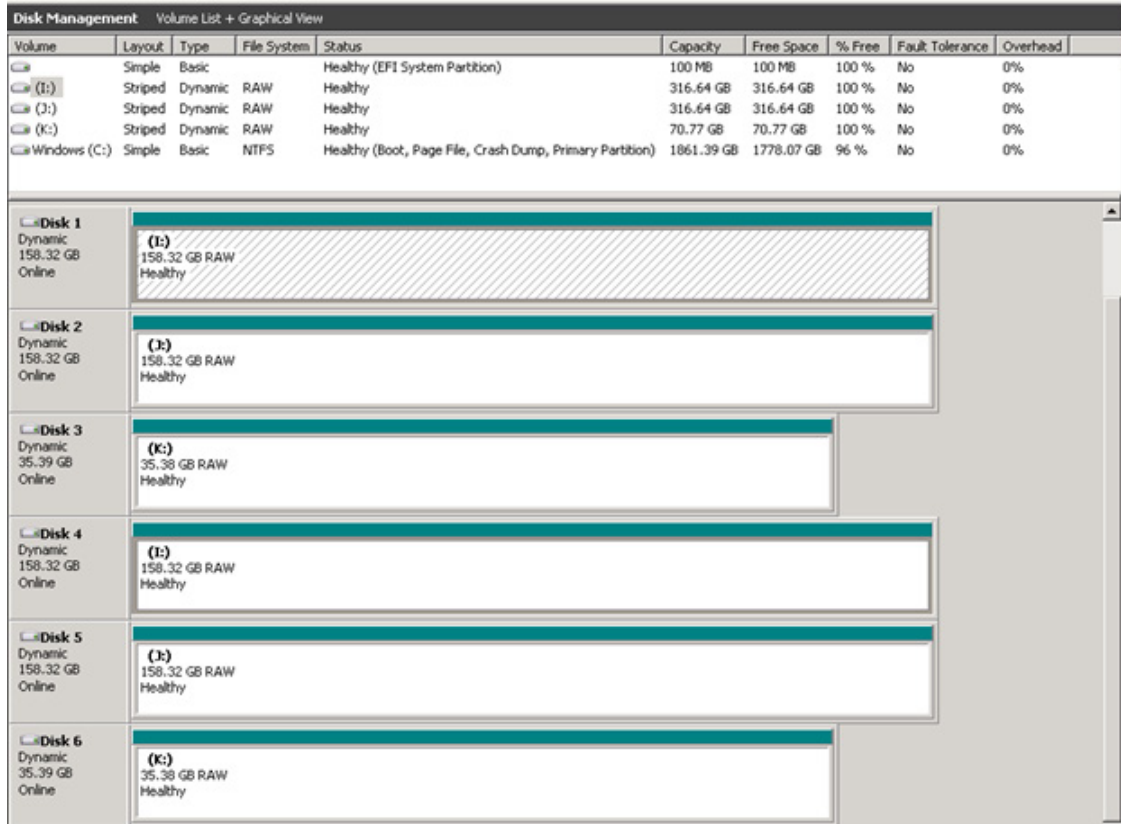


10. The **Disk Management** window now appears as follows:





11. Repeat steps 2-11 for the remaining two logical volumes.
12. After all three logical volumes have been created, the **Disk Management** window will appear as follows:



## **APPENDIX D: SPC-1 WORKLOAD GENERATOR STORAGE COMMANDS AND PARAMETERS**

### **ASU Pre-Fill**

The content of the command and parameter file used in the benchmark to execute the required ASU pre-fill operation is listed below.

```
compratio=1

sd=default,threads=8
sd=sd1,lun=\\.i:,threads=4
sd=sd2,lun=\\.j:,threads=4
sd=sd3,lun=\\.k:,threads=4

wd=default,rdpct=0,seek=-1,xfersize=512k
wd=wd1,sd=sd1
wd=wd2,sd=sd2
wd=wd3,sd=sd3

rd=asuprefill,wd=wd*,iorate=max,elapsed=24h,interval=60
```

### **Primary Metrics, Repeatability and Persistence Tests**

The content of SPC-1 Workload Generator command and parameter file used in this benchmark to execute the Primary Metrics (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*), Repeatability (*Repeatability Test Phase 1 and Repeatability Test Phase 2*) and Persistence Tests is listed below.

```
sd=asu1_1,lun=\\.i:
sd=asu2_1,lun=\\.j:
sd=asu3_1,lun=\\.k:
```

## **APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS**

The following script, **Run-SPC-1-PF-M+R1+R2+P1-821BSU+config-info-http-shutdown.ps1**, was invoked to execute the following in an uninterrupted execution sequence:

- The required ASU pre-fill.
- Generate the first set of detailed storage configuration information required for a remote audit.
- The commands to execute the Primary Metrics Test (*Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase*), Repeatability Test (*Repeatability Test Phase 1 and Repeatability Test Phase 2*), and SPC-1 Persistence Test Run 1 (*write phase*).
- Generate listing of TSC power off/power on information.

After successfully completion of the required TSC power off/power on cycle, a modified version of the same script, with the appropriate command lines activated and commented out, was invoked to execute the following in an uninterrupted execution sequence:

- Generate the second set of detailed storage configuration information required for a remote audit.
- The command to execute the SPC-1 Persistence Test Run 2 (*read phase*).

### **Run-SPC-1-PF-M+R1+R2+P1-821BSU+config-info-http-shutdown.ps1**

```
# PreFill ASU space with vdbench
#
cd C:\spc1-test-results\Java-Pre-Fill
#
C:\vdbench\vdbench-32-64.bat -f ASU-PreFill-script.cfg -o prefill.out
#
java -version
#
# SPC-1 Test Suite command file
#
cd C:\spc1-test-results\EX-AFA\HGST-SSD\SunsetCove+\4xSSD
#
# Get configuration information
get-date
#
.\getsshinfo2.2.ps1 -location C:\spc1-test-results\EX-AFA\HGST-
SSD\SunsetCove+\4xSSD\config-info-http-1.txt -computername 10.235.193.167 -username
manage -password !manage

#
cd 2016-05-23-2220-BSU-821-PF+M+R1+R2+P1
# Metrics sustainability -
#
java metrics -b 821 -s 1800:600 -t 28800
#
# Repeatability Runs
#
java -Xmx512m -Xms512m repeat1 -b 821 -s 600
java -Xmx512m -Xms512m repeat2 -b 821 -s 600
#
```

```
# copy spc1_persist.cfg spc1.cfg
#
# Persist runs
#
  java -Xmx512m -Xms512m persist1 -b 821
#
# Insert commands to power off & on ports on Ethernet switched PDU
#
# Get configuration information
cd ..
get-date
#
  .\gethttpinfo-shutdown.ps1 -location C:\spc1-test-results\EX-AFA\HGST-
SSD\SunsetCove+\4xSSD\config-info-restart.txt -computername 10.235.193.167 -
username manage -password !manage

#
# .\getsshinfo2.2.ps1 -location C:\spc1-test-results\EX-AFA\HGST-
SSD\SunsetCove+\4xSSD\config-info-http-2.txt -computername #10.235.193.167 -
username manage -password !manage
#
# Run second Persist command to validate contents of storage
#
# Run persist2 after power cycle
#
# cd 2016-05-23-2220-BSU-821-PF+M+R1+R2+P1
# java persist2
```