SPC Benchmark 1™
Full Disclosure Report

Huawei Technologies Co., Ltd.
Huawei OceanStor™ Dorado2100

SPC-1 V1.12

Submitted for Review: December 29, 2011
Submission Identifier: A00112
Revised: December 13, 2012

First Edition – December 2011

Trademarks

SPC BENCHMARK 1™ V1.12   FULL DISCLOSURE REPORT   Submission Identifier: A00112

Huawei Technologies Co., Ltd.   Submitted for Review: DECEMBER 29, 2011
Huawei OceanStor™ Dorado2100   Revised: December 13, 2012

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Huawei Technologies Co., Ltd.   Submitted for Review: DECEMBER 29, 2011
Huawei OceanStor™ Dorado2100   Revised: December 13, 2012

AUDIT CERTIFICATION

Storage Performance Council

Gradient SYSTEMS

Eric He
Huawei Symantec Technologies Co., Ltd.
Tianchen Road 88#
Chengdu, Sichuan, P.R. China 611711

December 28, 2011

The SPC Benchmark 1™ Reported Data listed below for the Huawei Symantec Oceanspace™ Dorado2100 were produced in compliance with the SPC Benchmark 1™ v1.12 Remote Audit requirements.

SPC Benchmark 1™ v1.12 Reported Data	
Tested Storage Product (TSP) Name:	
Huawei Symantec Oceanspace™ Dorado2100	
Metric	**Reported Result**
SPC-1 IOPS™	100,051.99
SPC-1 Price-Performance	$0.90/SPC-1 IOPS™
Total ASU Capacity	1,104.947 GB
Data Protection Level	Protected (Mirroring)
Total TSC Price (including three-year maintenance)	$90,320.79

The following SPC Benchmark 1™ Remote Audit requirements were reviewed and found compliant with 1.12 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 information supplied by Huawei Symantec Technologies Co., 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.

- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).

- Listings and commands to configure the Benchmark Configuration/Tested Storage Configuration, including customer tunable parameters that were changed from default values.

Storage Performance Council
643 Bair Island Road, Suite 103
Redwood City, CA 94062
AuditService@storageperformance.org
650.556.9384

AUDIT CERTIFICATION (CONT.)

Huawei Symantec Oceanspace™ Dorado2100   Page 2
SPC-1 Audit Certification
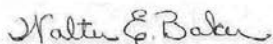
- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.

- The following Host System requirements were verified by information supplied by Huawei Symantec Technologies Co., Ltd.:

  ✓ The type of Host System including the number of processors and main memory.
  ✓ The presence and version number of the SPC-1 Workload Generator on the Host System.
  ✓ The TSC boundary within the Host System.

- The Test Results Files and resultant Summary Results Files received from Huawei Symantec Technologies Co., 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 were no differences between the Tested Storage Configuration (TSC) and the 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 were no audit notes or exceptions.

Respectfully,

Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

Huawei
Symantec

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http://www.huaweisymantec.com/en/

Date: December 16, 2011

From: Huawei Symantec Technologies Co., Ltd.

To: Walter E. Baker, SPC Auditor
           Gradient Systems, Inc.
           643 Bair Island Road. Suite 103
           Redwood City, CA 94063

Subject: SPC-1 Letter of Good Faith for the Huawei Symantec Oceanspace Dorado2100

Huawei Symantec Technologies Co., Ltd. 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 V1.12 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.

Signed: Date:

Su Liqing   December, 16. 2011

Su Liqing
Senior Vice President R&D

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Huawei Technologies Co., Ltd. – http://www.huawei.com/en/ Eric He – eric.heji@huawei.com No. 1899, Xiyuan Road Chengdu, 611731 P.R. China Phone: 0086 28 65281999 FAX: 0086 28 64686419
Test Sponsor Alternate Contact	Huawei Technologies Co., Ltd. – http://www.huawei.com/en/ Jarvis Wang – wangyaohui@huawei.com No. 1899, Xiyuan Road Chengdu, 611731 P.R. China Phone: 86 28 65281956 FAX: 86 28 64696419
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.12
SPC-1 Workload Generator revision number	V2.2.0
Date Results were first used publicly	December 29, 2011
Date the FDR was submitted to the SPC	December 29, 2011
Date revised FDR was submitted to the SPC	December 13, 2012

Date revised FDR was submitted to the SPC
  Updated company name, logo and product name
  to reflect the complete acquisition of Huawei Symantec
  by Huawei Technologies Co., Ltd.
Revision History:
  January 12, 2012
  Corrected Total Price in Audit Certification *(page vii)*
	December 13, 2012

Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	December 28, 2011

Tested Storage Product (TSP) Description

The Huawei OceanStor™ Dorado2100 (Dorado2100) is an FC-SAN solid state storage product designed for the enterprise-level high-performance storage market. Dorado2100 is designed with an SSD storage system architecture, advanced cache management and I/O scheduling algorithm to present stunning performance. It fits into scenarios such as large database query/retrieval, high-performance computing, and video editing.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Huawei OceanStor™ Dorado2100	
Metric	**Reported Result**
SPC-1 IOPS™	100,051.99
SPC-1 Price-Performance™	$0.90/SPC-1 IOPS™
Total ASU Capacity	1,104.947 GB
Data Protection Level	Protected *(Mirroring)*
Total TSC Price (including three-year maintenance)	$90,320.79

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

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

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

Storage Capacities, Relationships, and Utilization

The following diagram 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.
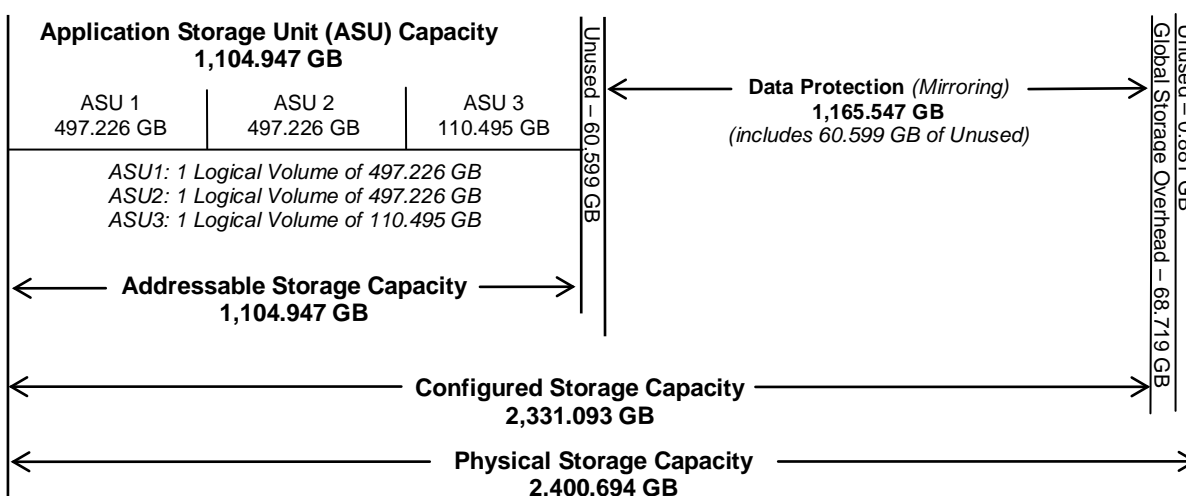
Application Storage Unit (ASU) Capacity
1,104.947 GB

ASU 1 497.226 GB	ASU 2 497.226 GB	ASU 3 110.495 GB

ASU1: 1 Logical Volume of 497.226 GB
ASU2: 1 Logical Volume of 497.226 GB
ASU3: 1 Logical Volume of 110.495 GB

Unused – 60.599 GB

Data Protection *(Mirroring)*
1,165.547 GB
(includes 60.599 GB of Unused)

Unused – 0.881 GB
Global Storage Overhead – 68.719 GB

Addressable Storage Capacity
1,104.947 GB

Configured Storage Capacity
2,331.093 GB

Physical Storage Capacity
2,400.694 GB

SPC-1 Storage Capacity Utilization	
Application Utilization	46.03%
Protected Application Utilization	92.05%
Unused Storage Ratio	5.09%

Application Utilization: Total ASU Capacity *(1,104.947 GB)* divided by Physical Storage Capacity *(2,400.694 GB)*

Protected Application Utilization: Total ASU Capacity *(1,104.947 GB)* plus total Data Protection Capacity *(1,165.547 GB)* minus unused Data Protection Capacity *(60.599 GB)* divided by Physical Storage Capacity *(2,400.694 GB)*

Unused Storage Ratio: Total Unused Capacity *(122.079 GB)* divided by Physical Storage Capacity *(2,400.694 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 19-20 in the Full Disclosure Report.

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.
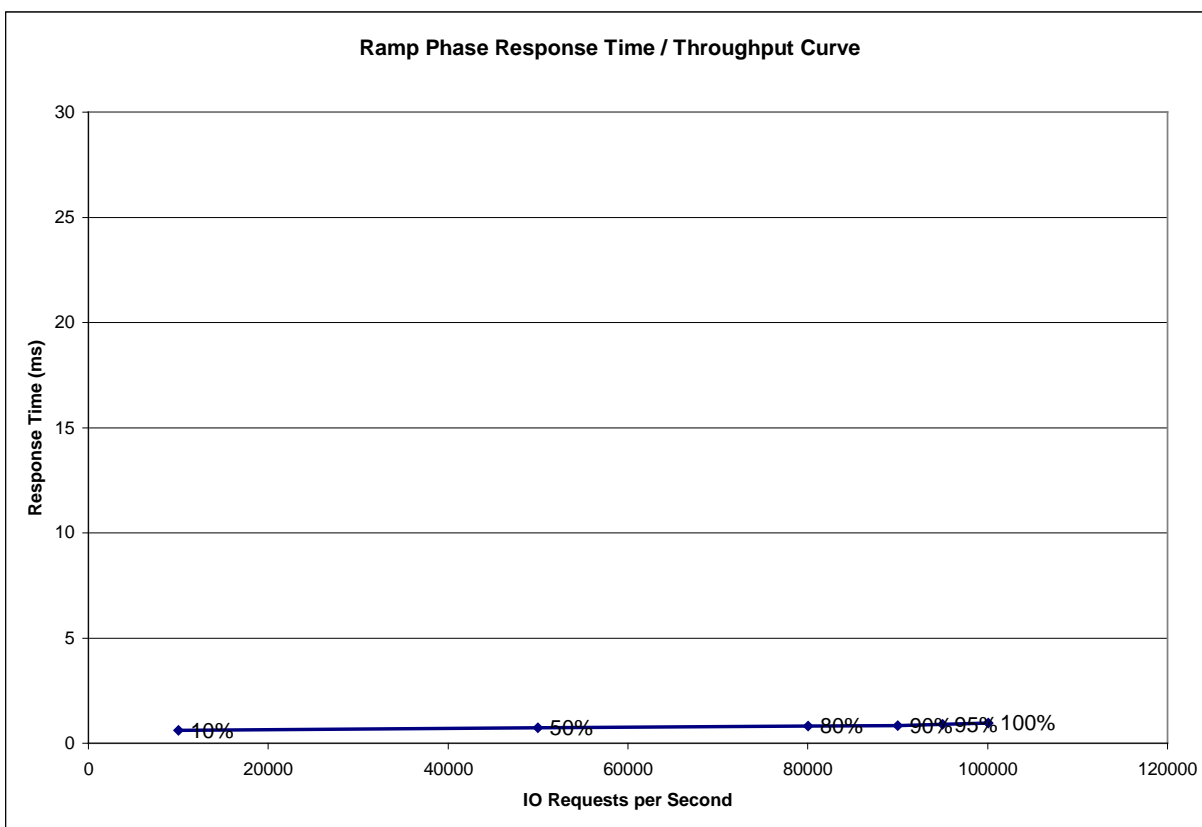
Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	9,995.00	49,988.27	80,024.46	89,996.36	94,984.18	100,051.99
Average Response Time (ms):						
All ASUs	0.61	0.74	0.81	0.85	0.90	0.95
ASU-1	0.56	0.62	0.70	0.74	0.77	0.79
ASU-2	0.75	0.76	0.85	0.89	0.93	0.95
ASU-3	0.64	1.00	1.02	1.05	1.16	1.30
Reads	0.64	0.66	0.79	0.85	0.89	0.92
Writes	0.58	0.80	0.82	0.85	0.91	0.97

SPC BENCHMARK 1™ V1.12   FULL DISCLOSURE REPORT   Submission Identifier: A00112

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Priced Storage Configuration Pricing

Product:Dorado2100				
Part #	Description	Quantity	Unit Price (USD)	Total Price(USD)
SDO21SLC24T	Dorado2100 High Performance Solid State Storage System-2.4TB(SPE31C0224,AC,24*100GB SLC SSD,8*8G FC Port,Maximum Supporting 16*8G FC Port,with HS HSSD Controller System Software)	1	52028.66	52028.66
14130321	Patch Cord,DLC/PC-DLC/PC,Multimode,2mm Parallel,3m	8	11.00	88.00
SDO21MP	Dorado2100 Multi-path Software	1	0.00	0.00
SDO21ISM	HS Integrated Storage Manager-Device Management License for Dorado2100(V100R003) (ESSENTIAL)	1	7432.56	7432.56
SDO21SSLCPAE	OceanStor HS Storage Array Control System Software-Include PAE License Certificate (ESSENTIAL)	1	14865.12	14865.12
QLE2562-CK	QLogic Dual Port 8Gb Fibre Channel to PCI Express Host Bus	4	1050.00	4200.00
			Total	78614.34
Warranty Uplift	Maintenance Service	Quantity		
TSGSDO21SLC24T	Upgrade from Standard to Gold service package in warranty period (3 years). Gold service package include:7*24 Remote Support. Access to all new software updates. 4 Business Hours Parts Delivery. 4 Business Hours Engineer Onsite.	1	11706.45	11706.45
			Total	**90,320.79**

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 with four (4) hours.

- Onsite present 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.

Huawei Technologies Co., Ltd. only sells its products to third-party resellers, who in turn, sell those products to U.S. customers. The above pricing, which also includes the required three-year maintenance and support, was obtained from one of those third-party resellers. See page 66 *("Appendix F: Third-Party Quotation")* for a copy of the third-party reseller quotation.

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

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

Priced Storage Configuration Diagram

4 - Qlogic dual-ported QLE 2562 FC HBAs
8 Fibre Channel Connections
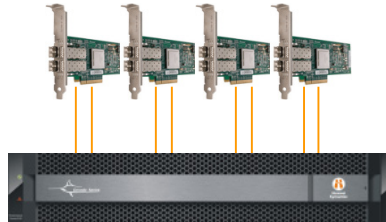
Huawei OceanStor™ Dorado2100

2 - Active-Active controllers
16 GB per controller (32 GB total)
4 - FC 4-port Adapters (8 Gbps)
8 – 8 Gbps SFPs

24 – 100 GB Solid State Devices (SSDs)

Priced Storage Configuration Components

Priced Storage Configuration:
UltraPath for Windows, version 5.2.3790.3959
4 – Qlogic dual-ported QLE2562 FC HBAs

Huawei OceanStor™ Dorado2100
  2 – Active-Active controllers
 	
    16 GB cache per controller *(32 total)*
    4 – FC 4-port 8 Gbps adapters
    8 – 8 Gbps SFPs
    8 – front-end connections *(total and used)*

24 – 100 GB Solid State Devices *(SSDs)*

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Huawei OceanStor™ Dorado2100   Revised: December 13, 2012

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 17 *(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 Benchmark Configuration (BC)/Tested Storage Configuration (TSC) was configured with local storage and, as such, did not employ a storage network.

Host System 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). Table 9-10 specifies the content, format, and appearance of the table.

The Host System and TSC table of components may be found on page 17 *(Host Systems and Tested Storage Configuration Components).*

Benchmark Configuration/Tested Storage Configuration Diagram

IBM System X3850 X5

4 - Qlogic dual-ported QLE 2562 FC HBAs
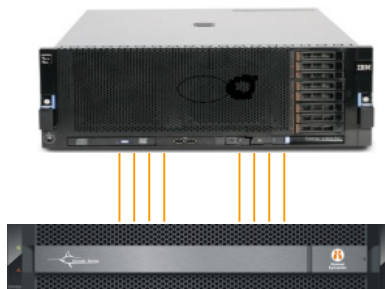
8 Fibre Channel Connections

Huawei OceanStor™ Dorado2100

2 - Active-Active controllers

16 GB per controller (32 GB total)

4 - FC 4-port Adapters (8 Gbps)

8 – 8 Gbps SFPs

24 – 100 GB Solid State Devices (SSDs)

Host Systems and Tested Storage Configuration Components

Host System:	Tested Storage Configuration (TSC):

IBM System X3850 X5
    4 – Intel Xeon 6-core 1.86 GHz processors
        with 12 MB of shared L3 cache
	UltraPath for Windows, version 5.2.3790.3959

	4 – Qlogic dual-ported QLE2562 FC HBAs
32 GB main memory	**Huawei OceanStor™ Dorado2100** **2 – Active-Active controllers**
Windows Server 2003 Enterprise Edition 64-bit w/SP2	

cygwin version 1.7.7-1
 with the "expect" and "openssh" packages
	16 GB cache per controller *(32 total)*
	        4 – FC 4-port 8 Gbps adapters
	        8 – 8 Gbps SFPs
	        8 – front-end connections *(total and used)*

PCIe	24 – 100 GB Solid State Devices *(SSDs)*

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 58 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 59 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 64.

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 54 contains definitions of terms specific to the SPC-1 Data Repository.

Storage Capacities and Relationships

Clause 9.4.3.6.1

Two tables and an illustration documenting the storage capacities and relationships of the SPC-1 Storage Hierarchy (Clause 2.1) shall be included in the FDR.

SPC-1 Storage Capacities

SPC-1 Storage Capacities		
Storage Hierarchy Component	**Units**	**Capacity**
Total ASU Capacity	Gigabytes (GB)	1,104.947
Addressable Storage Capacity	Gigabytes (GB)	1,104.947
Configured Storage Capacity	Gigabytes (GB)	2,331.093
Physical Storage Capacity	Gigabytes (GB)	2,400.694
Data Protection *(Mirroring)*	Gigabytes (GB)	1,165.547
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	68.719
Total Unused Storage	Gigabytes (GB)	122.079

SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	47.40%	46.03%
Required for Data Protection *(Mirroring)*		50.00%	48.55%
Addressable Storage Capacity		47.40%	46.03%
Required Storage		0.00%	0.00%
Configured Storage Capacity			97.10%
Global Storage Overhead			2.86%
Unused Storage:			
Addressable	0.00%		
Configured		5.20%	
Physical			0.04%

The Physical Storage Capacity consisted of 2,400.694 GB distributed over 24 solid state devices (SSDs), each with a formatted capacity of 100.029 GB. There was 0.881 GB (0.04%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 68.719 GB (2.86%) of the Physical Storage Capacity. There was 121.199 GB (5.20%) of Unused Storage within the Configured Storage Capacity. The Total ASU Capacity utilized 100% 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 1,165.547 GB of which 1,104.947 GB was utilized. The total Unused Storage was 122.079 GB.

SPC-1 Storage Capacities and Relationships Illustration

The various storage capacities configured in the benchmark result are illustrated below *(not to scale)*.
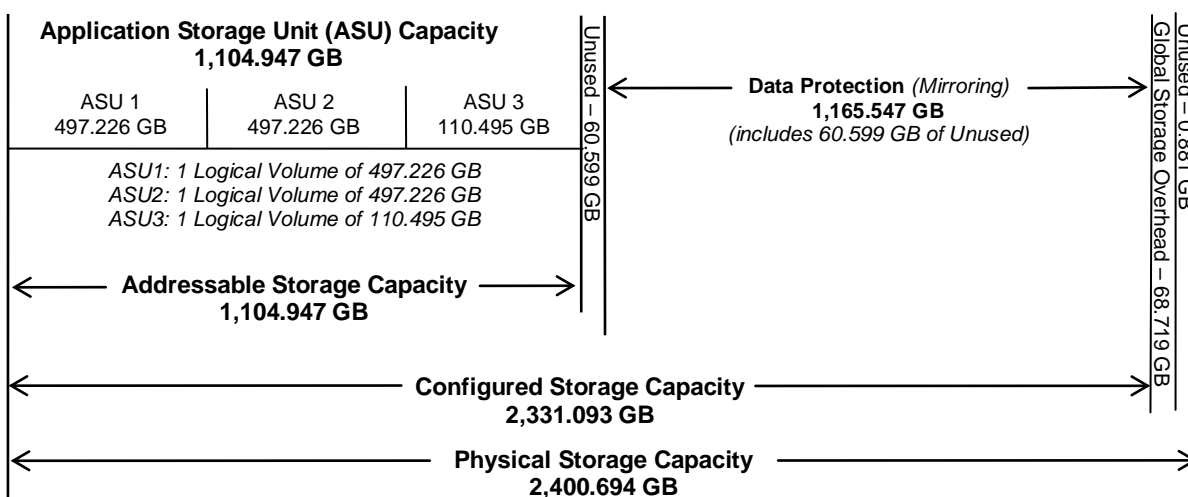
Logical Volume Capacity and ASU Mapping

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.

Logical Volume Capacity and Mapping		
ASU-1 (497.226 GB)	**ASU-2 (497.226 GB)**	**ASU-3 (110.495 GB)**
1 Logical Volume 497.226 GB per Logical Volume (497.226 used per Logical Volume)	1 Logical Volume 497.226 GB per Logical Volume (497.226 used per Logical Volume)	1 Logical Volume 110.495 GB per Logical Volume (110.495 used per Logical Volume)

The Data Protection Level used for all Logical Volumes was "Mirrored" as described on page 11. See "ASU Configuration" in the **IOPS Test Results File** for more detailed configuration information.

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	46.03%
Protected Application Utilization	92.05%
Unused Storage Ratio	5.09%

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. "SPC-1 Test Execution Definitions" on page 55 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
    - o 95% of IOPS Test Run
    - o 90% of IOPS Test Run
    - o 80% of IOPS Test Run
    - o 50% of IOPS Test Run
    - o 10% of IOPS Test Run (LRT)

- **Repeatability Test**
  - ➢ Repeatability Test Phase 1
    - o 10% of IOPS Test Run (LRT)
    - o IOPS Test Run
  - ➢ Repeatability Test Phase 2
    - o 10% of IOPS Test Run (LRT)
    - o 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.

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 three (3) 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 9.4.3.7.1

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 65.

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 table of data is not embedded in this document due to its size. The table is available via the following URL:

Sustainability Data Rate Table

Sustainability – Data Rate Distribution Graph
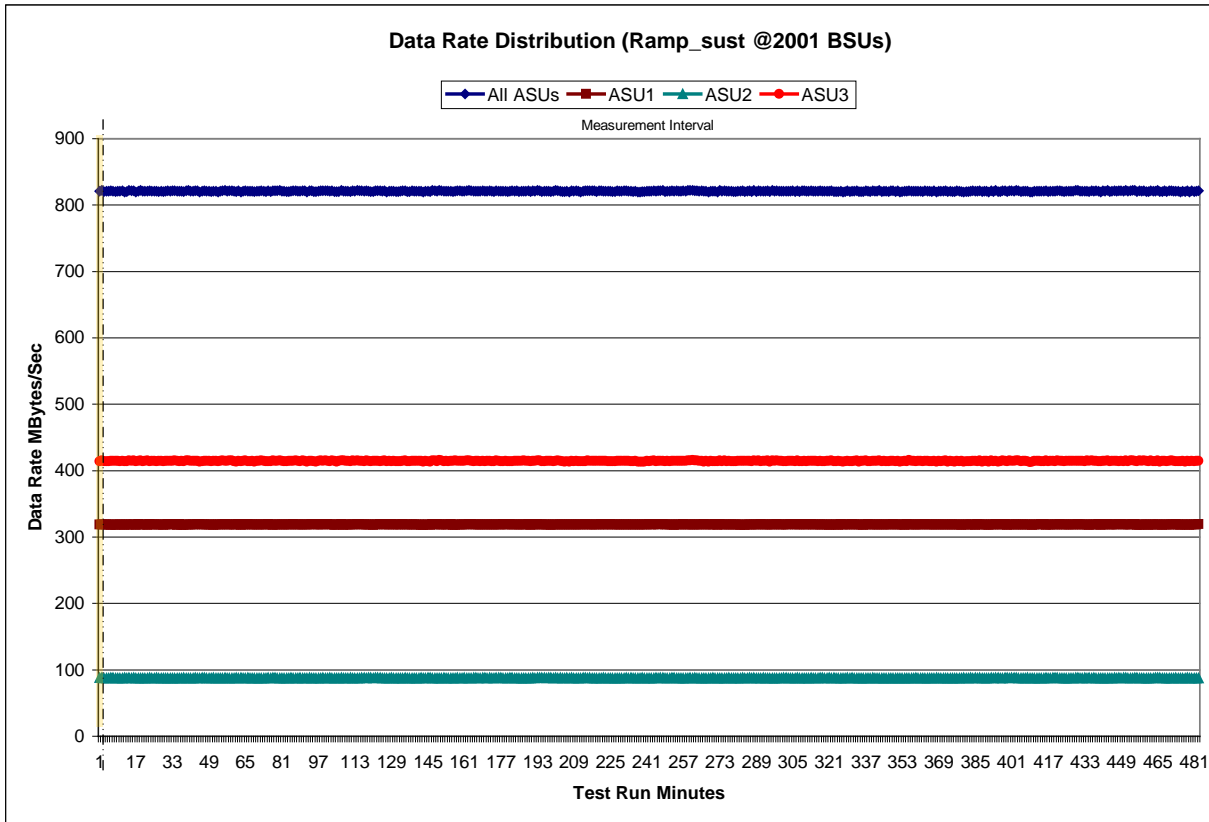
Sustainability – I/O Request Throughput Distribution Data

The Sustainability I/O Request Throughput table of data 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
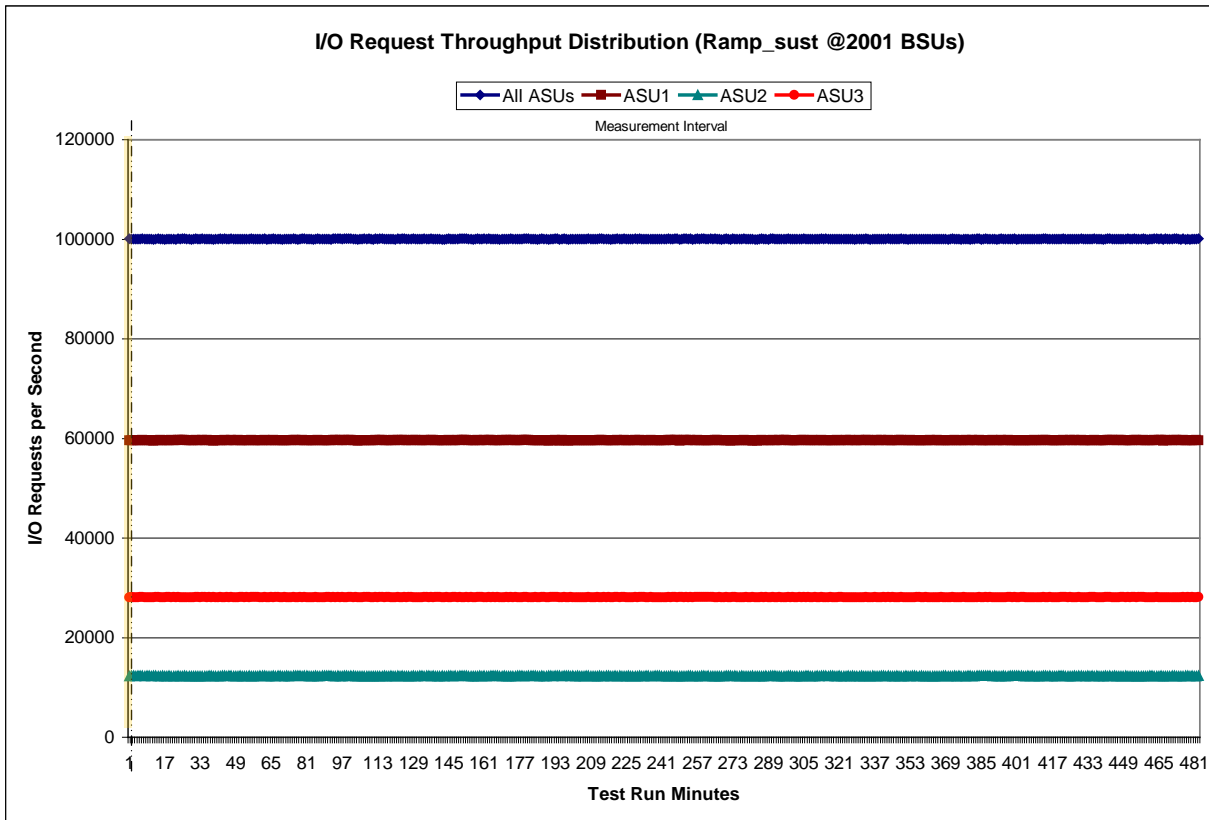
Sustainability – Average Response Time (ms) Distribution Data

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

Sustainability Average Response Time Table

Sustainability – Average Response Time (ms) Distribution Graph
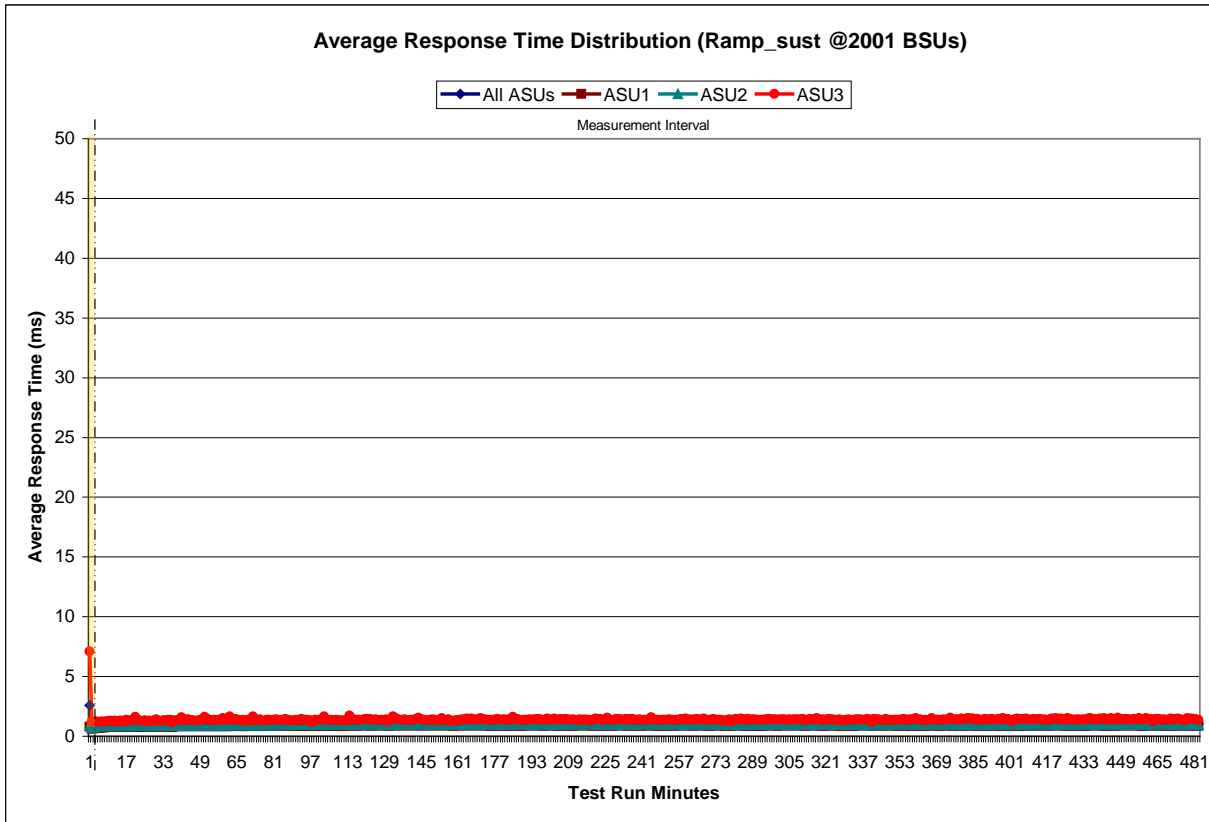
Sustainability – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	104,442,028	101,527,111	431,529,843	148,617,515	79,958,228	75,070,792	60,520,807	28,860,557
Write	46,733	240,741,874	578,714,848	432,018,407	215,664,236	115,268,509	87,919,623	32,209,769
All ASUs	104,488,761	342,268,985	1,010,244,691	580,635,922	295,622,464	190,339,301	148,440,430	61,070,326
ASU1	101,537,945	281,636,510	716,939,810	260,369,236	121,703,070	72,259,270	50,591,504	23,499,916
ASU2	2,947,230	53,920,060	152,833,040	58,339,729	27,768,248	16,581,094	12,257,640	6,178,619
ASU3	3,586	6,712,415	140,471,841	261,926,957	146,151,146	101,498,937	85,591,286	31,391,791

Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	37,784,117	20,067,788	15,910,049	8,705,950	8,066,049	4,936,290	5,499,681	2,050,087
Write	15,812,134	6,439,531	2,568,128	1,707,797	1,264,324	1,030,719	1,759,239	1,386,142
All ASUs	53,596,251	26,507,319	18,478,177	10,413,747	9,330,373	5,967,009	7,258,920	3,436,229
ASU1	30,650,585	16,380,242	13,013,644	7,262,438	6,736,726	4,156,882	4,772,117	1,948,616
ASU2	8,146,976	4,325,437	3,499,474	1,954,817	1,805,478	1,122,355	1,304,468	528,371
ASU3	14,798,690	5,801,640	1,965,059	1,196,492	788,169	687,772	1,182,335	959,242

Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	792,884	415,218	219,930	474,496	245,955	202,934	175,178	397,347
Write	1,139,519	934,958	796,251	3,058,539	1,396,648	441,267	270,480	2,513,790
All ASUs	1,932,403	1,350,176	1,016,181	3,533,035	1,642,603	644,201	445,658	2,911,137
ASU1	855,999	474,678	265,660	682,890	380,283	306,552	256,749	754,309
ASU2	222,831	119,526	65,021	152,613	80,124	63,550	52,955	165,628
ASU3	853,573	755,972	685,500	2,697,532	1,182,196	274,099	135,954	1,991,200

Sustainability – Response Time Frequency Distribution Graph
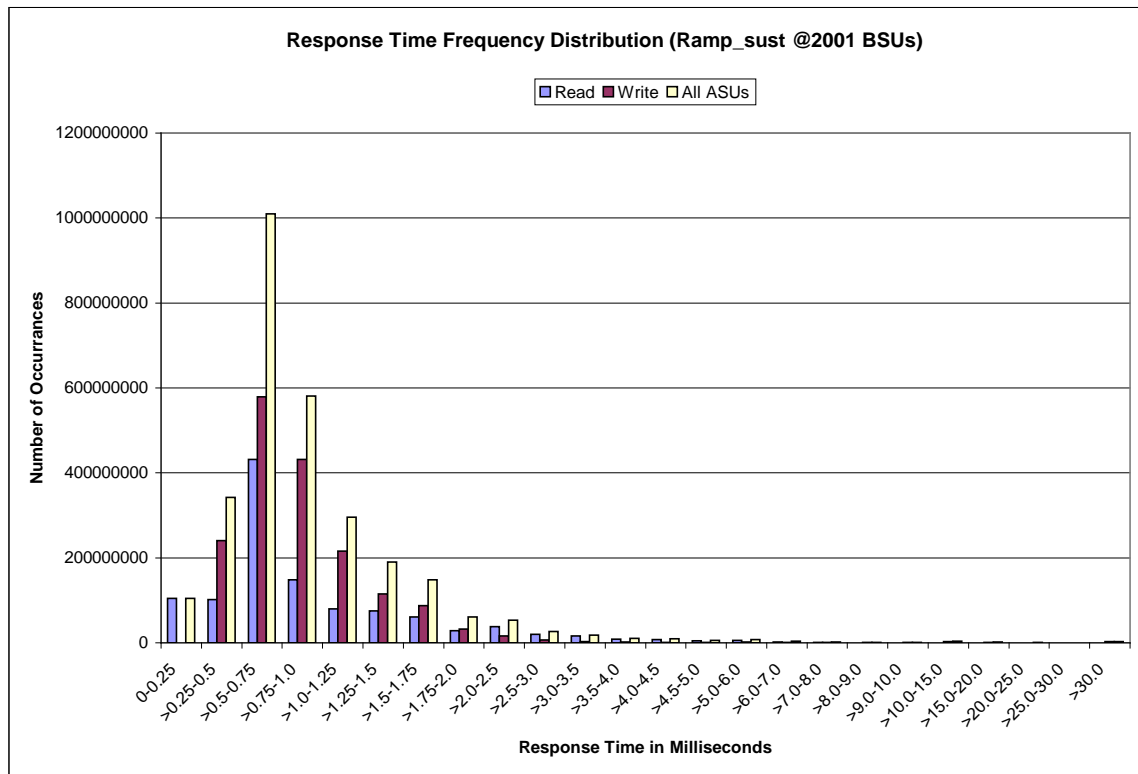
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

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 5.3.13.2

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 5.3.13.3

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	0.002	0.001	0.002	0.001	0.003	0.002	0.002	0.001

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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 9.4.3.7.2

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 t 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 65.

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

2,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:09:51	3:12:52	0-2	0:03:01
Measurement Interval	3:12:52	3:22:52	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	99,975.25	59,617.27	12,273.45	28,084.53
1	100,133.35	59,649.73	12,319.25	28,164.37
2	100,039.17	59,645.82	12,290.65	28,102.70
3	100,007.02	59,619.27	12,297.60	28,090.15
4	100,078.12	59,658.87	12,306.53	28,112.72
5	100,082.72	59,665.68	12,310.95	28,106.08
6	100,003.95	59,594.70	12,299.05	28,110.20
7	100,091.28	59,662.03	12,312.22	28,117.03
8	100,028.37	59,598.67	12,302.40	28,127.30
9	100,083.05	59,625.80	12,315.32	28,141.93
10	100,056.68	59,610.93	12,323.05	28,122.70
11	100,049.10	59,614.43	12,323.13	28,111.53
12	100,039.65	59,622.82	12,313.92	28,102.92
Average	*100,051.99*	*59,627.32*	*12,310.42*	*28,114.26*

IOPS Test Run – I/O Request Throughput Distribution Graph
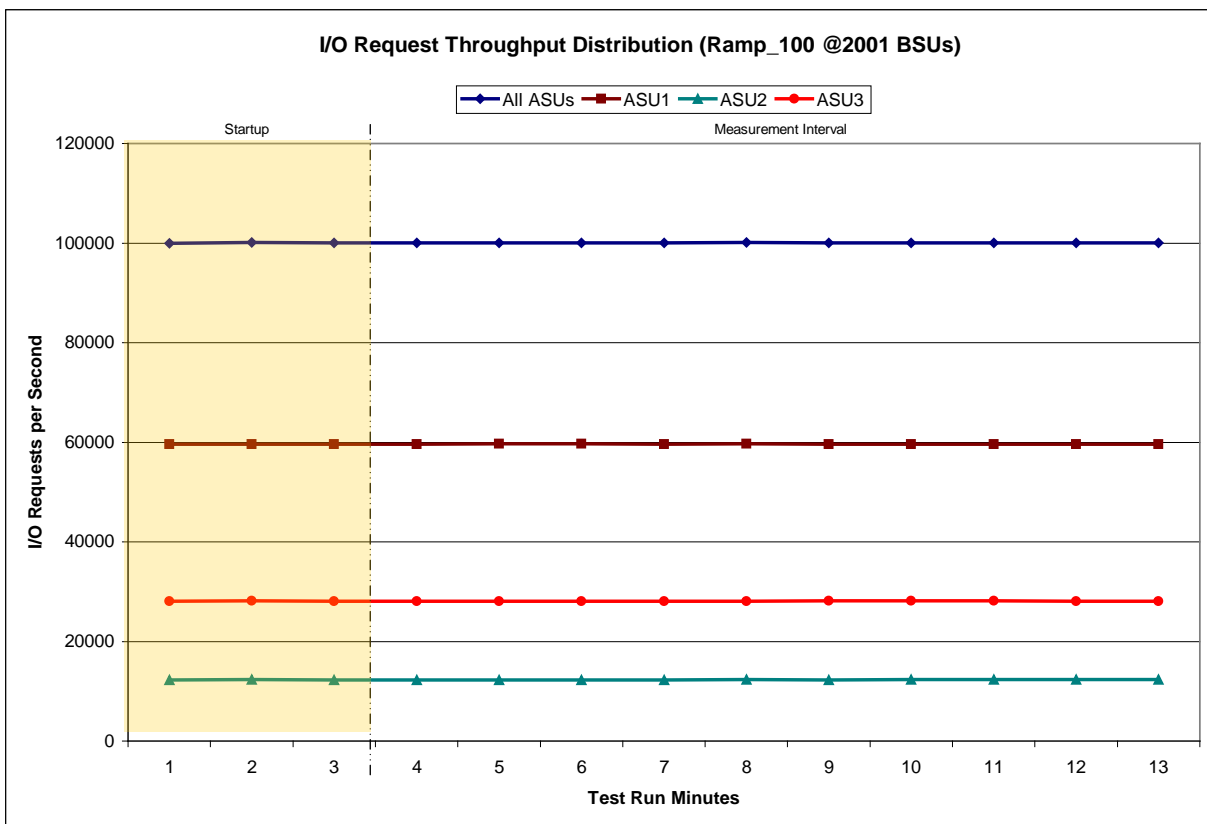
IOPS Test Run – Average Response Time (ms) Distribution Data

2,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:09:51	3:12:52	0-2	0:03:01
Measurement Interval	3:12:52	3:22:52	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.50	0.94	1.08	6.42
1	0.93	0.75	0.95	1.30
2	0.90	0.73	0.92	1.24
3	0.91	0.75	0.93	1.26
4	0.91	0.76	0.93	1.23
5	0.94	0.77	0.94	1.29
6	0.95	0.79	0.95	1.31
7	0.96	0.80	0.95	1.29
8	0.96	0.81	0.95	1.28
9	0.98	0.82	0.96	1.33
10	0.97	0.81	0.95	1.32
11	0.97	0.81	0.96	1.32
12	0.99	0.82	0.96	1.34
Average	*0.95*	*0.79*	*0.95*	*1.30*

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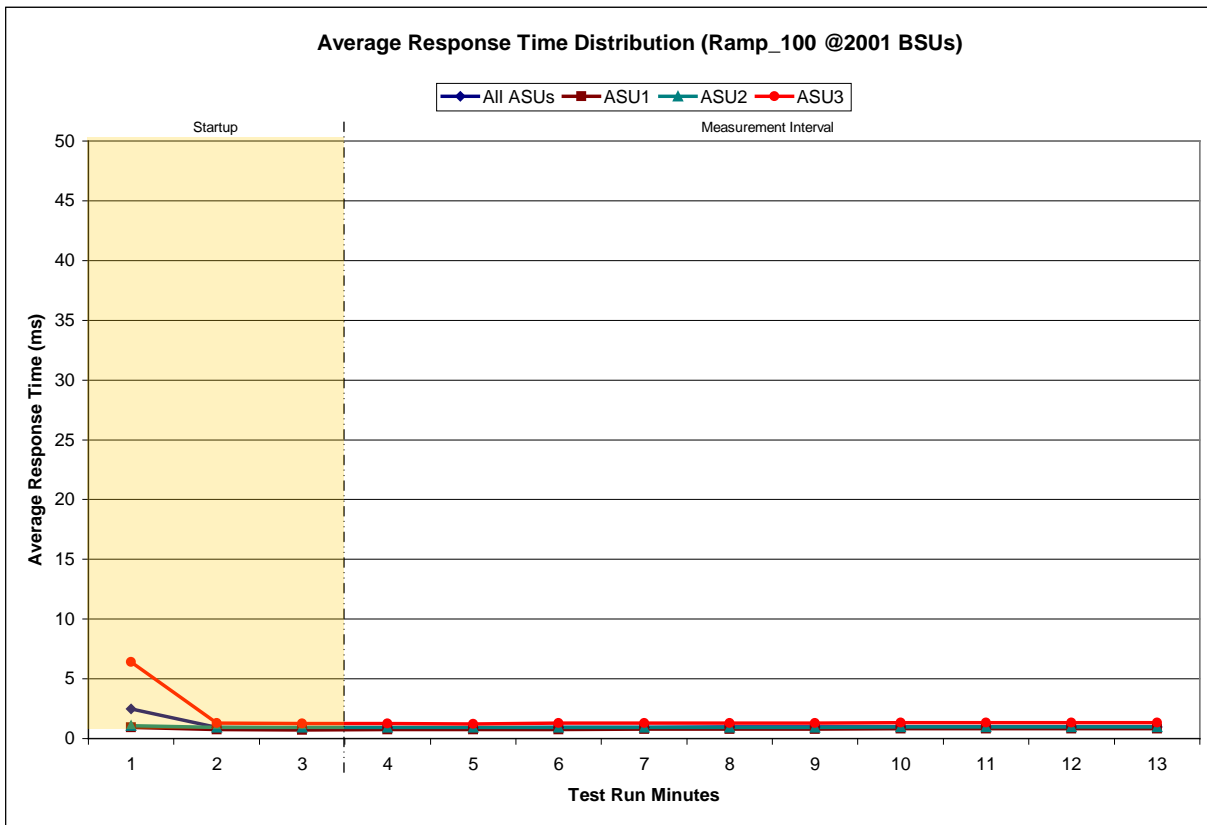
IOPS Test Run – Response Time Frequency Distribution Data

Response Time (ms)	0-0.25	>0.25-0.5	>0.5-0.75	>0.75-1.0	>1.0-1.25	>1.25-1.5	>1.5-1.75	>1.75-2.0
Read	4,293,068	2,819,186	7,602,723	2,559,769	1,377,117	1,374,033	1,108,461	534,472
Write	1,445	5,568,436	12,643,745	9,007,021	4,082,857	2,252,827	1,563,405	522,401
All ASUs	4,294,513	8,387,622	20,246,468	11,566,790	5,459,974	3,626,860	2,671,866	1,056,873
ASU1	4,185,181	6,950,071	13,702,973	4,723,306	2,040,999	1,246,795	883,545	417,228
ASU2	109,191	1,236,342	3,136,435	1,144,668	519,198	342,780	262,875	131,510
ASU3	141	201,209	3,407,060	5,698,816	2,899,777	2,037,285	1,525,446	508,135

Response Time (ms)	>2.0-2.5	>2.5-3.0	>3.0-3.5	>3.5-4.0	>4.0-4.5	>4.5-5.0	>5.0-6.0	>6.0-7.0
Read	698,594	395,414	310,540	166,372	152,034	93,350	102,975	35,990
Write	238,196	98,606	42,647	31,270	23,897	20,399	34,150	26,669
All ASUs	936,790	494,020	353,187	197,642	175,931	113,749	137,125	62,659
ASU1	546,621	310,679	244,931	133,914	122,513	75,990	86,865	33,823
ASU2	170,305	96,974	77,239	42,608	38,832	23,924	27,069	10,072
ASU3	219,864	86,367	31,017	21,120	14,586	13,835	23,191	18,764

Response Time (ms)	>7.0-8.0	>8.0-9.0	>9.0-10.0	>10.0-15.0	>15.0-20.0	>20.0-25.0	>25.0-30.0	>30.0
Read	12,696	5,783	3,067	7,854	4,891	4,565	3,709	6,968
Write	22,200	18,219	16,235	60,115	23,406	8,277	5,441	45,627
All ASUs	34,896	24,002	19,302	67,969	28,297	12,842	9,150	52,595
ASU1	13,952	7,172	4,035	11,913	7,556	6,665	5,416	14,213
ASU2	3,734	1,772	984	2,602	1,536	1,331	1,114	3,142
ASU3	17,210	15,058	14,283	53,454	19,205	4,846	2,620	35,240

IOPS Test Run –Response Time Frequency Distribution Graph
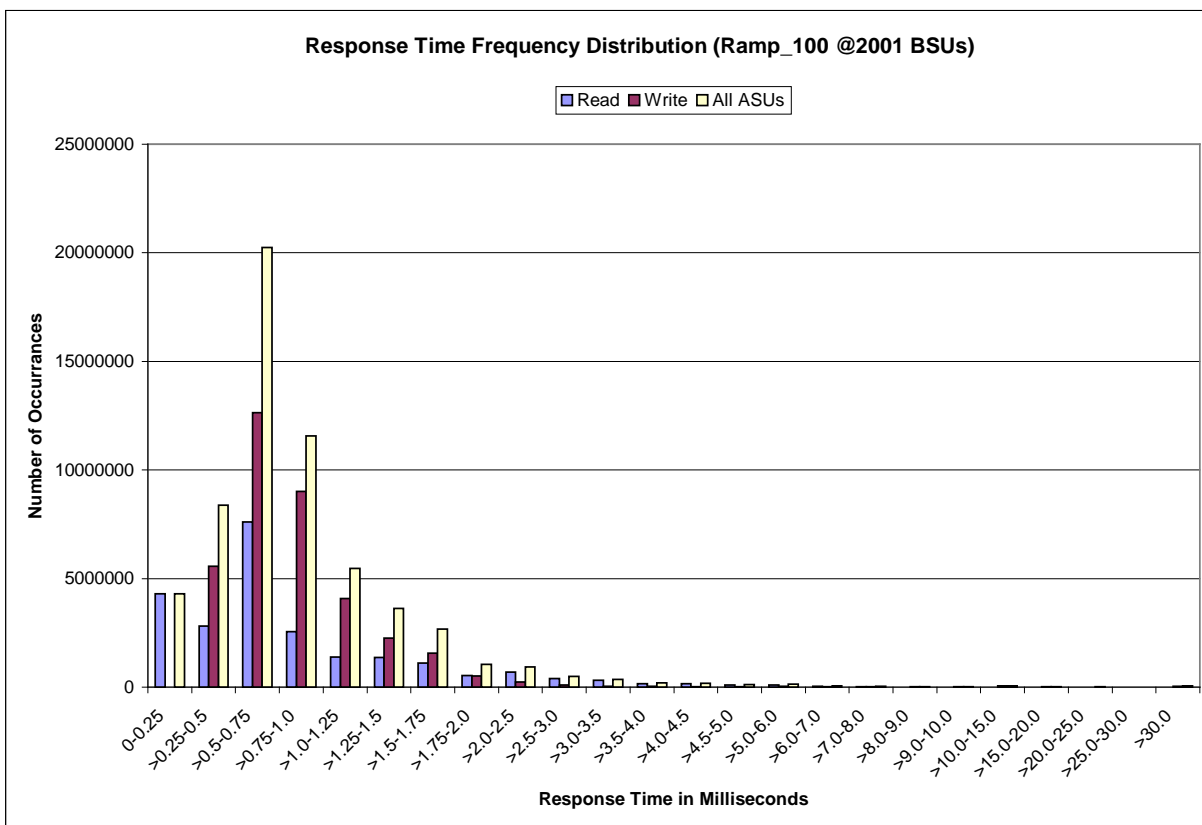
IOPS Test Run – I/O Request Information

I/O Requests Completed in the Measurement Interval	I/O Requests Completed with Response Time = or < 30 ms	I/O Requests Completed with Response Time > 30 ms
60,031,122	59,978,527	52,595

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 5.3.13.2

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 5.3.13.3

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	0.2099	0.0180	0.0700	0.0350	0.2810
COV	0.003	0.001	0.001	0.001	0.004	0.002	0.002	0.000

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 13.

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 9.4.3.7.3

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 65.

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 tables and graphs for completeness.

100% Load Level - 2,001 BSUs	Start	Stop	Interval	Duration	95% Load Level - 1,900 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:09:51	3:12:52	0-2	0:03:01	Start-Up/Ramp-Up	3:23:00	3:26:01	0-2	0:03:01
Measurement Interval	3:12:52	3:22:52	3-12	0:10:00	Measurement Interval	3:26:01	3:36:01	3-12	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	99,975.25	59,617.27	12,273.45	28,084.53	0	95,005.50	56,635.27	11,689.23	26,681.00
1	100,133.35	59,649.73	12,319.25	28,164.37	1	95,000.22	56,607.03	11,695.12	26,698.07
2	100,039.17	59,645.82	12,290.65	28,102.70	2	94,979.28	56,618.93	11,680.13	26,680.22
3	100,007.02	59,619.27	12,297.60	28,090.15	3	94,962.57	56,623.57	11,676.90	26,662.10
4	100,078.12	59,658.87	12,306.53	28,112.72	4	94,972.80	56,559.62	11,702.92	26,710.27
5	100,082.72	59,665.68	12,310.95	28,106.08	5	94,981.63	56,611.47	11,679.70	26,690.47
6	100,003.95	59,594.70	12,299.05	28,110.20	6	94,974.27	56,636.17	11,656.90	26,681.20
7	100,091.28	59,662.03	12,312.22	28,117.03	7	94,955.72	56,576.15	11,675.00	26,704.57
8	100,028.37	59,598.67	12,302.40	28,127.30	8	94,975.88	56,625.42	11,676.67	26,673.80
9	100,083.05	59,625.80	12,315.32	28,141.93	9	94,981.60	56,621.88	11,657.77	26,701.95
10	100,056.68	59,610.93	12,323.05	28,122.70	10	94,999.37	56,583.80	11,709.23	26,706.33
11	100,049.10	59,614.43	12,323.13	28,111.53	11	95,004.75	56,646.58	11,668.63	26,689.53
12	100,039.65	59,622.82	12,313.92	28,102.92	12	95,033.25	56,637.77	11,679.77	26,715.72
Average	*100,051.99*	*59,627.32*	*12,310.42*	*28,114.26*	*Average*	*94,984.18*	*56,612.24*	*11,678.35*	*26,693.59*

90% Load Level - 1,800 BSUs	Start	Stop	Interval	Duration	80% Load Level - 1,600 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	3:36:08	3:39:09	0-2	0:03:01	Start-Up/Ramp-Up	3:49:16	3:52:17	0-2	0:03:01
Measurement Interval	3:39:09	3:49:09	3-12	0:10:00	Measurement Interval	3:52:17	4:02:17	3-12	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	89,973.07	53,620.40	11,067.43	25,285.23	0	80,070.77	47,723.92	9,844.95	22,501.90
1	89,950.75	53,634.85	11,057.77	25,258.13	1	79,997.17	47,700.35	9,817.30	22,479.52
2	89,998.52	53,624.00	11,077.03	25,297.48	2	80,052.17	47,704.28	9,851.18	22,496.70
3	89,977.40	53,597.40	11,073.65	25,306.35	3	79,998.40	47,685.78	9,830.80	22,473.82
4	90,065.93	53,684.30	11,074.25	25,307.38	4	80,099.10	47,771.00	9,848.97	22,479.13
5	90,009.60	53,626.07	11,086.57	25,296.97	5	80,069.17	47,748.40	9,830.82	22,489.95
6	90,010.20	53,635.03	11,080.50	25,294.67	6	79,978.57	47,690.48	9,833.95	22,454.13
7	89,966.28	53,614.18	11,051.28	25,300.82	7	79,998.42	47,669.18	9,844.25	22,484.98
8	89,964.00	53,618.92	11,067.28	25,277.80	8	80,016.77	47,647.90	9,858.77	22,510.10
9	89,991.80	53,621.45	11,080.82	25,289.53	9	80,096.28	47,759.48	9,854.02	22,482.78
10	89,985.12	53,591.80	11,084.28	25,309.03	10	80,018.45	47,729.05	9,835.08	22,454.32
11	89,957.85	53,617.23	11,078.95	25,261.67	11	79,949.33	47,633.97	9,828.75	22,486.62
12	90,035.40	53,669.57	11,074.23	25,291.60	12	80,020.10	47,694.80	9,841.33	22,483.97
Average	*89,996.36*	*53,627.60*	*11,075.18*	*25,293.58*	*Average*	*80,024.46*	*47,703.01*	*9,841.47*	*22,479.98*

50% Load Level - 1,000 BSUs	Start	Stop	Interval	Duration	10% Load Level - 200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:02:22	4:05:23	0-2	0:03:01	Start-Up/Ramp-Up	4:15:26	4:18:27	0-2	0:03:01
Measurement Interval	4:05:23	4:15:23	3-12	0:10:00	Measurement Interval	4:18:27	4:28:27	3-12	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	49,980.50	29,787.93	6,138.33	14,054.23	0	10,019.63	5,977.15	1,227.78	2,814.70
1	49,999.88	29,806.07	6,148.05	14,045.77	1	10,002.52	5,958.30	1,235.60	2,808.62
2	50,014.00	29,791.13	6,145.87	14,077.00	2	9,976.78	5,940.10	1,224.73	2,811.95
3	49,988.23	29,827.48	6,138.38	14,022.37	3	10,000.80	5,962.32	1,226.60	2,811.88
4	50,011.90	29,848.62	6,138.37	14,024.92	4	9,993.12	5,946.50	1,229.97	2,816.65
5	49,997.33	29,799.23	6,159.92	14,038.18	5	9,995.52	5,954.58	1,225.05	2,815.88
6	49,995.02	29,804.38	6,152.62	14,038.02	6	10,000.63	5,955.15	1,227.80	2,817.68
7	50,005.02	29,814.67	6,146.63	14,043.72	7	9,989.12	5,949.00	1,228.03	2,812.08
8	49,934.33	29,754.98	6,146.60	14,032.75	8	10,000.70	5,963.90	1,224.55	2,812.25
9	50,007.48	29,789.28	6,153.03	14,065.17	9	9,993.98	5,950.42	1,228.67	2,814.90
10	49,989.12	29,814.50	6,153.32	14,021.30	10	9,977.12	5,944.08	1,235.90	2,797.13
11	49,943.78	29,758.50	6,142.75	14,042.53	11	10,000.75	5,949.37	1,230.82	2,820.57
12	50,010.48	29,815.30	6,145.83	14,049.35	12	9,998.30	5,958.53	1,234.28	2,805.48
Average	*49,988.27*	*29,802.70*	*6,147.75*	*14,037.83*	*Average*	*9,995.00*	*5,953.39*	*1,229.17*	*2,812.45*

Response Time Ramp Distribution (IOPS) Graph
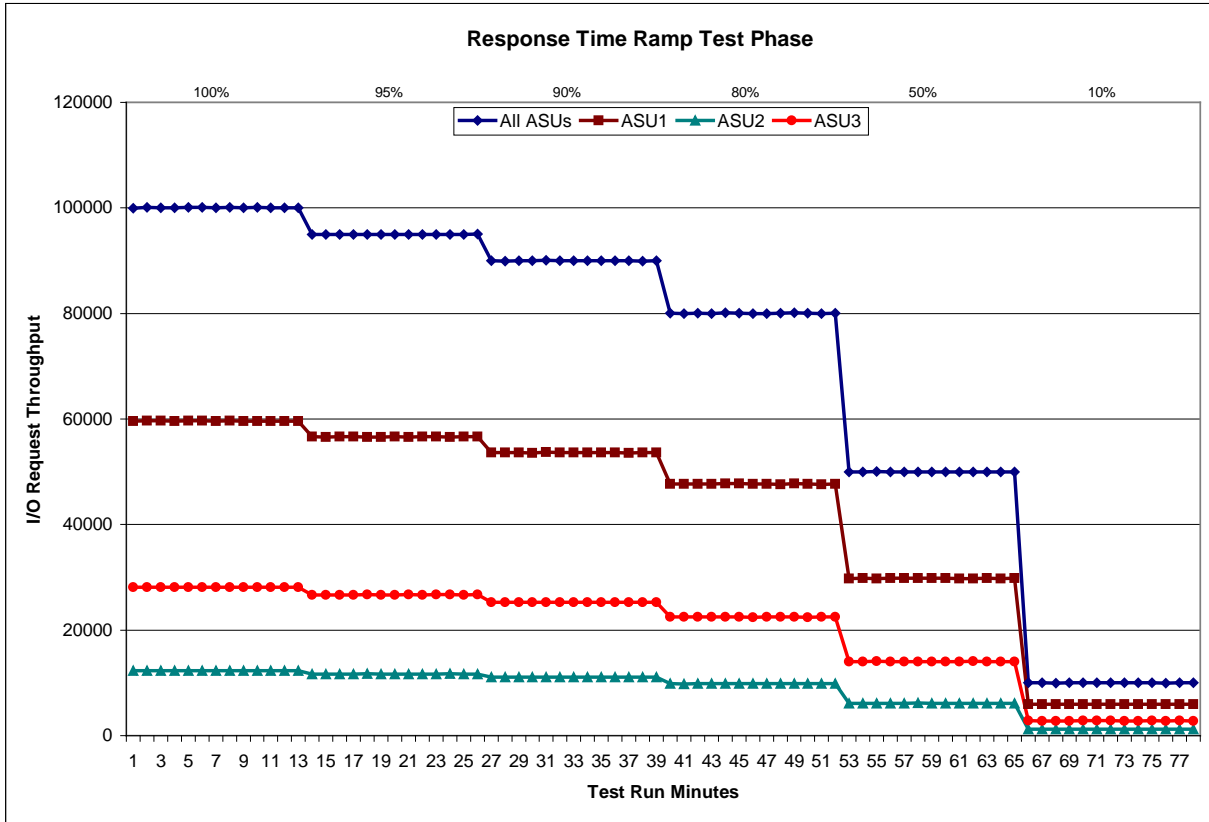
SPC-1 LRT™ Average Response Time (ms) Distribution Data

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:15:26	4:18:27	0-2	0:03:01
Measurement Interval	4:18:27	4:28:27	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.59	0.55	0.69	0.62
1	0.59	0.55	0.69	0.64
2	0.60	0.54	0.70	0.67
3	0.60	0.54	0.69	0.66
4	0.58	0.54	0.71	0.62
5	0.61	0.56	0.75	0.64
6	0.61	0.57	0.76	0.64
7	0.60	0.56	0.76	0.61
8	0.61	0.57	0.76	0.64
9	0.60	0.56	0.77	0.63
10	0.61	0.56	0.75	0.65
11	0.61	0.57	0.75	0.65
12	0.62	0.57	0.78	0.66
Average	*0.61*	*0.56*	*0.75*	*0.64*

SPC-1 LRT™ Average Response Time (ms) Distribution Graph
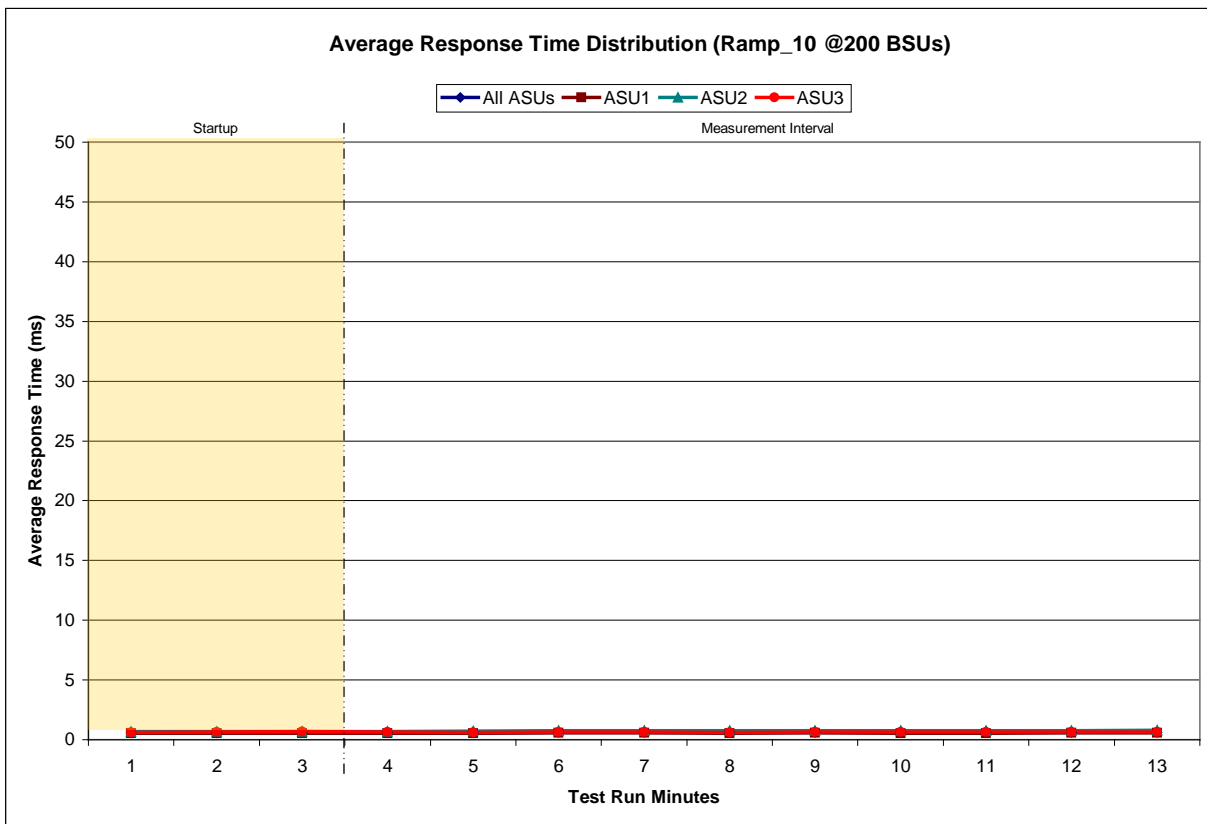
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

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 5.3.13.2

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 5.3.13.3

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	0.0351	0.2808	0.0701	0.2096	0.0181	0.0700	0.0349	0.2814
COV	0.006	0.002	0.003	0.003	0.011	0.004	0.011	0.002

Repeatability Test

Clause 5.4.5

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ primary metric and 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 9.4.3.7.4

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 65.

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™
Primary Metrics	*100,051.99*
Repeatability Test Phase 1	100,065.80
Repeatability Test Phase 2	100,058.76

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 greater than 95% of the reported SPC-1 IOPS™ Primary Metric.

	SPC-1 LRT™
Primary Metrics	*0.61 ms*
Repeatability Test Phase 1	0.61 ms
Repeatability Test Phase 2	0.60 ms

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 minus 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

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:28:35	4:31:35	0-2	0:03:00
Measurement Interval	4:31:35	4:41:35	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9,984.05	5,942.82	1,228.65	2,812.58
1	9,988.67	5,951.08	1,228.18	2,809.40
2	10,003.47	5,963.53	1,229.68	2,810.25
3	9,981.25	5,953.05	1,229.00	2,799.20
4	10,013.02	5,966.27	1,236.25	2,810.50
5	9,989.93	5,963.62	1,226.30	2,800.02
6	10,016.50	5,966.37	1,235.27	2,814.87
7	9,979.12	5,948.37	1,227.83	2,802.92
8	9,994.20	5,956.22	1,230.05	2,807.93
9	10,005.63	5,961.50	1,233.52	2,810.62
10	9,989.52	5,953.95	1,225.80	2,809.77
11	10,000.82	5,952.73	1,238.35	2,809.73
12	10,025.07	5,986.32	1,233.45	2,805.30
Average	*9,999.51*	*5,960.84*	*1,231.58*	*2,807.09*

Repeatability 1 LRT – I/O Request Throughput Distribution Graph
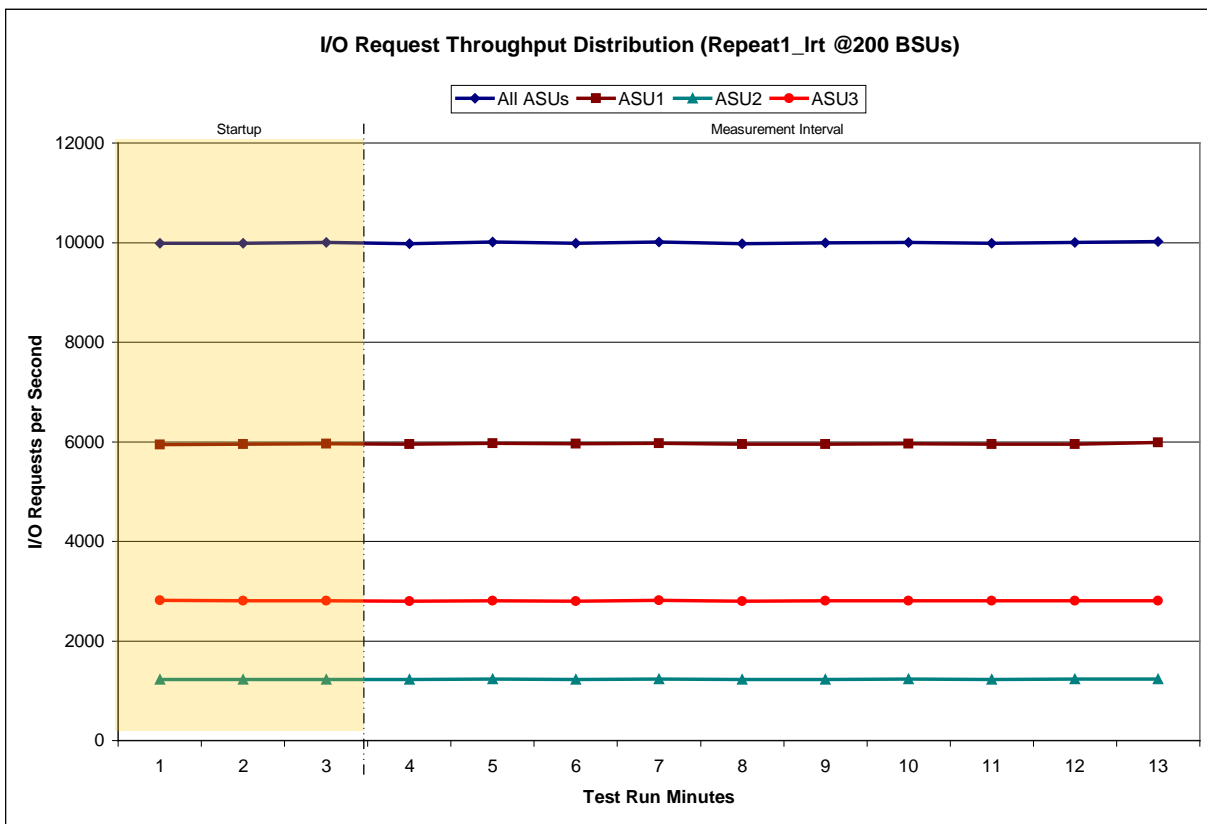
Repeatability 1 LRT –Average Response Time (ms) Distribution Data

200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:28:35	4:31:35	0-2	0:03:00
Measurement Interval	4:31:35	4:41:35	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.61	0.57	0.77	0.64
1	0.61	0.56	0.76	0.64
2	0.63	0.56	0.77	0.70
3	0.59	0.54	0.75	0.61
4	0.61	0.57	0.76	0.64
5	0.60	0.55	0.75	0.63
6	0.60	0.56	0.76	0.62
7	0.61	0.57	0.77	0.63
8	0.61	0.56	0.77	0.64
9	0.60	0.55	0.75	0.62
10	0.62	0.57	0.77	0.66
11	0.61	0.57	0.77	0.63
12	0.62	0.58	0.78	0.65
Average	*0.61*	*0.56*	*0.76*	*0.63*

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

Repeatability 1 IOPS – I/O Request Throughput Distribution Data

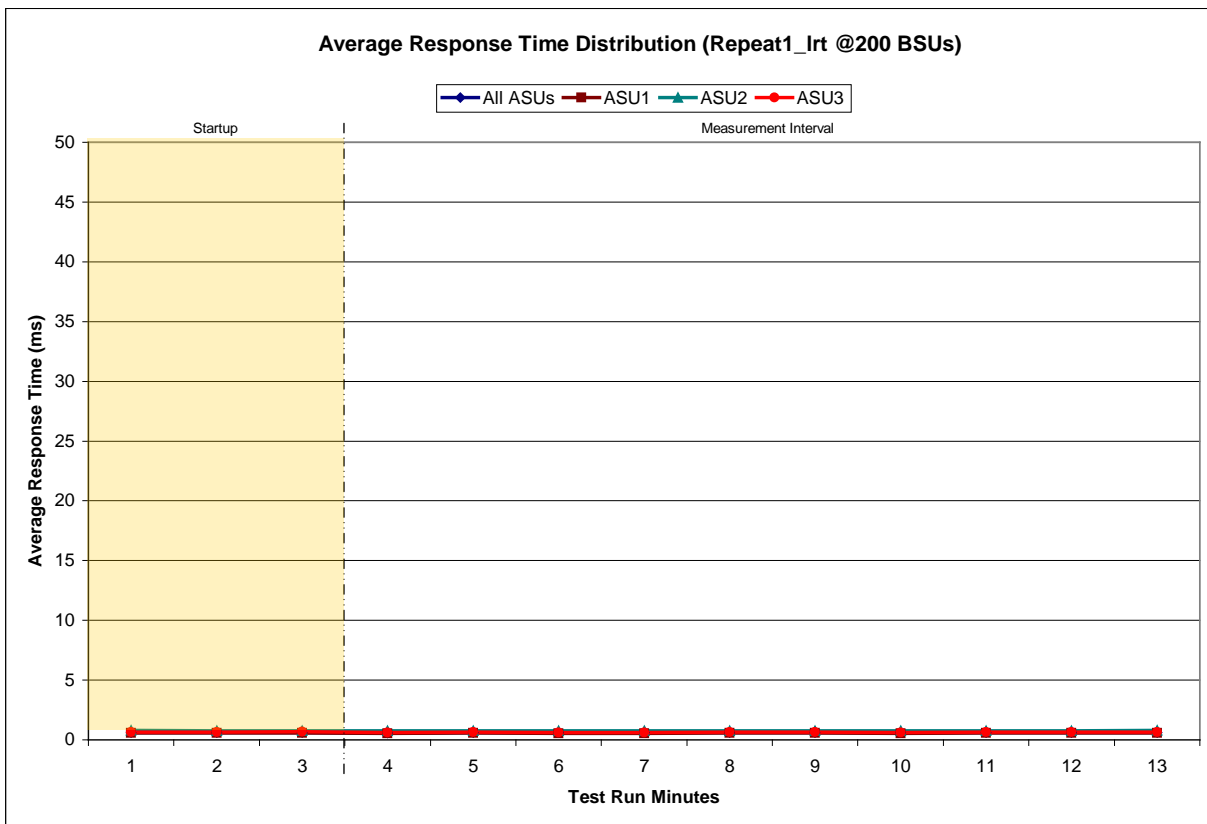| 2,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:41:43	4:44:44	0-2	0:03:01
Measurement Interval	4:44:44	4:54:44	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	100,134.43	59,699.83	12,306.87	28,127.73
1	100,017.87	59,591.28	12,298.45	28,128.13
2	100,106.48	59,659.90	12,298.05	28,148.53
3	100,057.40	59,631.25	12,307.60	28,118.55
4	100,052.27	59,636.63	12,293.17	28,122.47
5	100,086.35	59,673.12	12,299.23	28,114.00
6	100,061.78	59,636.75	12,288.95	28,136.08
7	99,956.55	59,569.60	12,293.67	28,093.28
8	100,059.05	59,641.88	12,335.45	28,081.72
9	100,095.57	59,655.32	12,332.12	28,108.13
10	100,136.25	59,676.38	12,320.68	28,139.18
11	100,067.68	59,614.92	12,321.57	28,131.20
12	100,085.08	59,657.85	12,327.38	28,099.85
Average	*100,065.80*	*59,639.37*	*12,311.98*	*28,114.45*

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

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

2,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:41:43	4:44:44	0-2	0:03:01
Measurement Interval	4:44:44	4:54:44	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	1.77	0.67	0.80	4.54
1	0.81	0.62	0.73	1.25
2	0.81	0.62	0.73	1.23
3	0.86	0.69	0.82	1.26
4	0.87	0.69	0.82	1.27
5	0.87	0.71	0.84	1.23
6	0.87	0.71	0.85	1.22
7	0.89	0.73	0.86	1.27
8	0.90	0.73	0.86	1.26
9	0.91	0.74	0.87	1.27
10	0.94	0.76	0.88	1.35
11	0.94	0.76	0.88	1.35
12	0.94	0.77	0.88	1.32
Average	*0.90*	*0.73*	*0.86*	*1.28*

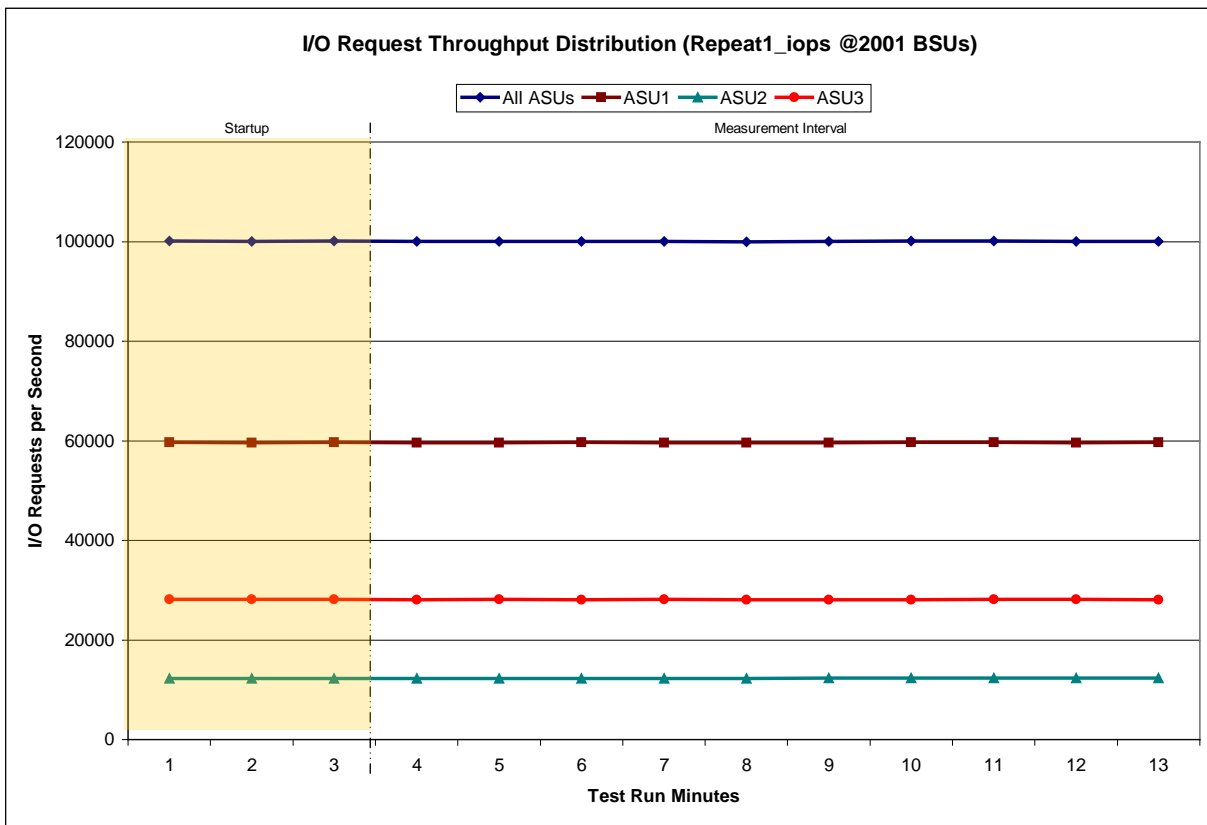## Repeatability 1 IOPS –Average Response Time (ms) Distribution Graph

Repeatability 2 LRT – I/O Request Throughput Distribution Data

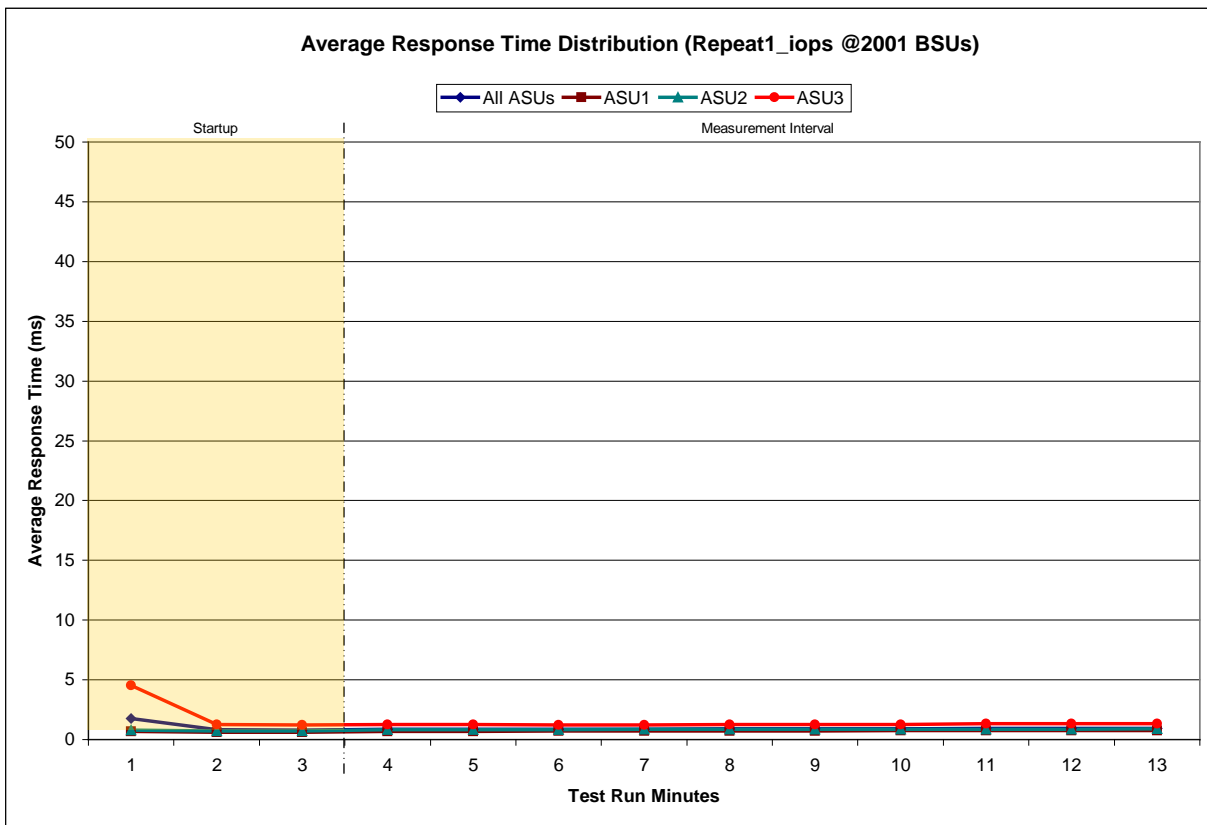| 200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:54:53	4:57:53	0-2	0:03:00
Measurement Interval	4:57:53	5:07:53	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	9,984.25	5,940.23	1,232.17	2,811.85
1	10,004.23	5,967.32	1,223.60	2,813.32
2	9,990.50	5,961.28	1,226.07	2,803.15
3	9,991.23	5,939.57	1,237.62	2,814.05
4	10,000.45	5,962.43	1,232.22	2,805.80
5	10,016.07	5,965.42	1,238.38	2,812.27
6	9,994.90	5,954.60	1,229.82	2,810.48
7	9,988.93	5,946.72	1,231.65	2,810.57
8	10,018.10	5,969.53	1,225.82	2,822.75
9	9,997.03	5,955.98	1,235.68	2,805.37
10	10,028.78	5,979.40	1,235.53	2,813.85
11	9,980.07	5,945.67	1,230.45	2,803.95
12	10,000.42	5,970.85	1,230.83	2,798.73
Average	*10,001.60*	*5,959.02*	*1,232.80*	*2,809.78*

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

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

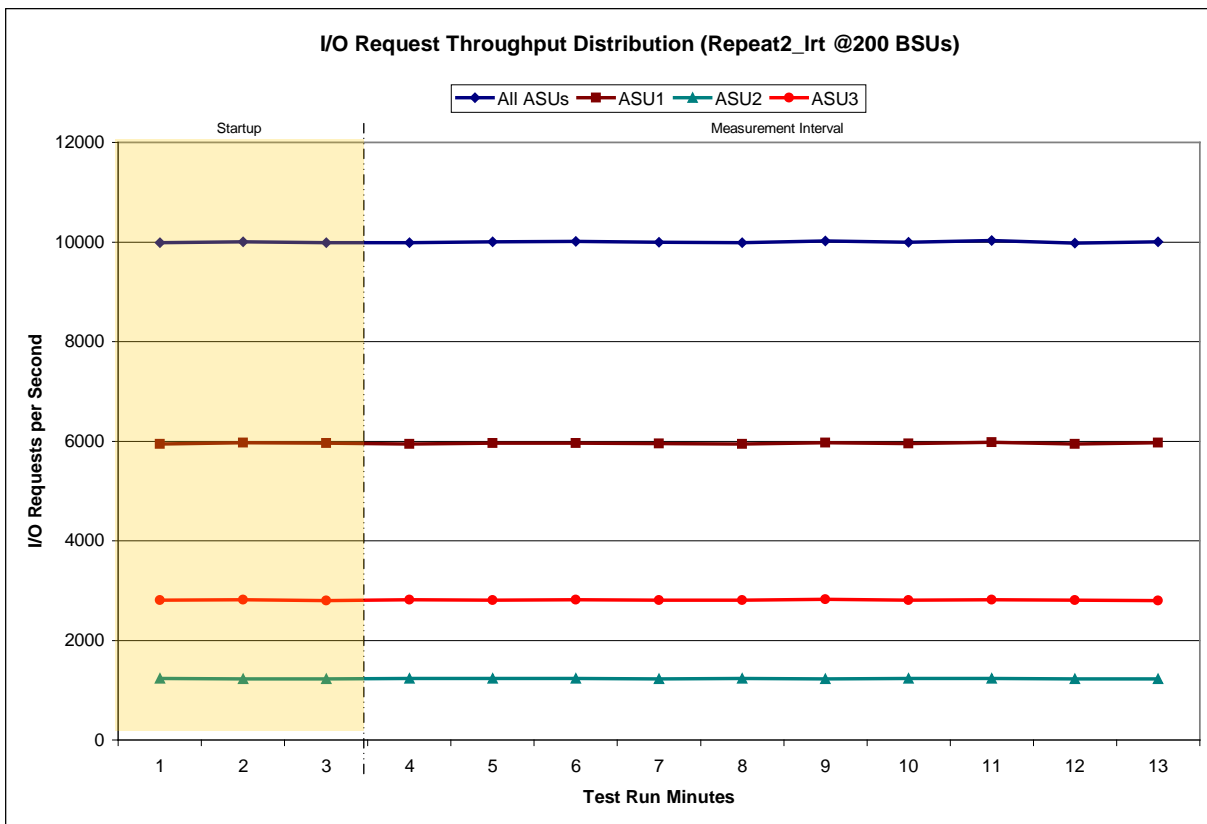| 200 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	4:54:53	4:57:53	0-2	0:03:00
Measurement Interval	4:57:53	5:07:53	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.60	0.58	0.69	0.61
1	0.61	0.58	0.69	0.62
2	0.62	0.59	0.74	0.63
3	0.61	0.57	0.76	0.61
4	0.60	0.57	0.74	0.62
5	0.59	0.55	0.73	0.61
6	0.60	0.55	0.74	0.63
7	0.60	0.56	0.73	0.63
8	0.60	0.56	0.74	0.62
9	0.62	0.57	0.76	0.65
10	0.61	0.56	0.75	0.63
11	0.60	0.55	0.74	0.63
12	0.60	0.56	0.75	0.61
Average	*0.60*	*0.56*	*0.74*	*0.63*

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

Repeatability 2 IOPS – I/O Request Throughput Distribution Data

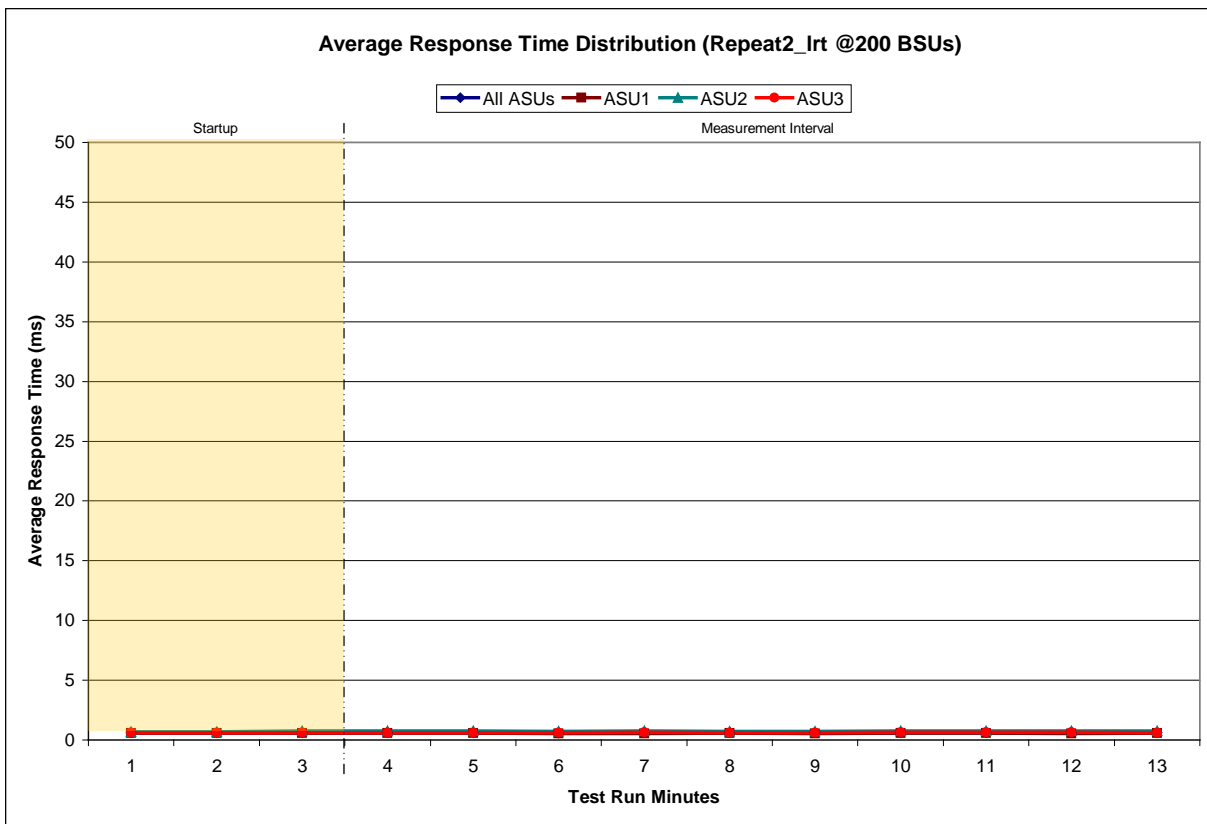| 2,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:08:01	5:11:02	0-2	0:03:01
Measurement Interval	5:11:02	5:21:02	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	100,087.78	59,633.90	12,326.10	28,127.78
1	100,045.37	59,572.93	12,328.95	28,143.48
2	100,050.42	59,659.78	12,273.92	28,116.72
3	100,075.62	59,618.50	12,324.83	28,132.28
4	100,097.78	59,679.93	12,294.20	28,123.65
5	100,035.98	59,645.10	12,303.40	28,087.48
6	100,083.78	59,669.18	12,304.05	28,110.55
7	100,017.28	59,595.60	12,317.42	28,104.27
8	100,024.03	59,620.85	12,307.72	28,095.47
9	100,041.07	59,631.32	12,305.77	28,103.98
10	100,129.17	59,622.50	12,345.52	28,161.15
11	100,012.72	59,635.93	12,288.03	28,088.75
12	100,070.20	59,682.28	12,298.12	28,089.80
Average	*100,058.76*	*59,640.12*	*12,308.91*	*28,109.74*

Repeatability 2 IOPS – I/O Request Throughput Distribution Graph
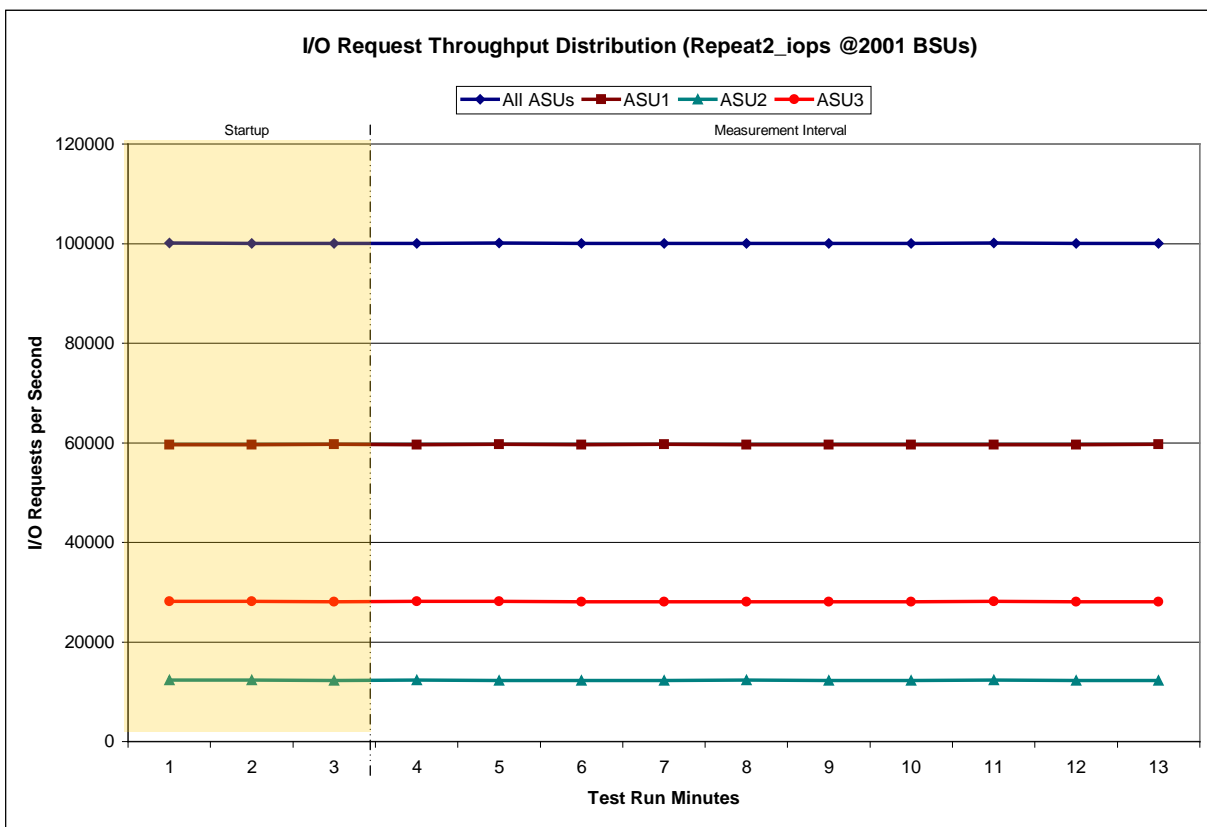
Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

2,001 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	5:08:01	5:11:02	0-2	0:03:01
Measurement Interval	5:11:02	5:21:02	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	2.31	0.72	0.86	6.32
1	0.81	0.62	0.73	1.23
2	0.81	0.63	0.74	1.22
3	0.83	0.67	0.80	1.18
4	0.85	0.68	0.81	1.22
5	0.87	0.70	0.83	1.24
6	0.91	0.73	0.86	1.34
7	0.91	0.73	0.85	1.34
8	0.88	0.72	0.84	1.23
9	0.90	0.73	0.85	1.27
10	0.90	0.74	0.85	1.27
11	0.92	0.75	0.86	1.31
12	0.92	0.76	0.87	1.30
Average	*0.89*	*0.72*	*0.84*	*1.27*

Repeatability 2 IOPS –Average Response Time (ms) Distribution Graph
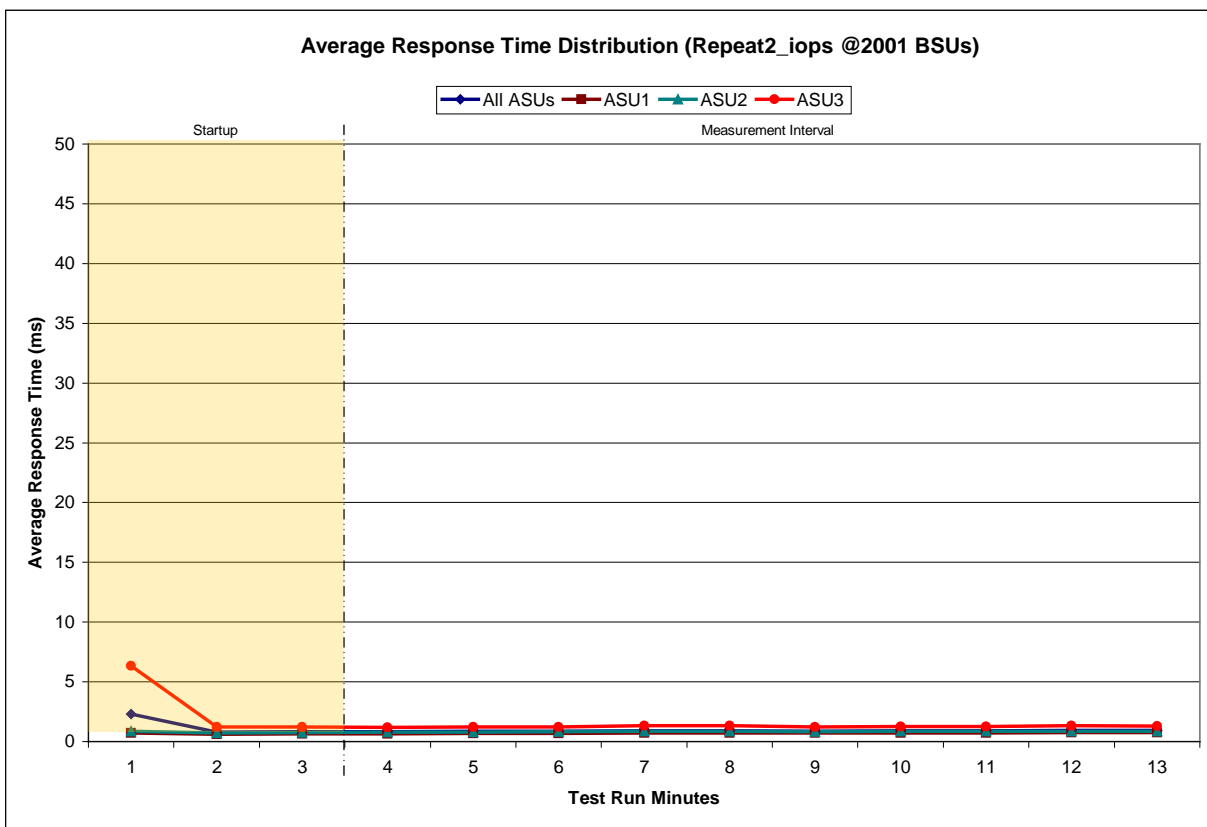
Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

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 5.3.13.2

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 5.3.13.3

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	0.2809	0.0700	0.2102	0.0181	0.0701	0.0350	0.2807
COV	0.008	0.001	0.004	0.004	0.010	0.003	0.006	0.002

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
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2809	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.002	0.001	0.001	0.001	0.002	0.001	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
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2809	0.0699	0.2101	0.0180	0.0702	0.0351	0.2809
COV	0.005	0.001	0.004	0.003	0.011	0.005	0.007	0.002

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
IM	*0.0350*	*0.2810*	*0.0700*	*0.2100*	*0.0180*	*0.0700*	*0.0350*	*0.2810*
MIM	0.0350	0.2809	0.0700	0.2101	0.0180	0.0700	0.0350	0.2809
COV	0.002	0.001	0.001	0.001	0.003	0.002	0.002	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.*

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 65.

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	149,731,360
Total Number of Logical Blocks Verified	90,402,080
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 9.2.4.9

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 Huawei OceanStor™ Dorado2100 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 found in the Priced Storage Configuration Pricing section on page 14.

TESTED STORAGE CONFIGURATION (TSC) AND PRICED STORAGE CONFIGURATION DIFFERENCES

Clause 9.4.3.3.7

The Executive Summary shall contain a pricing a list of all differenced 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 14.

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 Remote Audit of the Huawei OceanStor™ Dorado2100 .

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 gigibyte (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: This level will ensure data protection in the event of a single point of failure of any configured storage device. A brief description of the data protection utilized is included in the Executive Summary.

Unprotected: No claim of data protection is asserted in the event of a single point of failure.

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

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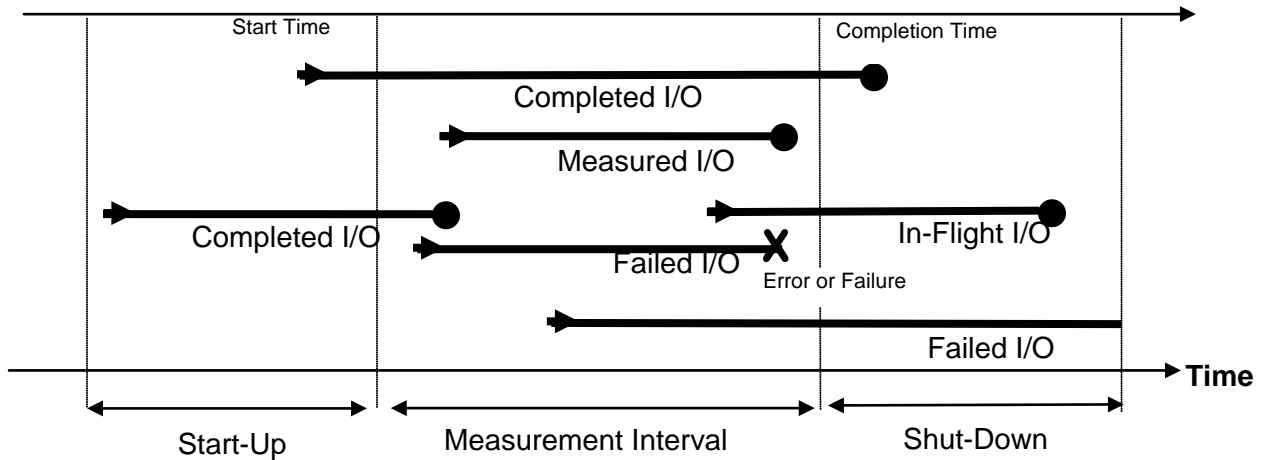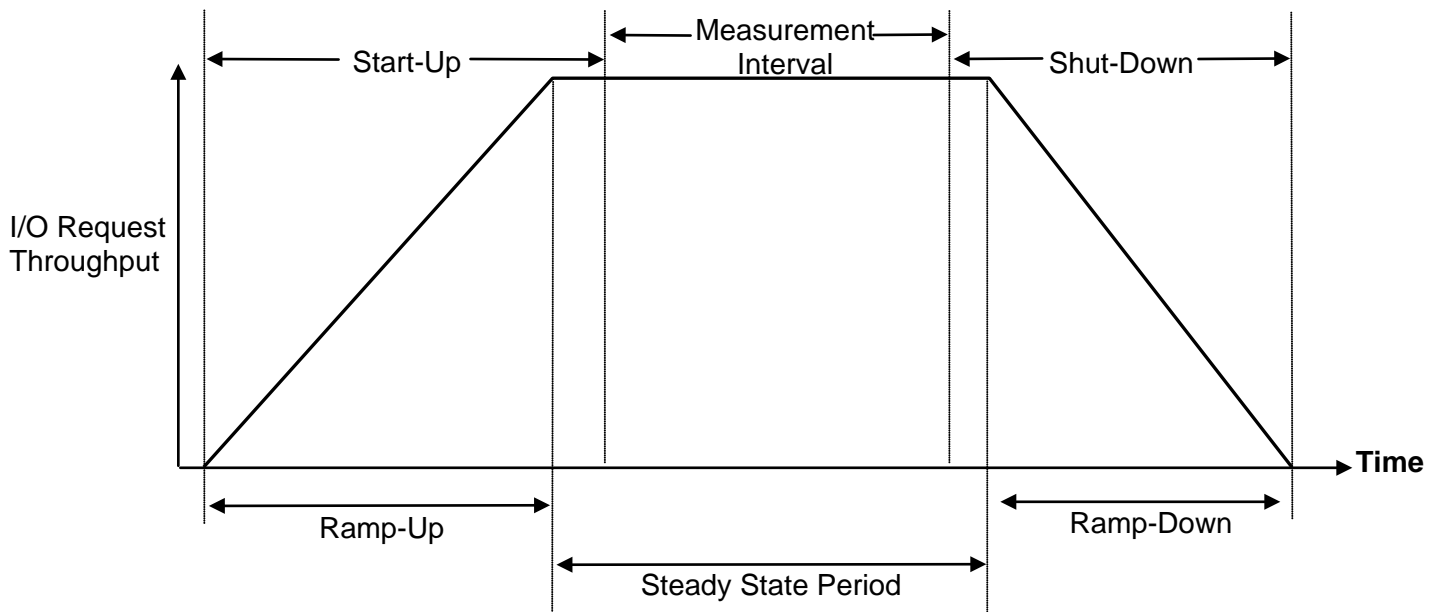
APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

There were no customer tunable parameter or options changed from their default values.

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

Cygwin is installed on the Host System with the **cygwin** packages, **expect** and **openssh**. The TCL scripts referenced below are executed by **expect**, using **ssh** for communication with the TSC.

Step 1: Create RAID groups and LUNs

The **mklun.tcl** script creates 4 RAID groups and 4 LUNs *(1 LUN per RAID group)* and maps the LUNs to host group 0, which is the default host group, as detailed below.

- The ***createrg*** command creates the RAID groups from the 24 Solid State Devices *(SSDs)* with the mapping illustrated below.

  - ➢ RAID groups 0 and 1 each contain 10 SSDs and are used for ASU-1 and ASU-2.
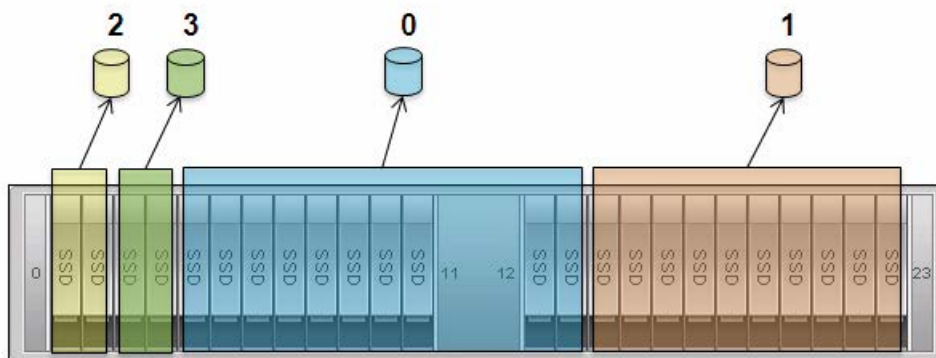 - ➢ RAID groups 2 and 3 each contain 2 SSDs and are both used for ASU-3
- The ***createlun*** command creates each LUN, 1 LUN per RAID group, using all of the available RAID group capacity.
- The **addhostmap** command maps each LUN to a host/host group.

Step 2: Create the Volumes

The LUNs, created above, are rescanned and initialized on the Windows 2003 Host System and the **mkvolume.script** is executed to create 3 SPC-1 Logical Volumes, which comprise the required SPC-1 ASUs.

The script:

- Creates an 8 MiB primary partition for alignment on each of the 4 disks *(LUNs)*.
- Converts each disk to "dynamic".
- Creates a 474,192 MiB volume using disks 1 and 2 for ASU-1, assigning the letter X.
- Creates a 474,192 MiB volume using disks 1 and 2 for ASU-2, assigning the letter Y.
- Creates a 105,376 MiB volume using disks 3 and 4 for ASU-3, assigning the letter Z.

The referenced scripts appear below.

mklun.tcl

```
if { $argc < 1 } {
     puts "USAGE: mklun.tcl \"DEBUG_PASSWORD\""
     exit 0
}
set stor 129.22.243.3
set stor_user admin
set stor_pswd 123456
set dvlp_pswd  [ lindex $argv 0 ]

# login storage

spawn ssh $stor_user@$stor

expect {
     "assword" {
             send "$stor_pswd\r"
     }
     "yes/no" {
             send "yes\r"
             expect "assword"
             send "$stor_pswd\r"
     }
}
expect ">"

set timeout 60

set lunid 0
set rgid 0

send "showdisk -logic\r"
expect ">"

# create ASU1/ASU2 RAIDs & LUNs

foreach disklist { 0,4:0,5:0,6:0,7:0,8:0,9:0,10:0,11:0,12:0,13:
0,14:0,15:0,16:0,17:0,18:0,19:0,20:0,21:0,22:0,23: } {
     send "createrg -n ASU-$rgid -l 10 -num 2 -list $disklist\r"
     expect "(y/n)"
     send "y\r"
     expect ">"
     send "chgrgiospindown -sw on -rg $rgid -idle 0\r"
     expect "(y/n)"
     send "y\r"
     expect ">"
     send "showrg -rg $rgid\r"
     expect ">"
     if [ expr $lunid%2 ] {
             set ctrl b
     } else {
             set ctrl a
     }
     send "createlun -rg $rgid -n ASU-$lunid -susize 512 -c $ctrl\r"
     set sucsses 0
     while { $sucsses == 0 } {
             expect {
                     "Error" {
```

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```
                                expect ">"
                                sleep 1
                                send "createlun -rg $rgid -n ASU-$lunid -susize 512 -c
    $ctrl\r"
                        }
                        ">" {
                                set sucsses 1
                        }
                }
        }
        send "showlun -lun $lunid\r"
        expect ">"
        send "addhostmap -group 0 -devlun $lunid\r"
        set sucsses 0
        while { $sucsses == 0 } {
                expect {
                        "Error" {
                                expect ">"
                                sleep 1
                                send "addhostmap -group 0 -devlun $lunid\r"
                        }
                        ">" {
                                set sucsses 1
                        }
                }
        }
        send "showhostmap -map $lunid\r"
        expect ">"
        incr lunid
        incr rgid
}

# create ASU3 RAIDs & LUNs

foreach disklist { 0,0:0,1: 0,2:0,3: } {
        send "createrg -n ASU-$rgid -l 1 -list $disklist\r"
        expect "(y/n)"
        send "y\r"
        expect ">"
        send "showrg -rg $rgid\r"
        expect ">"
        if [ expr $lunid%2 ] {
                set ctrl b
        } else {
                set ctrl a
        }
        send "createlun -rg $rgid -n ASU-$lunid -susize 512 -c $ctrl\r"
        set sucsses 0
        while { $sucsses == 0 } {
                expect {
                        "Error" {
                                expect ">"
                                sleep 1
                                send "createlun -rg $rgid -n ASU-$lunid -susize 512 -c
    $ctrl\r"
                        }
                        ">" {
                                set sucsses 1
                        }
                }
        }
        send "showlun -lun $lunid\r"
        expect ">"
```

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```
        send "addhostmap -group 0 -devlun $lunid\r"
        set sucsses 0
        while { $sucsses == 0 } {
                expect {
                        "Error" {
                                expect ">"
                                sleep 1
                                send "addhostmap -group 0 -devlun $lunid\r"
                        }
                        ">" {
                                set sucsses 1
                        }
                }
        }
        send "showhostmap -map $lunid\r"
        expect ">"
        incr lunid
        incr rgid
}

# change the properties of LUNs

send "developer\r"
expect "Password:"
send "$dvlp_pswd\r"
expect ">"
send "chgdiskunplug -unplug 1\r"
expect ">"
send "chglun_inner -pretype 0 -wrtype 2 -lun 0\r"
expect "(y/n)"
send "y\r"
expect ">"
send "chglun_inner -pretype 0 -wrtype 2 -lun 1\r"
expect "(y/n)"
send "y\r"
expect ">"
send "chglun_inner -pretype 0 -wrtype 1 -mirrorsw 1 -lun 2\r"
expect "(y/n)"
send "y\r"
expect ">"
send "chglun_inner -pretype 0 -wrtype 1 -mirrorsw 1 -lun 3\r"
expect "(y/n)"
send "y\r"
expect ">"
send "exit\r"
expect ">"

# show storage profiles

send "showrg\r"
expect ">"
send "showlun\r"
expect ">"
send "showhostmap -group 0\r"
expect ">"
send "showdisk -logic\r"
expect ">"
send "exit\r"
expect "(y/n):"
send "y\r"
expect "closed"
```

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mkvolume.script

```
select disk 1
create partition primary size=8 align=8192
convert dynamic
select disk 2
create partition primary size=8 align=8192
convert dynamic
select disk 3
create partition primary size=8 align=8192
convert dynamic
select disk 4
create partition primary size=8 align=8192
convert dynamic
create volume stripe size=237096 disk=1,2
assign letter=X
create volume stripe size=237096 disk=1,2
assign letter=Y
create volume stripe size=52688 disk=3,4
assign letter=Z
```

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

The content of SPC-1 Workload Generator command and parameter files, used in this benchmark to execute the Primary Metrics and Repeatability, is listed below.

```
sd=asu1_1,lun=\\.\X:,size=497226350592
sd=asu2_1,lun=\\.\Y:,size=497226350592
sd=asu3_1,lun=\\.\Z:,size=110494744576
```

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APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

ASU Pre-Fill, Primary Metrics Test, Repeatability Test, Persistence Test Run 1, TSC power off/power on and Persistence Test Run 2

The following script was used to execute the required ASU pre-fill, 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 Persistence Test Run 1 in an uninterrupted sequence. The script pauses until the required TSC power off/power on cycle is completed then executes Persistence Test Run 2.

```
@echo off

expect shstorage.tcl > profile1_storage.log

echo %date% %time% > profile1_volume.log
diskpart /s shvolume.script >> profile1_volume.log
echo %date% %time% >> profile1_volume.log

call ..\vdbench\vdbench.bat -f prefilling.cfg -o prefilling

java -Xmx1024m -cp ..\spc1 metrics -b 2001 -t 28800
java -Xmx1024m -cp ..\spc1 repeat1 -b 2001
java -Xmx1024m -cp ..\spc1 repeat2 -b 2001

java -Xmx512m -cp ..\spc1 persist1 -b 2001

echo.please power cycle TSC, then reactive all disks.
pause

expect shstorage.tcl > profile2_storage.log

echo %date% %time% > profile2_volume.log
diskpart /s shvolume.script >> profile2_volume.log
echo %date% %time% >> profile2_volume.log

java -Xmx512m -cp ..\spc1 persist2
```

APPENDIX F: THIRD-PARTY QUOTATION

PC MALL CORPORATE QUOTATION

Prepared by: Joe Krasnow

Email: jkrasnow@pcmall.com

Phone: 312-546-8518

Fax: 310-360-3916

PCMall®

Contact: ACCOUNTS PAYABLE

Company: THE OPTIONS CLEARING CORP.

Phone: 312-322-4472

Quote Date: 2011-12-26

Quote # : S9999912

ACCT# 119859130

PC Mall #	Product Description	Mfg.	Qty.	Unit Price	Ext. Price
SDO21SLC24T	Dorado2100 High Performance Solid State Storage System-2.4TB (SPE31C0224,AC,24*100GB SLC SSD,8*8G FC Port, Maximum Supporting 16*8G FC Port, with HS HSSD Controller System Software)	Huawei Symantec	1	$52,028.66	$52,028.66
14130321	Patch Cord,DLC/PC-DLC/PC,Multimode,2mm Parallel,3m	Huawei Symantec	8	$11.00	$88.00
SDO21MP	Dorado2100 Multi-path Software	Huawei Symantec	1		
SDO21ISM	HS Integrated Storage Manager-Device Management License for Dorado2100(V100R003) (ESSENTIAL)	Huawei Symantec	1	$7,432.56	$7,432.56
SDO21SSLCPAE	Oceanspace HS Storage Array Control System Software Include PAE License Certificate (ESSENTIAL)	Huawei Symantec	1	$14,865.12	$14,865.12
TSGSDO21SLC24T	Upgrade from Standard to Gold service package in warranty period (3 years). Gold service package include:7*24 Remote Support. Access to all new software updates. 4 Business Hours Parts Delivery. 4 Business Hours Engineer Onsite.	Huawei Symantec	1	$11,706.45	$11,706.45
QLE2562-CK	QLogic Dual Port 8Gb Fibre Channel to PCI Express Host Bus	Qlogic	4	$1,050.00	$4,200.00
				Total:	$90,320.79

View Terms of Service and Policies at PCMall.com

***   Pricing and availability are subject to change. Final pricing to be discussed at time of purchase.   ***

Shipping, handling, and tax per client selected method will be prepaid and added.

PCMall Quote Page 1 of 1