SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

SUN MICROSYSTEMS, INC.
SUN STOREDGE™ 9910

SPC-1 V1.4

Submitted for Review
May 20, 2002

First Edition – May 2002

Trademarks

SPC Benchmark 1, SPC-1 IOPS, and SPC-1 LRT are trademarks of the Storage Performance Council. SE9910 and Sun StorEdge are registered trademarks of Sun Microsystems, Inc..

Notes

The following terms, used in this document, are defined as:

- Kilobyte (KB) is equal to 1,000 (10^3) bytes.
- Megabyte (MB) is equal to 1,000,000 (10^6) bytes.
- Gigabyte (GB) is equal to 1,000,000,000 (10^9) bytes.
- Terabyte (TB) is equal to 1,000,000,000,000 (10^{12}) bytes.

Table of Contents

AUDIT CERTIFICATION

Test Sponsor: Sun Microsystems, Inc.
Kathleen Holmgen
Network Storage Marketing VP
UNWK16-318
7777 Gateway Blvd.
Newark, CA 94560

May 1, 2002

I verified the SPC Benchmark 1™ measurement for the Sun StorEdge™ 9910 and the results listed below were produced in compliance with the SPC Benchmark 1™ V1.4 requirements.

SPC-1 Results	
Tested Storage Configuration (TSC) Name: Sun StorEdge™ 9910	
Metric	**Reported Result**
SPC-1 IOPS™	8,404.22
SPC-1 Price-Performance	$74.29 / SPC-1 IOPS™
Total ASU Capacity	343.51 GB
Data Protection Level	Mirroring
SPC-1 LRT™	2.07 ms
Total TSC Price (including three-year maintenance)	$624,377.44

The following requirements were verified:

- The following Data Repository storage items were verified:
  - ✓ 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 physical presence of all components that comprised the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).
- Listings and commands to configure the BC.
- The type of Host System including the number of processors and main memory.
- The presence and version number of each Workload Generator on each Host System.

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- The TSC boundary within each Host System.
- Correct execution and successful completion of the following:
  - ✓ Data Persistence Test
  - ✓ Sustainability Test Phase
  - ✓ IOPS Test Phase
  - ✓ Response Time Ramp Test Phase
  - ✓ Repeatability Test

Audit Notes:

The Logical Volume and ASU storage capacities configured by the VERITAS Volume manager were:

ASU 1 – Logical Volume 1 – 154.62 GB

ASU 2 – Logical Volume 2 – 154.62 GB

ASU 3 – Logical Volume 3 – 8.59 GB
Logical Volume 4 – 8.59 GB
Logical Volume 5 – 8.59 GB
Logical Volume 6 – 8.59 GB

The ASU "size" parameter was not used in the benchmark measurement, which should have caused the workload generator to use the storage capacities reported by the VERITAS Volume Manager. That was not the case because the capacities reported to the workload generator from the system were slightly different. The actual Logical Volume and ASU storage capacities reported to and used by the SPC-1 Workload Generator were:

ASU 1 – Logical Volume 1 – 154.6465 GB

ASU 2 – Logical Volume 2 – 154.6293 GB

ASU 3 – Logical Volume 3 – 8.5458 GB
Logical Volume 4 – 8.5710 GB
Logical Volume 5 – 8.5458 GB
Logical Volume 6 – 8.5710 GB

The difference between the two sets of capacities was small enough so that there was no impact on the performance of the Tested Storage Configuration.

Respectfully,

Walter E. Baker

Walter E. Baker
SPC Auditor

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LETTER OF GOOD FAITH

Date: *Date results are 1st provided to the SPC Audit Service for a given benchmark run.*

From: *Kathleen Holmgen, Network StorageMarketing VP, Sun Microsystems*

To: *Walter Baker, SPC Auditor, Gradient System*

Subject: Letter of Good Faith for the SPC Benchmark-1™ results published on the SE9910 Configuration.

This Letter of Good Faith between Sun Microsystems Corporation ("hereafter known as the Test Sponsor") and the Storage Performance Council (hereafter know as the SPC), documents that:

1. Fidelity and candor has been and will be maintained in reporting any anomalies in the SPC Benchmark-1™ results, even if not explicitly required for disclosure in the SPC Benchmark-1™ specification.
2. No attempt has been or will be made to deceive the SPC Audit Service, SPC, customers, or the public regarding the authenticity or accuracy of SPC Benchmark-1™ results on the SE9910 Configuration. As such, the SPC-1 Full Disclosure Report that will document SPC Benchmark-1™ results (per Clause 10 of the SPC Benchmark-1™ Specification) on the SE9910 Configuration is authentic and accurate.
3. The SE9910 configuration used for reporting SPC Benchmark-1™ results, as documented in the Full Disclosure Report (per Clause 10 of the SPC Benchmark-1™ Specification), has not been misrepresented to the SPC or SPC Audit Service in any way.
4. SPC Benchmark-1™ results on the SE9910 Configuration are compliant with the spirit, intent, and letter of the SPC Benchmark-1™.
5. That the SPC Benchmark-1™ results do not represent a "Benchmark Special" as documented in Clause 0.2 of the SPC Benchmark-1™ specification.

Kathleen Holmgren, Network Storage Marketing VP of Sun Microsystems

Date:

EXECUTIVE SUMMARY

TEST SPONSOR AND CONTACT INFORMATION

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Sun Microsystems, Inc. www.sun.com Leah Schoeb leah.schoeb@sun.com UBRM05-194 500 Eldorado Blvd. Broomfield, CO 8002 Phone: (303) 272-3034 FAX: (303) 272-9559
Test Sponsor Alternate Contact	Sun Microsystems, Inc. www.sun.com Chris Wood chris.wood@sun.com UNWK16-311 7777 Gateway Blvd. Newark, CA 94560 Phone: (510) 936-2954
Auditor	Storage Performance Council www.storageperformance.org Auditor's Name AuditService@storageperformance.org 1060 El Camino Real, Suite F 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	V1.4
SPC-1 Workload Generator revision number	V1.0
Date Results were first used publicly	May 1, 2002
Date FDR was submitted to the SPC	May 20, 2002
Date the TSC is/was available for shipment to customers	August 21, 2001
Date the TSC completed audit certification	May 1, 2002

SUMMARY OF RESULTS

SPC-1 Results	
Tested Storage Configuration (TSC) Name: Sun StorEdge™ 9910	
Metric	**Reported Result**
SPC-1 IOPS™	8,404.22
SPC-1 Price-Performance	$74.29 / SPC-1 IOPS™
Total ASU Capacity	343.51 GB
Data Protection Level	Mirroring
SPC-1 LRT™	2.07 ms
Total TSC Price (including three-year maintenance)	$624,377.44

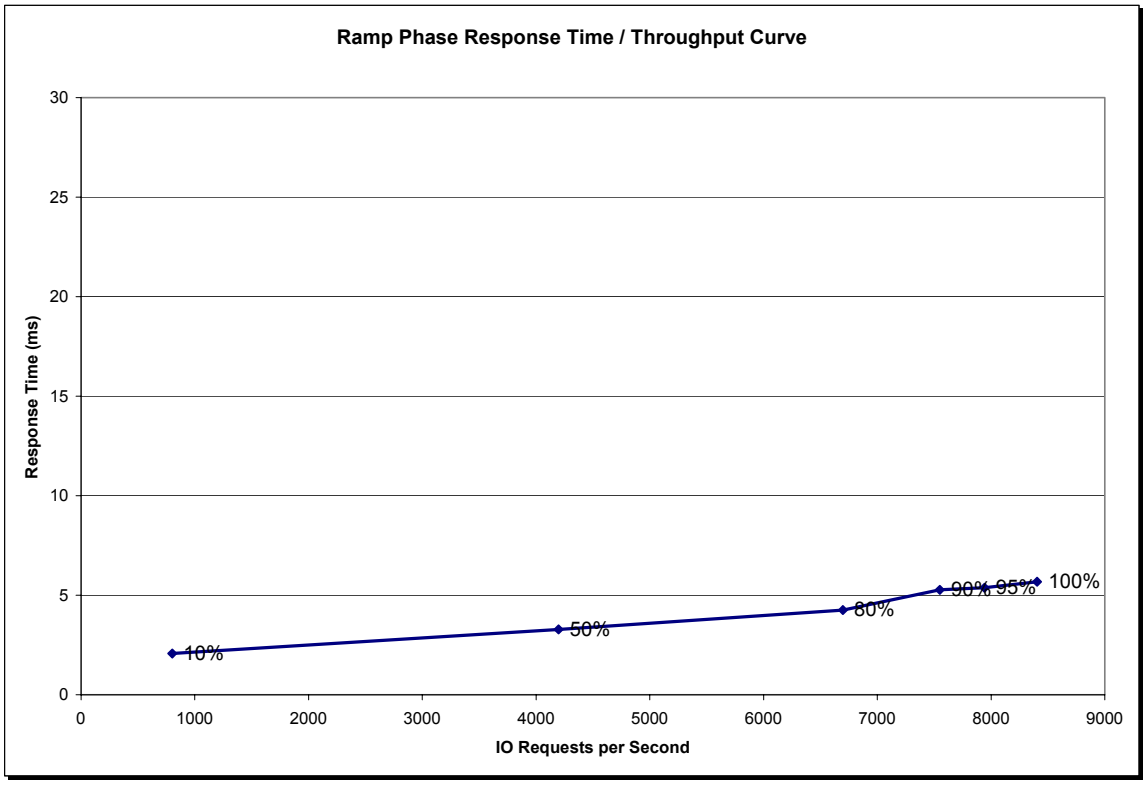
SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

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 Mirroring has two or more identical copies of user data maintained on separate disks.

The **SPC-1 LRT™** metric is the Average Response Time measured at the 10% load point, as illustrated on the next page. SPC-1 LRT™ represents the Average Response Time measured on a lightly loaded Tested Storage Configuration (TSC).

RESPONSE TIME – THROUGHPUT CURVE GRAPH



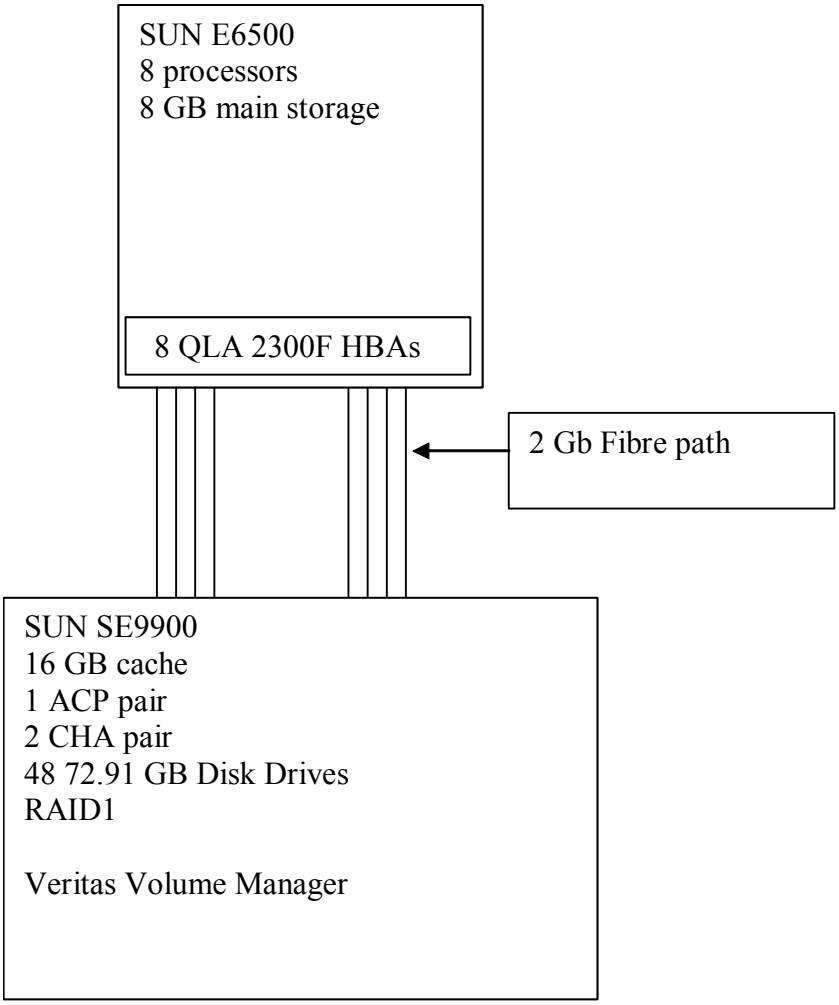
The Response Time-Throughput Curve illustrates the Average Response Time (milliseconds) and I/O Request Throughput at 100%, 95%, 90%, 80%, 50%, and 10% of the workload level used to generate the SPC-1 IOPS™ metric. The SPC-1

The Average Response Time measured at the 100% load point cannot exceed 30 milliseconds or the benchmark measurement is invalid.

TESTED STORAGE CONFIGURATION PRICING

P/N	Description	Qty	Ext US List
SE9910-STRGBASE	**SUN SE9910 PRODUCT**	1	$595,541.00
T8-041-100028-01	HDS Logo for Sun SE9900 Series	1	
T8-DKC-F415I-1UC	Pwr Cable Kit-Single Phase USA	1	
T8-DKC415I-5	SE9910 Disk Controller Frame	1	
T8-DKC-F410I-1024	Cache Memory Module (1024MB)	16	
T8-IP0806-1	SE9900 Hi-Trk Ethernet Cnct Kt	1	
T8-IP0807-4	SE9900 Hi-Track PCMCIA Mdm Kit	1	
T8-IP0809-100	SE9900 Ethernet Thinnet Cable	1	
T8-IP1000-2CD	SE9900 PCAnywhere CD ROM	1	
T8-DKC-F410I-SNMP	SE9900 SNMP Support Kit	1	
T8-041-100034-01	SE9900 Microcode Kit	1	
XT8-JZ-050SL025PC	Plenum SC to LC Cable, 25M	8	
T8-DKU-F405I-72J4	4 HDD Canisters - 73GB	11	
T8-DKU-F405I-72J1	1 HDD Canister - 73GB	4	
T8-DKC-F410I-S256	Shared Memory Module (256MB)	4	
T8-DKC-F410I-8HSE	2Gb/sec fibre channel adapter	2	
XT8-044-100040-01	SE9900 Resource Mgr Base Lic	1	
XT8-044-100209-01A	SE9900 Resource Mgr 1TB Lic.	1	
XT8-044-100210-01B	SE9900 Resource Mgr 2-3TB Lic	2	
	3-yr Sun extended SW Warrenty	1	
	3-yr Sun HW Warrenty	1	
X6767A	**Sun Storagedge 2G FC PCI Single-Channel Network Adapter**	8	$14,000.00
VVMGS-999-E999	**VxVM 3.1.1 Enterprise Lic**	1	$12,999.00
VVMGS-E999	**VxVM 3.1.1 3 year Maintenance Agreement**	1	$1,837.44
		Total	$624,377.44

BENCHMARK CONFIGURATION/TESTED STORAGE CONFIGURATION DIAGRAM



Host System:	**Storage System:**
Sun E6500	Sun StorEdge™ 9910
UID=E6500	UID=SE9910
8 UltraSPARC™ II 464 MHz CPUs	16 GB Cache
32/64 KB (instruction/data) L1 Cache	1 ACP pair
8 MB L2 Ecache	2 CHA pair
8 GB RAM	11 – 4 HDD Canisters, 4 – 1 HDD Canister
Solaris8	48 x 72.91 GB disk drives
8 FC PCI Single-Channel Network Adapters	VERITAS Volume Manager

DATA REPOSITORY

DEFINITIONS

Physical Storage Capacity: The formatted capacity of all storage devices physically present in the Tested Storage Configuration (TSC), excluding any storage that cannot be configured for use by the benchmark.

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.

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.

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.

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.

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

STORAGE HIERARCHY CAPACITY

Storage Hierarchy Capacity		
Storage Hierarchy Component	**Units**	**Capacity**
ASU Capacity	Gigabytes (GB)	343.51
Addressable Storage Capacity	Gigabytes (GB)	343.51
Configured Storage Capacity	Gigabytes (GB)	687.02
Physical Storage Capacity	Gigabytes (GB)	3,499.00

LOGICAL VOLUME CAPACITY AND ASU MAPPING

Logical Volume Capacity and Mapping		
ASU-1 (154.6465 GB)	**ASU-2 (154.6293 GB)**	**ASU-3 (34.2336 GB)**
dgasu1a/vol01 (154.6465 GB)	dgasu2a/vol01 (154.6293 GB)	dgasu3a/vol01 (8.5458 GB)
		dgasu3a/vol03 (8.5710 GB)
		dgasu3a/vol02 ((8.5458 GB)
		dgasu3a/vol04 (8.5710 GB)

The eleven disk array groups presented for ASU1 and ASU2 are divided into 638 logical devices. 128 of these logical devices are presented to the host, 16 per interface through 8 interfaces. The volumes appear to the host platform as individual SCSI disks. At the host, the VERITAS volume manager is used to stripe these logical devices into two 154.62 GB volumes using the default striping unit and striping across all 8 interfaces.

Four additional logical devices are presented from two disk array groups for ASU3. One of these array groups is dedicated to ASU3, the other is shared with ASU1 and ASU2. Instrumentation on the disk array showed that the shared group was lightly loaded during testing, so ASU3 was added to this group for load-balancing purposes. The VERITAS volume manager is only used to control the size of these volumes, which are presented as four 8.59 GB single-disk VxVM volumes for testing purposes, one through each of four interfaces which are shared with ASU1 and ASU2.

The actual capacities used by the SPC-1 Workload Generator are listed in the above table.

The Data Protection Level used for all Logical Volumes was **Mirroring** as described on page 9.

See "ASU Configuration" in the IOPS Test Results File for more detailed configuration information.

CONFIGURATION INFORMATION

TUNING PARAMETERS AND OPTIONS

The value for each customer-tunable parameter that has been altered from its default value for all components of the Benchmark Configuration (BC). Those customer-tunable parameters include but are not limited to:

- *Operating system and application configuration parameters.*
- *Array controller options.*
- *HBA options*
- *Options for each component in a network used to connect storage to the Host System(s).*

The following customer-tunable parameters were altered for this test:

QLogic Fiber Adapter card (QLA2300) driver:

- 64-bit addressing has been turned on for this test and the Fiber Channel
- data rate has been forced to 2GB.

Solaris Operating System:

- semsys:seminfo_semmni=2000
- set maxphys=262144
- set sd:sd_max_throttle=32

These changes are a normal part of installation of the **Veritas Volume Manager**:

```
* vxvm_START (do not remove)
forceload: drv/vxdmp
forceload: drv/vxio
forceload: drv/vxspec
* vxvm_END (do not remove)

* vxfs_START -- do not remove the following lines:
*
* VxFS requires a stack size greater than the default 8K.
* The following values allow the kernel stack size
* for all threads to be increased to 16K.
*
set lwp_default_stksize=0x4000
```

TESTED STORAGE CONFIGURATION (TSC)

All scripts and/or commands used to configure all components of the TSC. Each script or list of commands should clearly reference its associated component as identified in the Benchmark Configuration/Tested Storage Configuration Diagram.

Tested Storage Configuration (TSC) information can be found in the Data Repository section on page 13.

BENCHMARK CONFIGURATION (BC)

All scripts and/or commands used to configure the BC to support the TSC and SPC-1 Workload Generator.

The scripts/commands used are documented above in ***Tuning Parameters and Options***.

HOST SYSTEM(S) CONFIGURATION

A description of the configuration and features of each Host System in the BC that executes the SPC-1 Workload Generator.

The Host System configuration is description in the **Benchmark Configuration/Tested Storage Configuration Diagram** section *(page 12)* of this document.

SPC-1 BENCHMARK EXECUTION RESULTS

DEFINITIONS

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. Comment: Steady Stated is achieved only after caches in the TSC have filled and as a result the I/O Request throughput of the TSC has stabilized.*

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.*

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 Figure 5-1 below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.*

SUSTAINABILITY TEST PHASE

The Sustainability Test Phase consists of one Test Run at the 100 % load point with a Measurement Interval of three (3) hours. The intent is to demonstrate a sustained maximum I/O Request Throughput as well as insuring the Tested Storage Configuration (TSC) has reached steady state prior to measuring the maximum I/O Request Throughput (SPC-1™ IOPS).

The reported I/O Request Throughput of the Sustainability Test Run must be within 5% of the reported SPC-1™ IOPS primary metric. The Average Response Time measured in Sustainability Test Run cannot exceed thirty (30) milliseconds.

SPC-1 Workload Generator Input Parameters

A link to the SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, and Test Runs is listed below.

Input Parameters *(Sustainability, IOPS, and Response Time Ramp)*

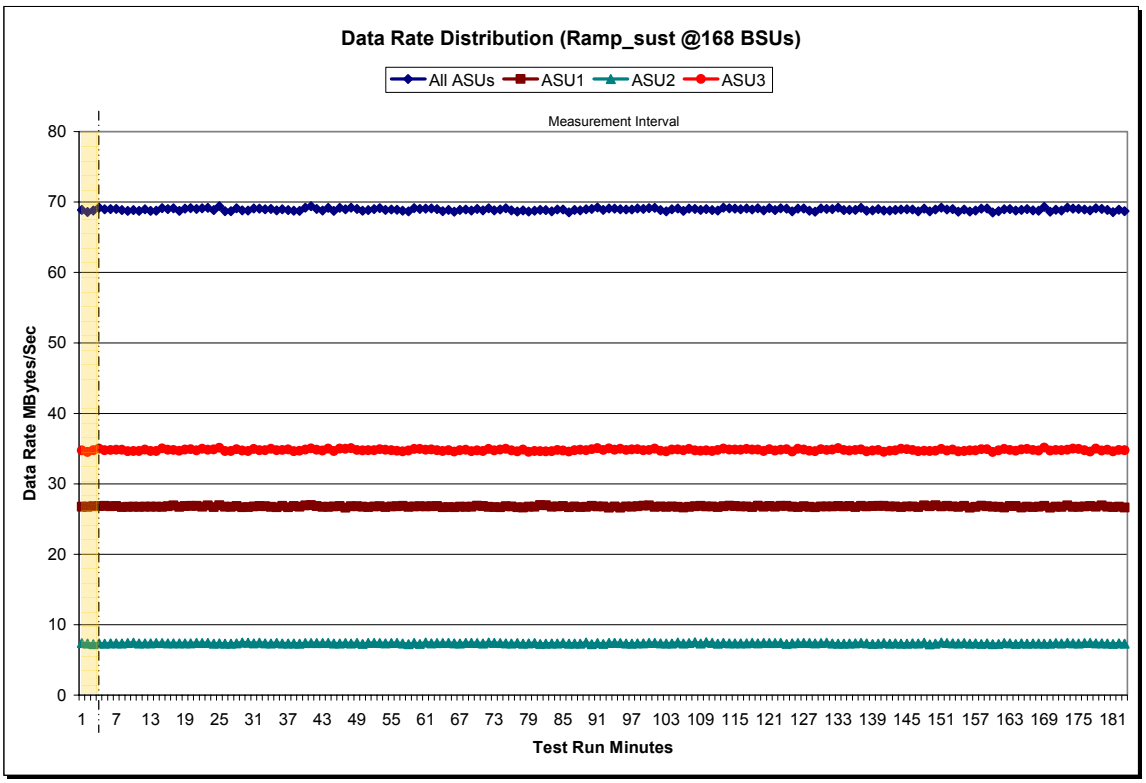
Sustainability Test Results File

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

Sustainability Test Results File

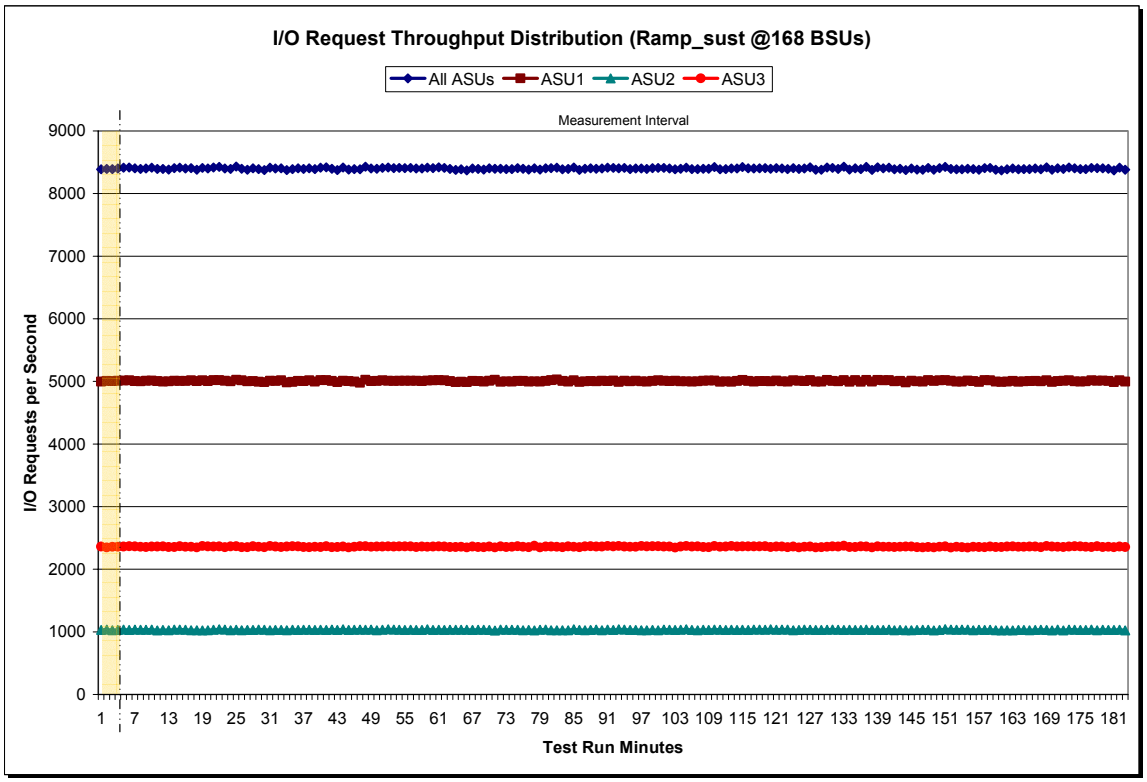
Sustainability – Data Rate Distribution

The Measurement Interval duration for the Sustainability Test Run was 180 minutes (Test Run Minutes 3-183).



Sustainability – I/O Request Throughput Distribution

The Measurement Interval duration for the Sustainability Test Run was 180 minutes (Test Run Minutes 3-183).



Sustainability – Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.035*	*0.281*	*0.070*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.281	0.070	0.210	0.018	0.070	0.035	0.281
COV	0.007	0.003	0.005	0.003	0.01	0.011	0.005	0.003

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.*

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%.*

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

IOPS TEST PHASE

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.

SPC-1 Workload Generator Input Parameters

A link to the SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, and Test Runs is listed below.

Input Parameters *(Sustainability, IOPS, and Response Time Ramp)*

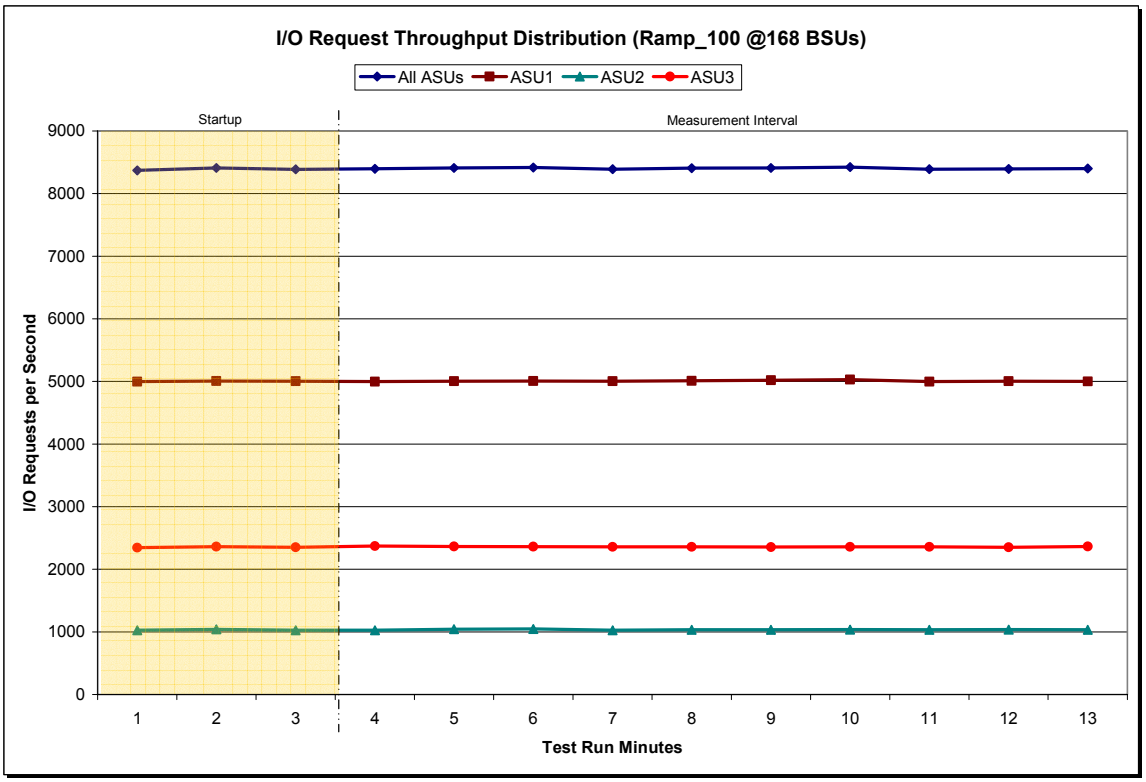
IOPS Test Results File

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

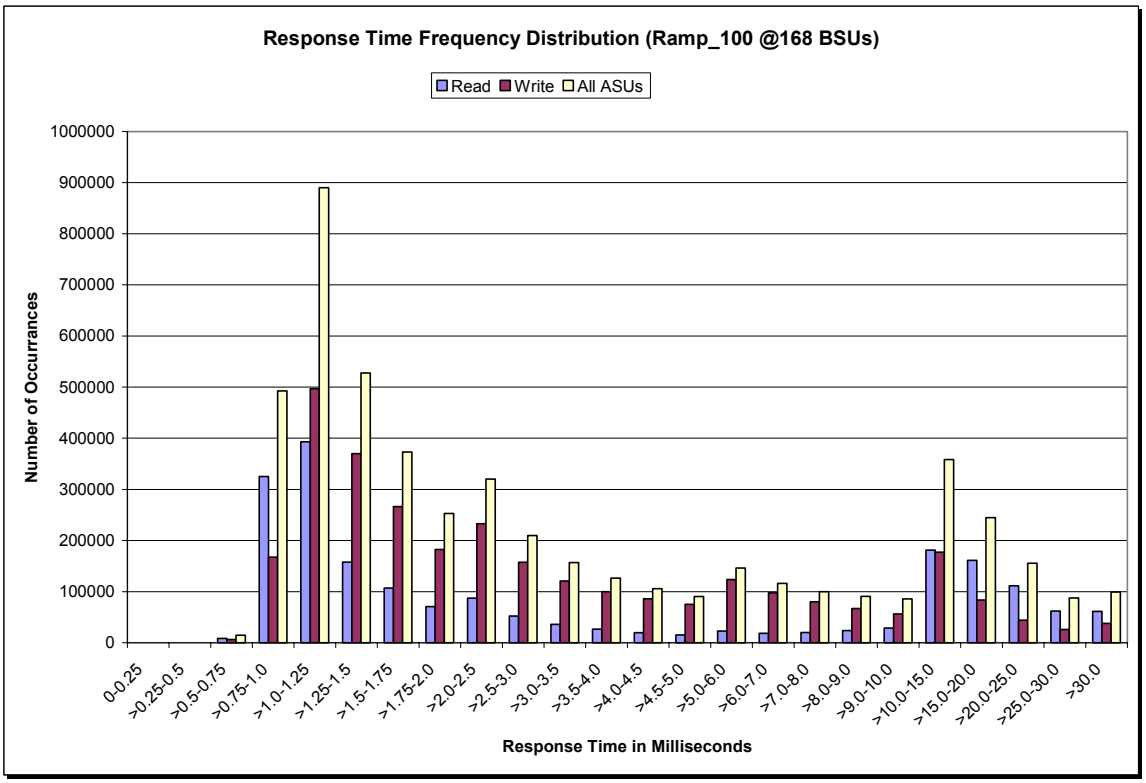
IOPS Test Results File

IOPS Test Run – I/O Request Throughput Distribution

The Measurement Interval duration for the IOPS Test Run was 10 minutes (Test Run Minutes 3-13).

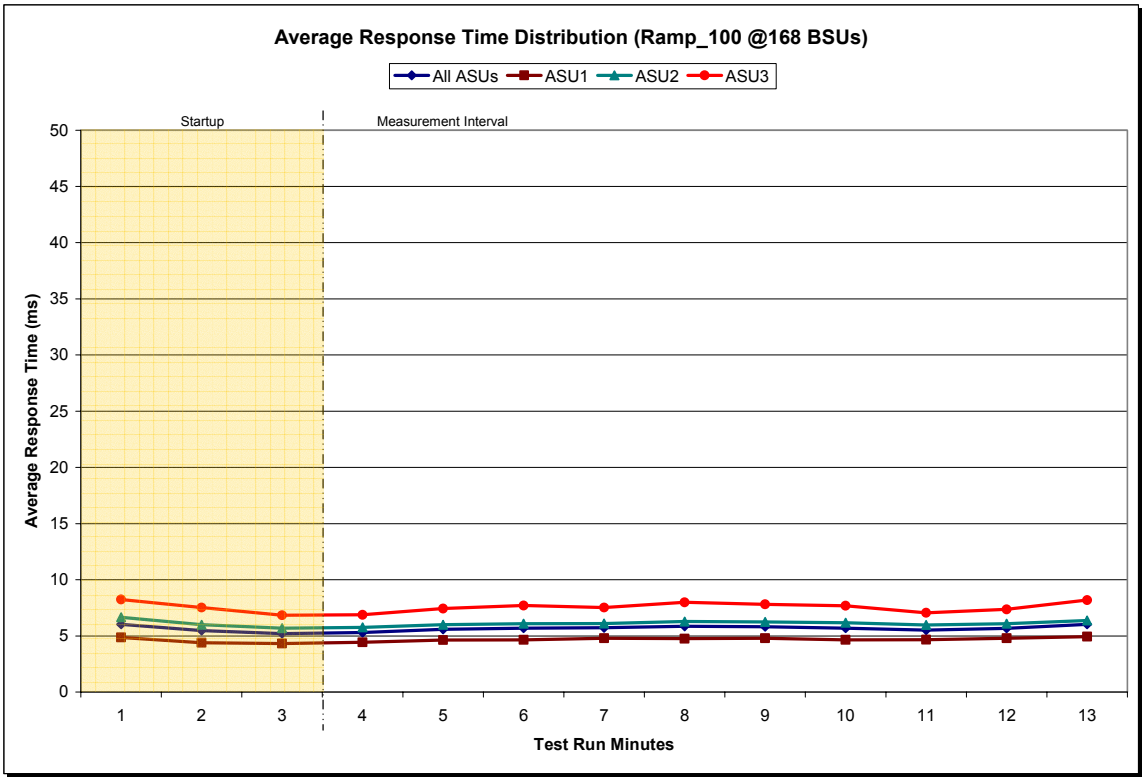


IOPS Test Run – Frequency Response Time Distribution



IOPS Test Run – Average Response Time Distribution

The Measurement Interval duration for the IOPS Test Run was 10 minutes (Test Run Minutes 3-13).



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
5,042,473	4,943,275	99,198

IOPS Test Run – Measured Intensity Multiplier and Coefficient of Variation

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
IM	*0.035*	*0.281*	*0.0700*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.280	0.069	0.210	0.018	0.070	0.035	0.280
COV	0.007	0.003	0.006	0.003	0.011	0.006	0.008	0.002

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.*

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%.*

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

RESPONSE TIME RAMP TEST PHASE

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 ***Error! Bookmark not defined.****.*

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

SPC-1 Workload Generator Input Parameters

A link to the SPC-1 Workload Generator input parameters for the Sustainability, IOPS, Response Time Ramp, and Test Runs is listed below.

Input Parameters *(Sustainability, IOPS, and Response Time Ramp)*

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

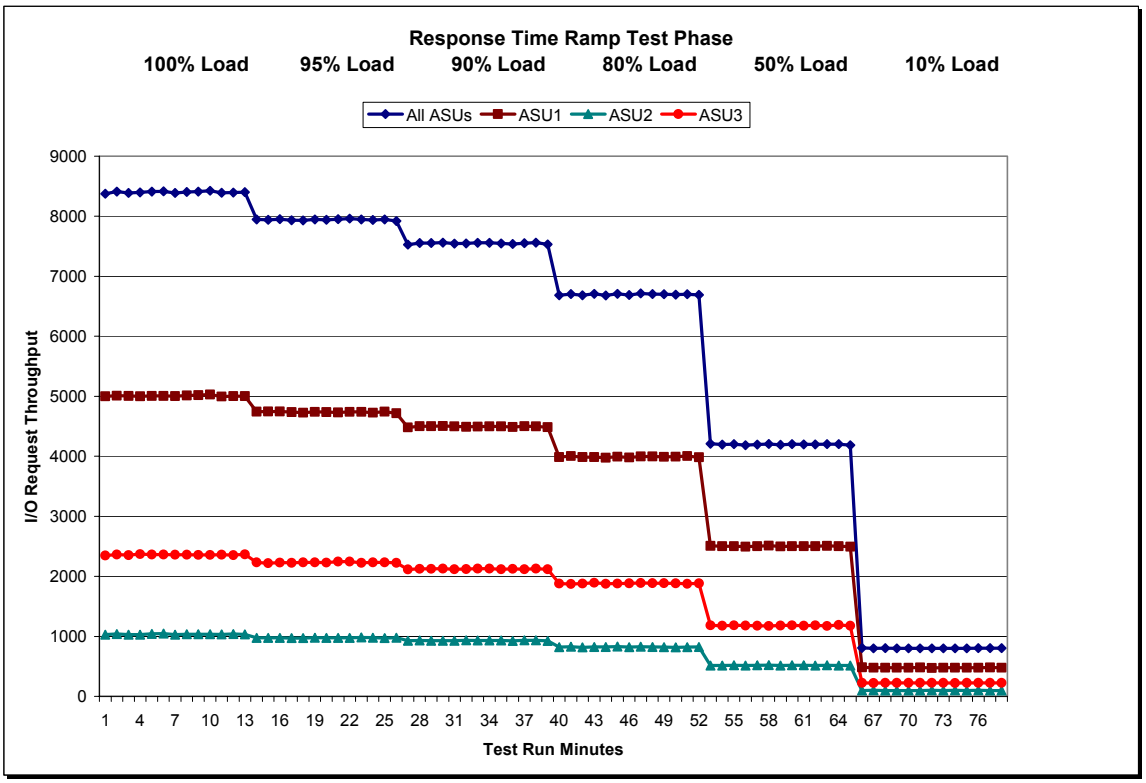
90% Load Level

80% Load Level

50% Load Level

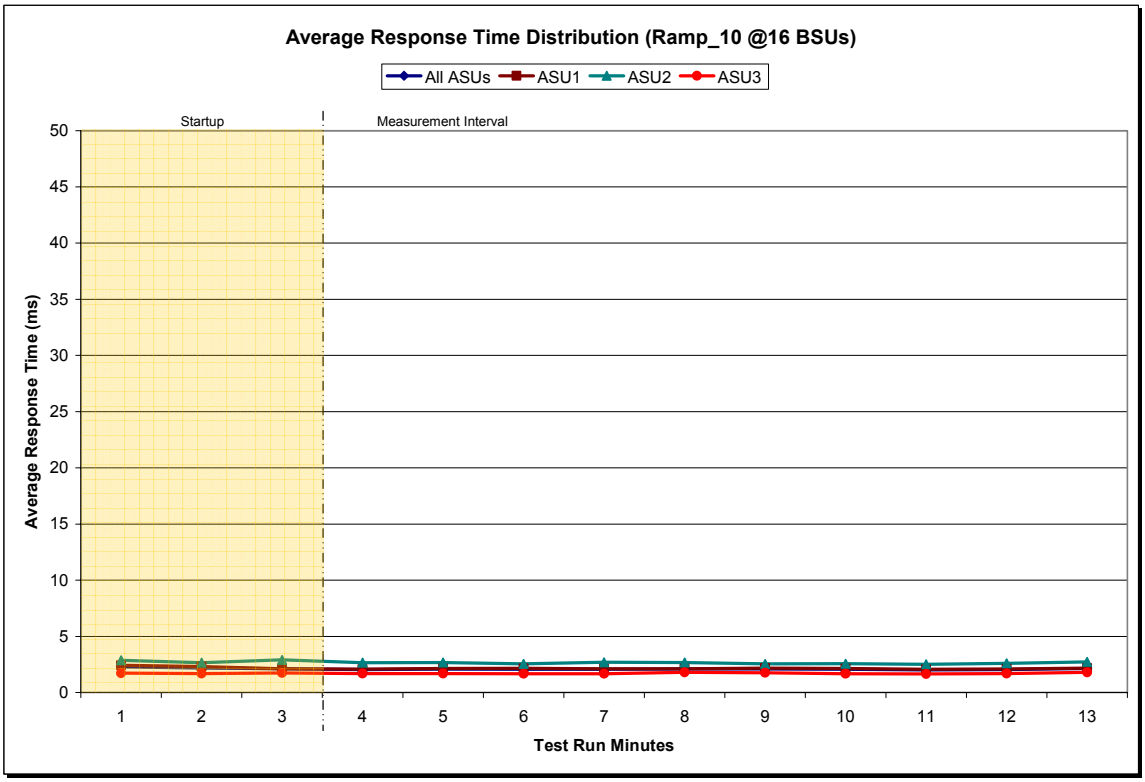
10% Load Level

Response Time Ramp Distribution (IOPS)



SPC-1 LRT™ Average Response Time Distribution

The Measurement Interval duration for the LRT (10%) Response Time Ramp Test Run was 10 minutes (Test Run Minutes 3-13).



SPC-1 LRT™ (10%) – 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*	*0.281*	*0.070*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.281	0.069	0.210	0.018	0.069	0.035	0.280
COV	0.016	0.007	0.012	0.009	0.042	0.014	0.020	0.006

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.*

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%.*

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

REPEATABILITY TEST

The Repeatability Test demonstrates the repeatability and reproducibility of the SPC-1 IOPS™ and SPC-1 LRT™ primary metrics 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™ primary metric. Each Average Response Time value must be less than the SPC-1 LRT™ primary metric plus 5%.

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.

SPC-1 Workload Generator Input Parameters

A link to the SPC-1 Workload Generator input parameters for the Repeatability Test Runs is listed below.

Input Parameters *(Repeatability1)*

Input Parameters *(Repeatability2)*

Response Time Ramp Test Results File

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

	SPC-1 IOPS™	SPC-1 LRT™
Primary Metrics	*8,404.22*	*2.07*
Repeatability Test Phase 1	8,397.89	1.99
Repeatability Test Phase 2	8,404.40	2.15

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

Repeatability Test Run 1 (LRT)

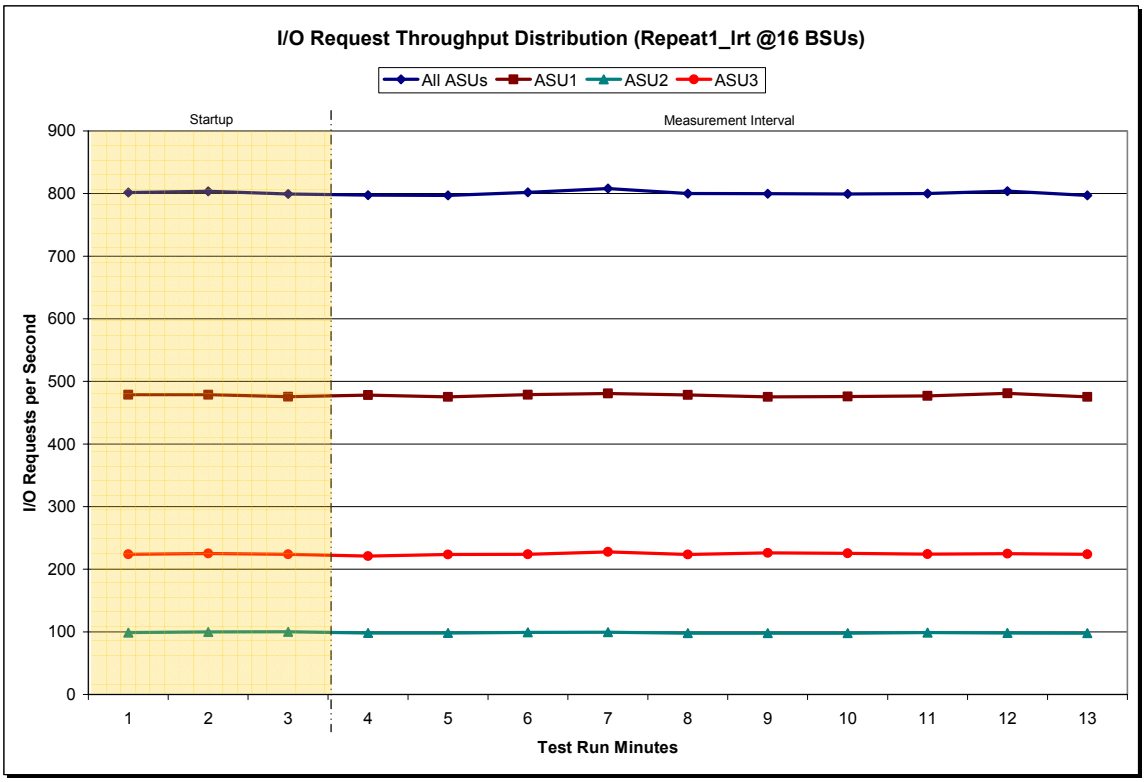
Repeatability Test Run 1 (IOPS)

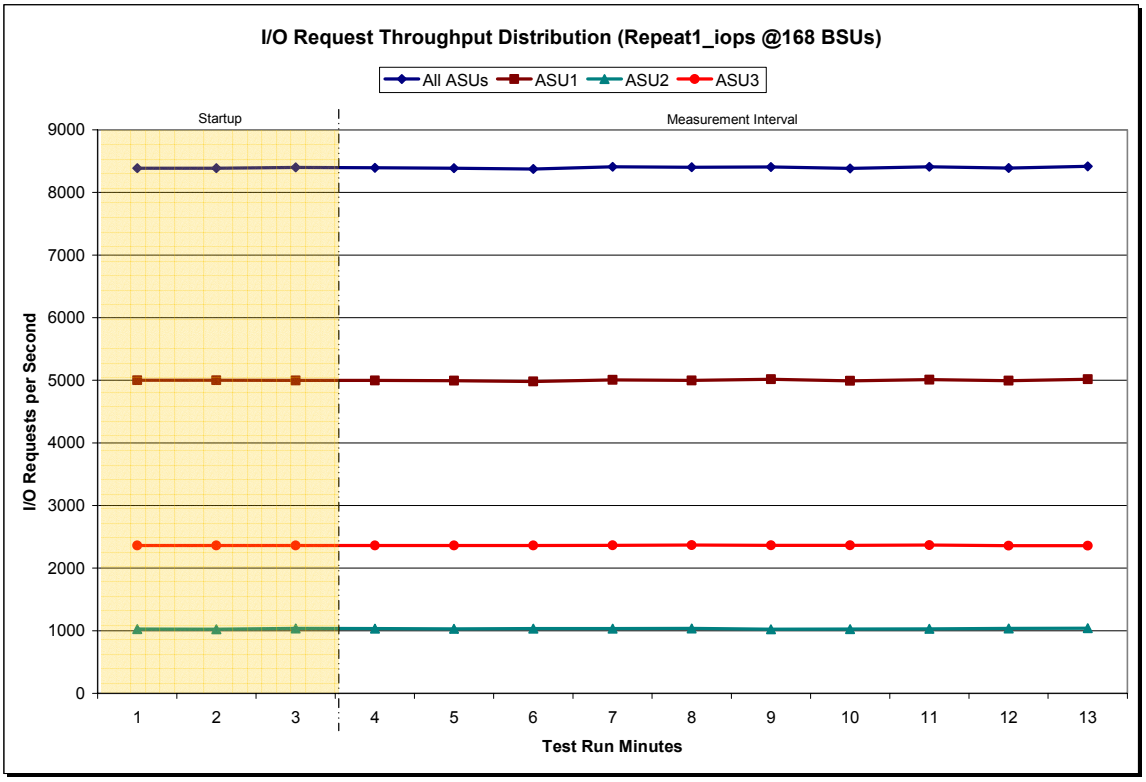
Repeatability Test Run 2 (LRT)

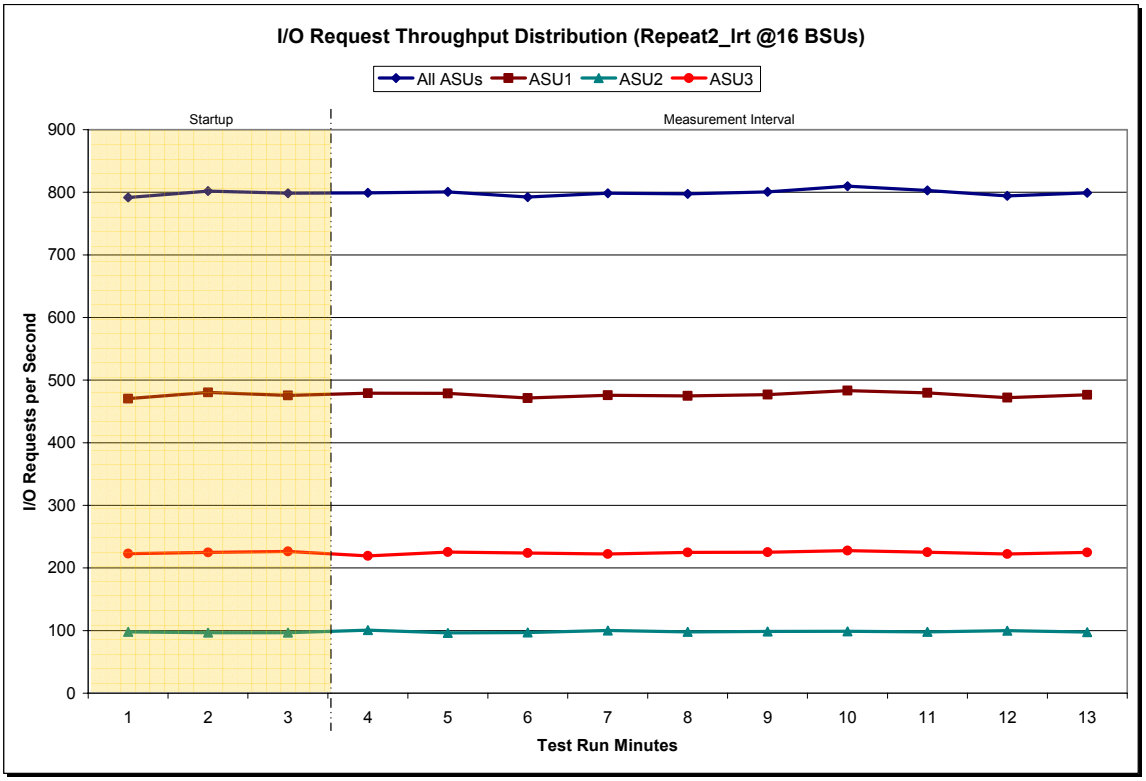
Repeatability Test Run 2 (IOPS)

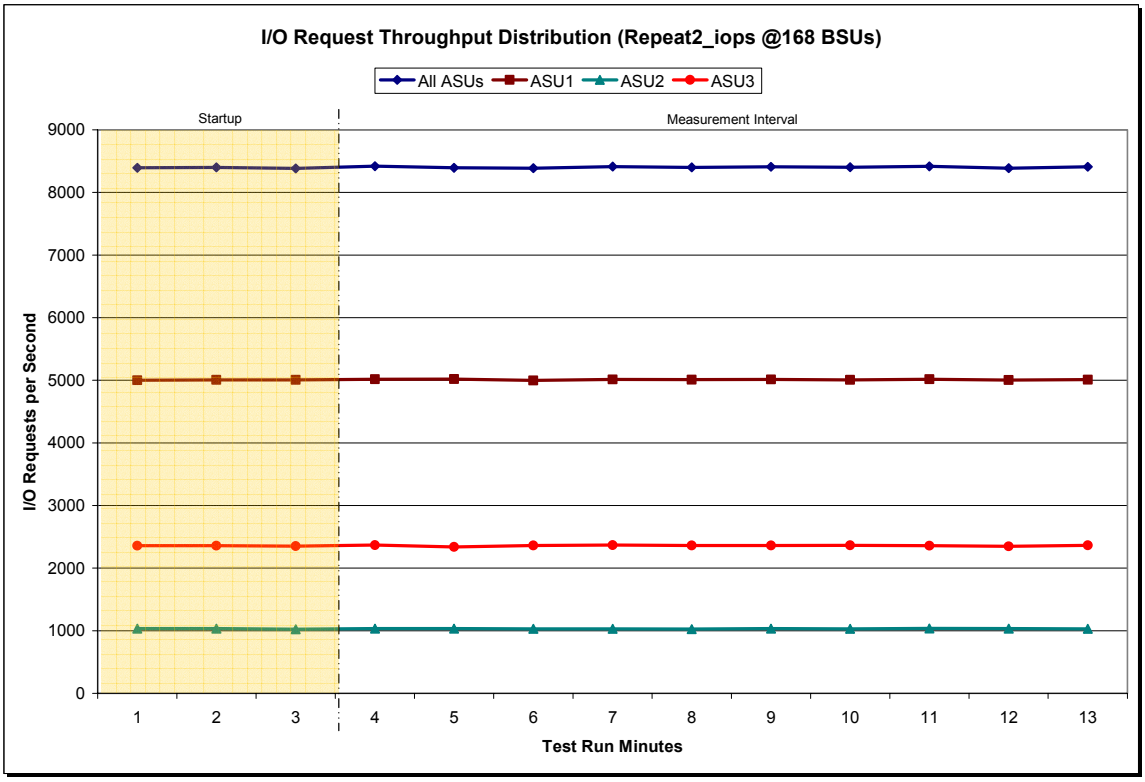
I/O Request Throughput Distribution

The Measurement Interval duration for each Repeatability Test Run was 10 minutes (Test Run Minutes 3-13).



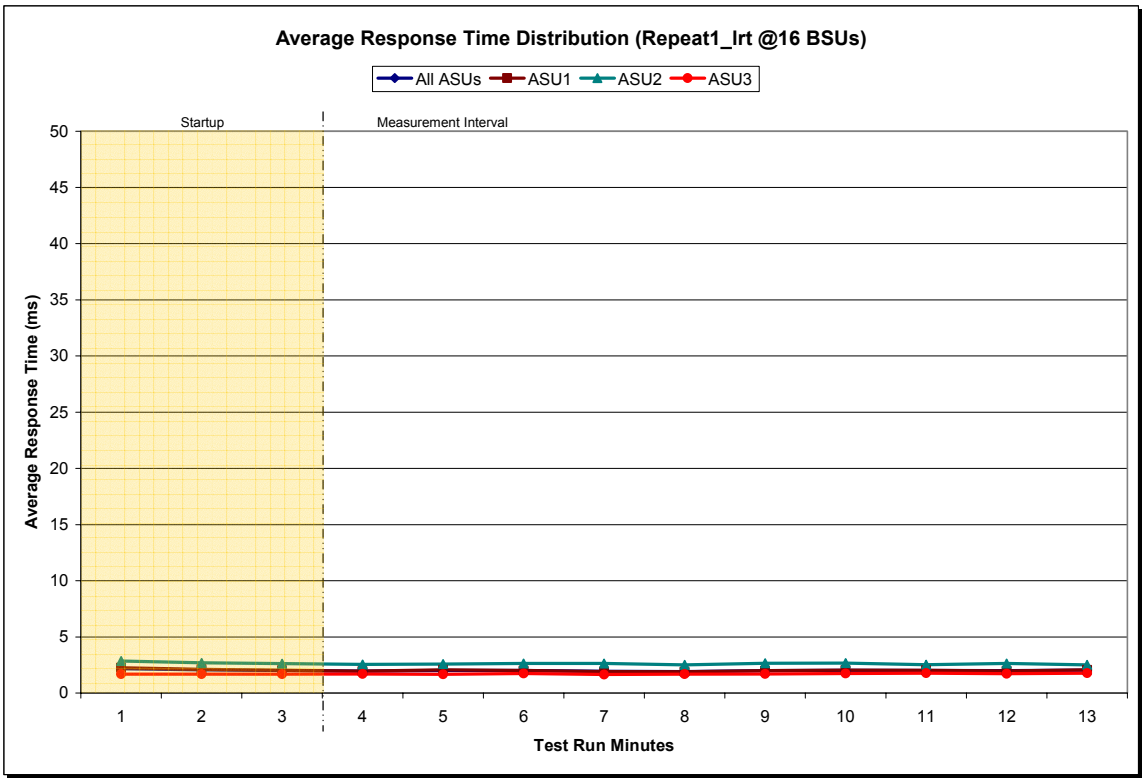

I/O Request Throughput Distribution (Repeat1_iops @168 BSUs)
All ASUs
ASU1
ASU2
ASU3
Startup
Measurement Interval
I/O Requests per Second
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Test Run Minutes

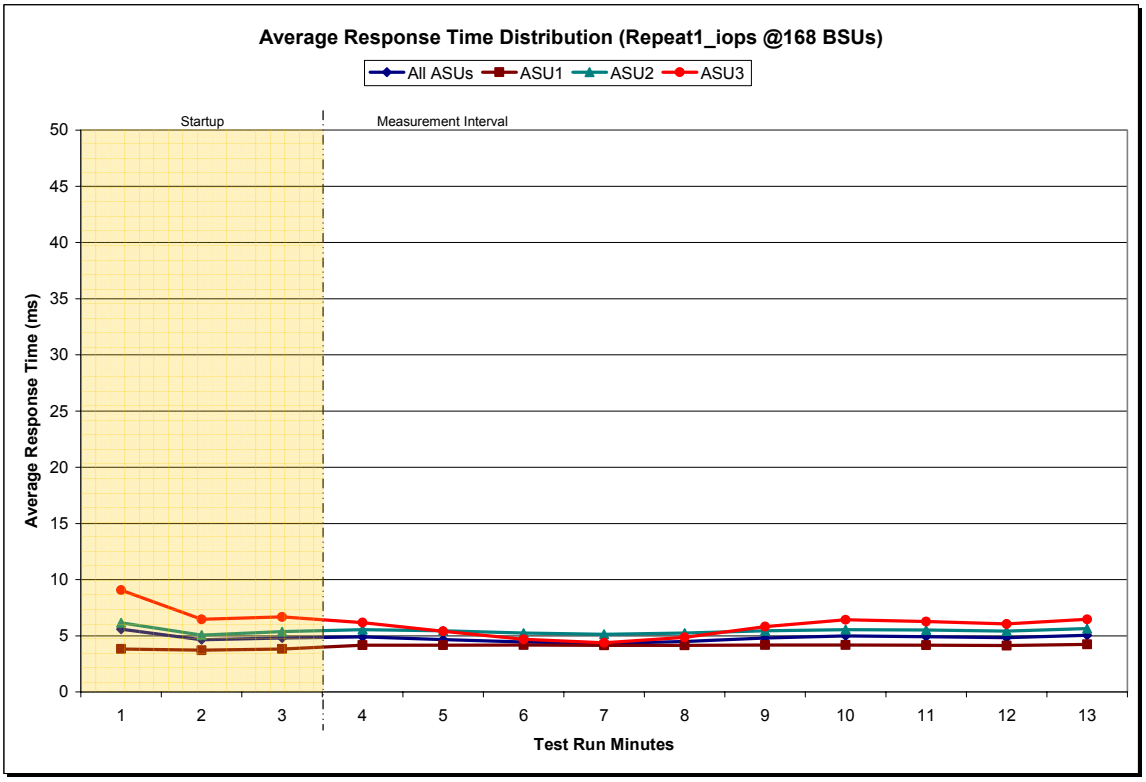

I/O Request Throughput Distribution (Repeat2_Irt @16 BSUs)
All ASUs
ASU1
ASU2
ASU3
Startup
Measurement Interval
I/O Requests per Second
900
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Test Run Minutes

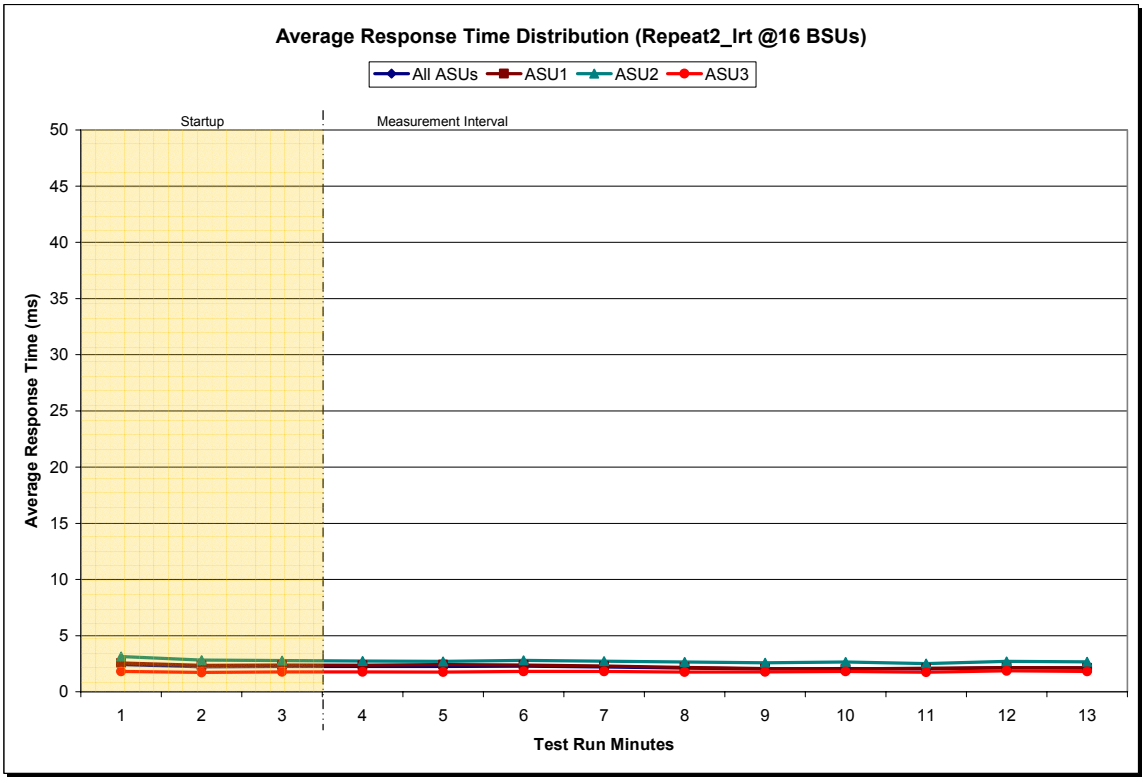

I/O Request Throughput Distribution (Repeat2_iops @168 BSUs)
All ASUs
ASU1
ASU2
ASU3
Startup
Measurement Interval
I/O Requests per Second
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Test Run Minutes

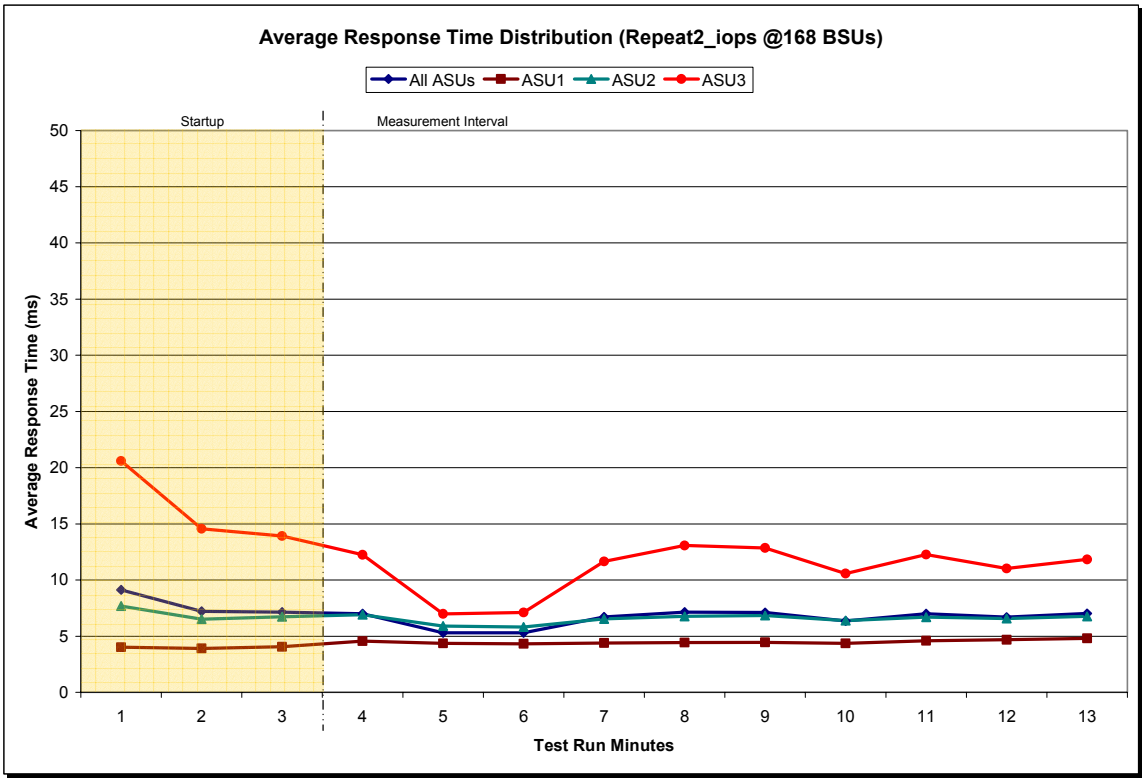
Average Response Time Distribution

The Measurement Interval duration for each Repeatability Test Run was 10 minutes (Test Run Minutes 3-13).




Average Response Time Distribution (Repeat1_iops @168 BSUs)
All ASUs
ASU1
ASU2
ASU3
Startup
Measurement Interval
Average Response Time (ms)
0
5
10
15
20
25
30
35
40
45
50
1
2
3
4
5
6
7
8
9
10
11
12
13
Test Run Minutes


Average Response Time Distribution (Repeat2_Irt @16 BSUs)
All ASUs
ASU1
ASU2
ASU3
Startup
Measurement Interval
Average Response Time (ms)
0
5
10
15
20
25
30
35
40
45
50
1
2
3
4
5
6
7
8
9
10
11
12
13
Test Run Minutes


Average Response Time Distribution (Repeat2_iops @168 BSUs)
All ASUs
ASU1
ASU2
ASU3
Startup
Measurement Interval
Average Response Time (ms)
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Test Run Minutes

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	*0.035*	*0.281*	*0.070*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.280	0.069	0.209	0.018	0.070	0.035	0.281
COV	0.006	0.004	0.005	0.002	0.008	0.006	0.010	0.002

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.*

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%.*

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

Repeatability 1 (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	*0.035*	*0.281*	*0.070*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.281	0.070	0.210	0.018	0.069	0.035	0.280
COV	0.017	0.005	0.017	0.010	0.037	0.015	0.022	0.008

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	*0.035*	*0.281*	*0.070*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.281	0.069	0.210	0.018	0.069	0.035	0.280
COV	0.009	0.002	0.005	0.002	0.013	0.002	0.007	0.004

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	*0.035*	*0.281*	*0.070*	*0.210*	*0.018*	*0.070*	*0.035*	*0.281*
MIM	0.035	0.280	0.070	0.210	0.018	0.069	0.035	0.280
COV	0.027	0.009	0.016	0.013	0.022	0.017	0.025	0.010

DATA PERSISTENCE TEST

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 IOP™ 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 Benchmark Configuration 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.

SPC-1 Workload Generator Input Parameters

A link to the SPC-1 Workload Generator input parameters for the Data Persistence Test is listed below.

Input Parameters *(Persistence 1)*

Input Parameters *(Persistence 2)*

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	19,163,680
Total Number of Logical Blocks Verified	15,151,120
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks	10:00
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.

TESTED STORAGE CONFIGURATION (TSC) AVAILABILITY DATE

The Sun StorEdge™ 9910, as documented in this Full Disclosure Report was available for shipment to customers on 21 August 2001.

PRICING INFORMATION

Pricing information may found in the Tested Storage Configuration Pricing section on page 11.

ANOMALIES OR IRREGULARITIES

The Logical Volume and ASU storage capacities configured by the VERITAS Volume manager were:

ASU 1 – Logical Volume 1 – 154.62 GB

ASU 2 – Logical Volume 2 – 154.62 GB

ASU 3 – Logical Volume 3 – 8.59 GB
Logical Volume 4 – 8.59 GB
Logical Volume 5 – 8.59 GB
Logical Volume 6 – 8.59 GB

The ASU "size" parameter was not used in the benchmark measurement, which should have caused the workload generator to use the storage capacities reported by the VERITAS Volume Manager. That was not the case because the capacities reported to the workload generator from the system were slightly different. The actual Logical Volume and ASU storage capacities reported to and used by the SPC-1 Workload Generator were:

ASU 1 – Logical Volume 1 – 154.6465 GB

ASU 2 - Logical Volume 2 – 154.6293 GB

ASU 3 – Logical Volume 3 – 8.5458 GB
Logical Volume 4 – 8.5710 GB
Logical Volume 5 – 8.5458 GB
Logical Volume 6 – 8.5710 GB

The difference between the two sets of capacities was small enough so that there was no impact on the performance of the Tested Storage Configuration.