SPC BENCHMARK 1™
FULL DISCLOSURE REPORT

TEXAS MEMORY SYSTEMS, INC.
TEXAS MEMORY SYSTEMS RAMSAN-630

SPC-1 V1.12

Submitted for Review: May 10, 2011
Submission Identifier: A00105

First Edition – May 2011

Trademarks

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AUDIT CERTIFICATION

Timothy Logan
Texas Memory Systems, Inc.
10777 Westheimer, Ste. 600
Houston, TX 77042

May 10, 2011

The SPC Benchmark 1™ Reported Data listed below for the Texas Memory Systems RamSan-630 were produced in compliance with the SPC Benchmark 1™ v1.12 Onsite Audit requirements.

SPC Benchmark 1™ v1.12 Reported Data	
Tested Storage Product (TSP) Name:	
Texas Memory Systems RamSan-630	
Metric	**Reported Result**
SPC-1 IOPS™	400,503.26
SPC-1 Price-Performance	$1.05/SPC-1 IOPS™
Total ASU Capacity	8,116.579 GB
Data Protection Level	Protected (RAID-5)
Total TSC Price (including three-year maintenance)	$419,292.00

The following SPC Benchmark 1™ Onsite 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 physical inspection and information supplied by Texas Memory Systems, Inc.:
  - ✓ Physical Storage Capacity and requirements.
  - ✓ Configured Storage Capacity and requirements.
  - ✓ Addressable Storage Capacity and requirements.
  - ✓ Capacity of each Logical Volume and requirements.
  - ✓ Capacity of each Application Storage Unit (ASU) and requirements.
- The Total Application Storage Unit (ASU) Capacity was filled with random data using Vdbench 5.03 Beta prior to the execution of the SPC-1 Tests.
- An appropriate diagram of the Benchmark Configuration (BC)/Tested Storage Configuration (TSC).

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

AUDIT CERTIFICATION *(CONT.)*
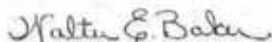
- Physical verification of the components to match the above diagram.

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

- SPC-1 Workload Generator commands and parameters used for the audited SPC Test Runs.

- The following Host System requirements were verified by physical inspection and information supplied by Texas Memory Systems, Inc.:

  - ✓ 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 execution of each Test, Test Phase, and Test Run was observed and found compliant with all of the requirements and constraints of Clauses 4, 5, and 11 of the SPC-1 Benchmark Specification.

- The Test Results Files and resultant Summary Results Files received from Texas Memory Systems, Inc. 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

- The Measurement Interval duration of the Sustainability Test Phase was eight (8) hours.

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

- The submitted pricing information met all of the requirements and constraints of Clause 8 of the SPC-1 Benchmark Specification.

- The Full Disclosure Report (FDR) met all of the requirements in Clause 9 of the SPC-1 Benchmark Specification.

- This successfully audited SPC measurement is not subject to an SPC Confidential Review.

Audit Notes:

There were no audit notes or exceptions.

Respectfully,

Walter E. Baker

Walter E. Baker
SPC Auditor

Storage Performance Council
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LETTER OF GOOD FAITH

Texas Memory Systems, Inc.

10777 Westheimer #600, Houston, TX 77042   713.266.3200

April 21, 2011
From: Daniel Scheel, President, Texas Memory Systems, Inc.

Subject: SPC-1 Letter of Good Faith for the RamSan-630

Texas Memory Systems 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 full in compliance with Version 1.12 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:

Daniel Scheel, President   4-21-2011

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	Texas Memory Systems, Inc. – http://www.ramsan.com Timothy Logan – timothy.logan@texmemsys.com 10777 Westheimer, Ste. 600 Houston, TX 77042 Phone: (713) 266-3200 FAX: (713) 266-0332
Test Sponsor Alternate Contact	Texas Memory Systems, Inc. – http://www.ramsan.com Jamon Bowen – jamon.b@texmemsys.com 10777 Westheimer, Ste. 600 Houston, TX 77042 Phone: (713) 266-3200 FAX: (713) 266-0332
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	V2.1.0
Date Results were first used publicly	May 10, 2011
Date the FDR was submitted to the SPC	May 10, 2011
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	May 10, 2011

Tested Storage Product (TSP) Description

The Texas Memory Systems' RamSan-630 rack mounted SLC NAND Flash system is a 3U enterprise class designed solid state disk offering scalable performance and affordable high capacity. In addition it offers:

- 1-10TB usable SLC NAND Flash storage capacity
- ECC and RAID protection designed in at the chip level
- Extremely low latency, providing both outstanding transaction and bandwidth performance
- Fibre Channel or Infiniband connectivity

The SPC-1 result demonstrates the latest performance ability of the Texas Memory Systems' RamSan product line. This product is available for purchase today.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: Texas Memory Systems RamSan-630	
Metric	**Reported Result**
SPC-1 IOPS™	400,503.26
SPC-1 Price-Performance™	$1.05/SPC-1 IOPS™
Total ASU Capacity	8,116.579 GB
Data Protection Level	Protected *(RAID-5)*
Total TSC Price (including three-year maintenance)	$419,292.00

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** using *RAID-5*.

The Texas Memory Systems RamSan-630 uses a modified RAID-5 algorithm to ensure that the failure of a Flash memory chip does not result in data corruption. The modification to the RAID-5 makes an important leap forward over HDD-based RAID-5 write performance. On HDD RAID-5 implementations, any time even a small block of data is written, the RAID-5 controller must read back the entire data stripe and the parity bits, then rewrite the data, and finally rewrite the parity. But the RamSan-630 always writes to a new location on the Flash medium as part of its wear leveling algorithm, so a read of the old data and parity before a write is not required.

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.
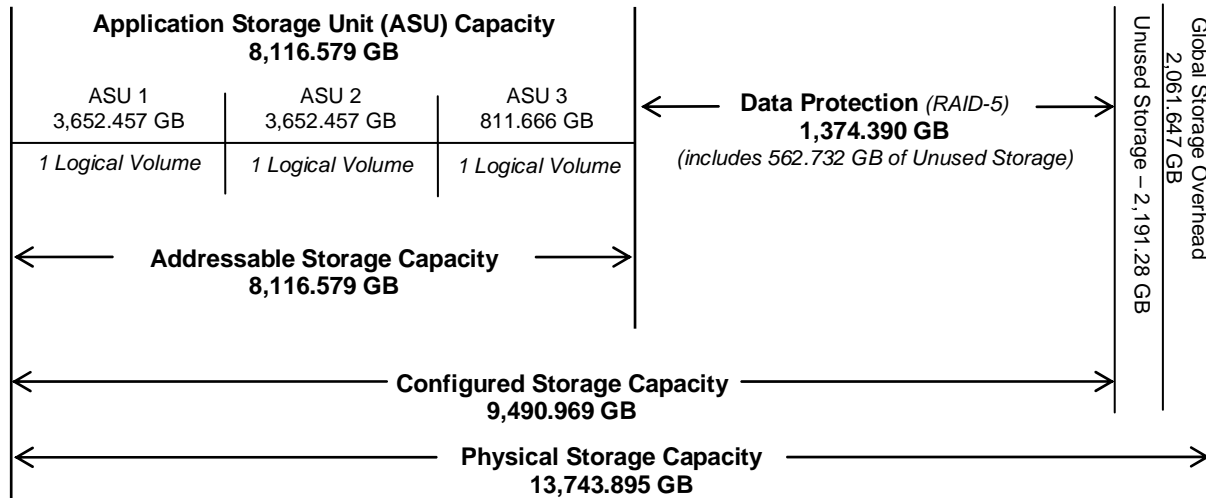
SPC-1 Storage Capacity Utilization	
Application Utilization	59.06%
Protected Application Utilization	64.96%
Unused Storage Ratio	20.04%

Application Utilization: Total ASU Capacity *(8,116.579 GB)* divided by Physical Storage Capacity *(8,116.579 GB)*

Protected Application Utilization: (Total ASU Capacity *(8,116.579 GB)* plus total Data Protection Capacity *(1,374.390 GB)* minus unused Data Protection Capacity *(562.732 GB)* divided by Physical Storage Capacity *(8,116.579 GB)*

Unused Storage Ratio: Total Unused Capacity *(2,754.011 GB)* divided by Physical Storage Capacity *(8,116.579 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.
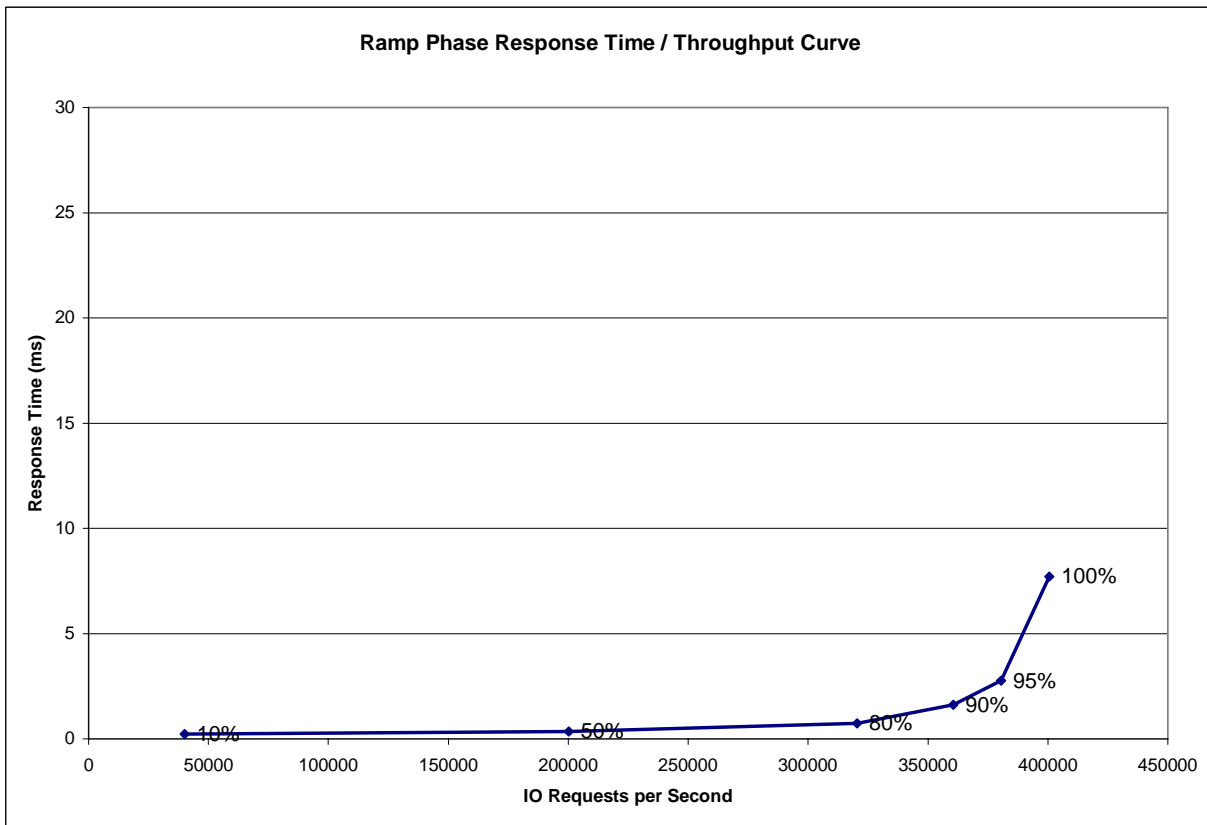
Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	40,045.71	200,250.39	320,375.99	360,425.44	380,450.36	400,503.26
Average Response Time (ms):						
All ASUs	0.22	0.34	0.75	1.61	2.76	7.71
ASU-1	0.25	0.36	0.72	1.45	2.48	8.14
ASU-2	0.24	0.36	0.73	1.43	2.22	4.36
ASU-3	0.15	0.28	0.80	2.04	3.60	8.25
Reads	0.34	0.45	0.69	0.98	1.39	4.88
Writes	0.14	0.27	0.78	2.02	3.65	9.55

Priced Storage Configuration Pricing

Ln #	Qty	Part	Description	Unit Price	Ext Price
HARDWARE					
1	1	U-RS630/10	RamSan-630 (10TB)	$314,500.00	$314,500.00
2	1	U-630-FC-381-i	Included FC Interface	$0.00	$0.00
3	4	U-630-FC-381	Additional FC Interface	$4,000.00	$16,000.00
4	1	U-630-SparesKit-GM/500GB-i	Included Spares Kit with 500GB Flash	$0.00	$0.00
5	1	U-630-RackSL	Rack Slide Kit	$200.00	$200.00

Hardware List Price	$330,700.00
Hardware Discount	0% -
Hardware Sub-Total	$330,700.00

Ln #	Qty	Part	Description	Unit Price	Ext Price
SUPPORT					
6	1	i-Warranty-Critical	Critical Warranty	$72,710.00	$72,710.00

Support List Price	$72,710.00
Support Discount	0% -
Support Sub-Total	$72,710.00

Ln #	Qty	Part	Description	Unit Price	Ext Price
Third-Party Components					
8	10	QLE2562-CK	QLogic 8Gb PCIe x8 Fibre Channel 2-port HBA	$1,549.80	$15,498.00
9	10	J9281B	Tripp Lite multimode duplex Fibre Channel cable LC/LC 2m	$38.40	$384.00

ADDITIONAL ITEMS SUB-TOTAL	$15,882.00

TOTAL PURCHASE PRICE	**$419,292.00**

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.**

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

Texas Memory Systems
RamSan-630

20 – 640 GiB Solid State Devices *(SSDs)*
5 – dual-port FC-381 8Gb FC interfaces
10 – Qlogic QLE2562 8Gb FC HBAs

Priced Storage Configuration Components

Priced Storage Configuration Components:
10 – Qlogic QLE2562-CK 8Gb Fibre Channel HBAs

Texas Memory System RamSan-630
    5 – dual-port FC-381 8Gb Fibre Channel interfaces
    10 – FC-381 8Gb Fibre Channel connections *(10 used)*
    20 – 640 GiB Solid State Devices *(SSDs)*

10 – multimode duplex Fibre Channel LC/LC 2m cables
1 – U-630 Spares Kit with 500 GB Flash
1 – Rack Slide Kit

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 storage network configuration is illustrated on page 17 *(Benchmark Configuration/Tested Storage Configuration Diagram).*

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 System(s) and Tested Storage Configuration Components).*

Benchmark Configuration/Tested Storage Configuration Diagram

**Texas Memory Systems
RamSan-630**

20 – 640 GiB Solid State Devices *(SSDs)*
5 – dual-port FC-381 8Gb FC interfaces
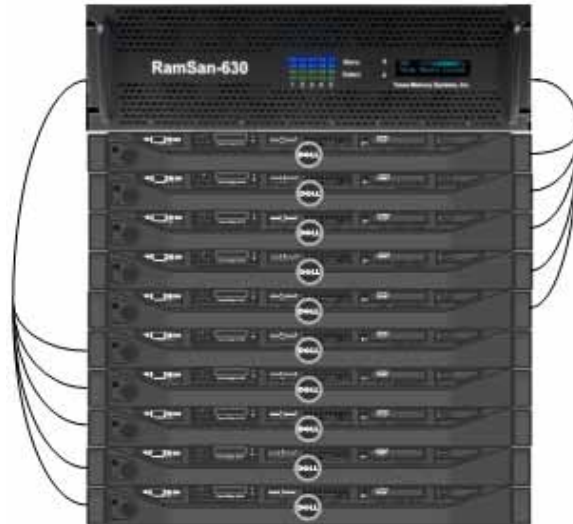
10 – Dell™ PowerEdge™ R310 Host Systems
Windows Server 2003 x86 Enterprise Edition w/SP2

10 – Qlogic QLE2562 8Gb FC HBAs

Host System(s) and Tested Storage Configuration Components

Host System:	Tested Storage Configuration Components:

10 – Dell™ PowerEdge™ R310 Host Systems
    each with:
    1 – Intel® Xeon® X3430 2.4 GHz Processor
        8 MB cache
    8 GB main memory
    2 – PCIe Generation 2 x8 slots
    Microsoft Windows Server 2003 x86
        Enterprise Edition w/SP2
	10 – Qlogic QLE2562-CK 8Gb Fibre Channel HBAs

	Texas Memory System RamSan-630
	    5 – dual-port FC-381 8Gb Fibre Channel interfaces
	    10 – FC-381 8Gb Fibre Channel connections *(10 used)*
	    20 – 640 GiB Solid State Devices *(SSDs)*

	10 – multimode duplex Fibre Channel LC/LC 2m cables
	1 – U-630 Spares Kit with 500 GB Flash
	1 – Rack Slide Kit

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 61.

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)	8,116.579
Addressable Storage Capacity	Gigabytes (GB)	8,116.579
Configured Storage Capacity	Gigabytes (GB)	9,490.969
Physical Storage Capacity	Gigabytes (GB)	13,743.895
Data Protection *(RAID-5)*	Gigabytes (GB)	1,374.390
Required Storage	Gigabytes (GB)	0.000
Global Storage Overhead	Gigabytes (GB)	2,061.647
Total Unused Storage	Gigabytes (GB)	2,754.011

SPC-1 Storage Hierarchy Ratios

	Addressable Storage Capacity	Configured Storage Capacity	Physical Storage Capacity
Total ASU Capacity	100.00%	85.52%	59.06%
Required for Data Protection *(Mirrored)*		14.48%	10.00%
Addressable Storage Capacity		85.52%	59.06%
Required Storage		0.00%	0.00%
Configured Storage Capacity			69.06%
Global Storage Overhead			15.00%
Unused Storage:			
Addressable	0.00%		
Configured		0.00%	
Physical			15.94%

The Physical Storage Capacity consisted of 13,743.895 GB distributed over 20 solid state devices (SSDs) each with a formatted capacity of 687.195 GB. There was 2,191.28 GB (15.94%) of Unused Storage within the Physical Storage Capacity. Global Storage Overhead consisted of 2,061.647 GB (15.00%) of the Physical Storage Capacity. There was 0.000 GB (0.00%) 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 *(RAID-5)* capacity was 1,374.390 GB of which 811.658 GB was utilized. The total Unused Storage was 2,754.011 GB.

SPC-1 Storage Capacities and Relationships Illustration

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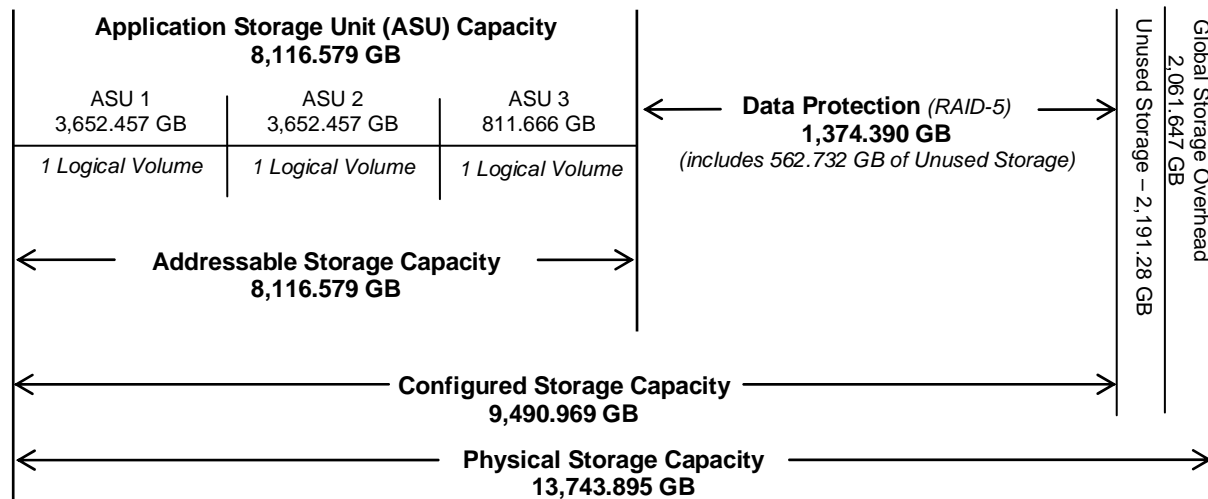
Logical Volume Capacity and ASU Mapping

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 (3,652.457 GB)	ASU-2 (3,652.457 GB)	ASU-3 (811.666 GB)
1 Logical Volume 3,652.457 GB per Logical Volume (3,652.457 used per Logical Volume)	1 Logical Volume 3,652.457 GB per Logical Volume (3,652.457 used per Logical Volume)	1 Logical Volume 811.666 GB per Logical Volume (811.666 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	59.06%
Protected Application Utilization	64.96%
Unused Storage Ratio	20.04%

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 62.

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 Tables

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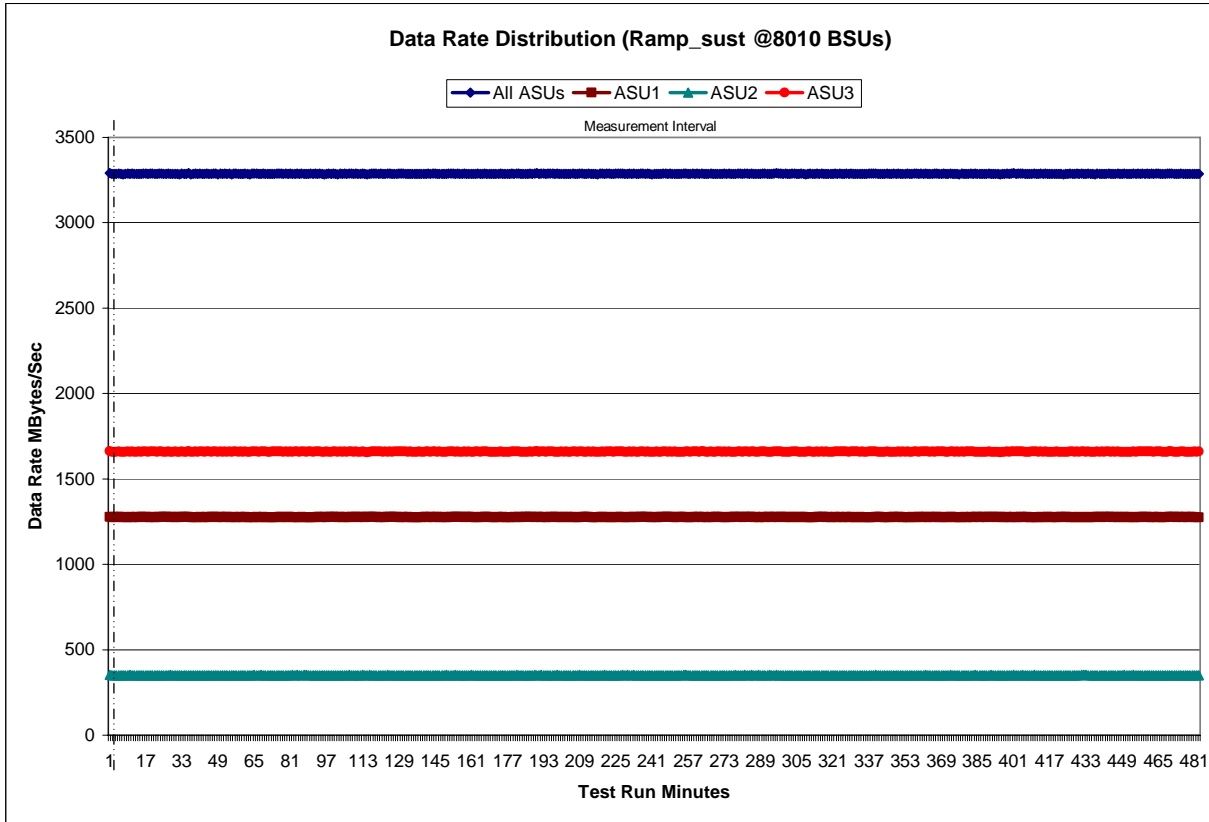
Sustainability – I/O Request Throughput Distribution Data

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 Data Rate Tables

Sustainability – I/O Request Throughput Distribution Graph
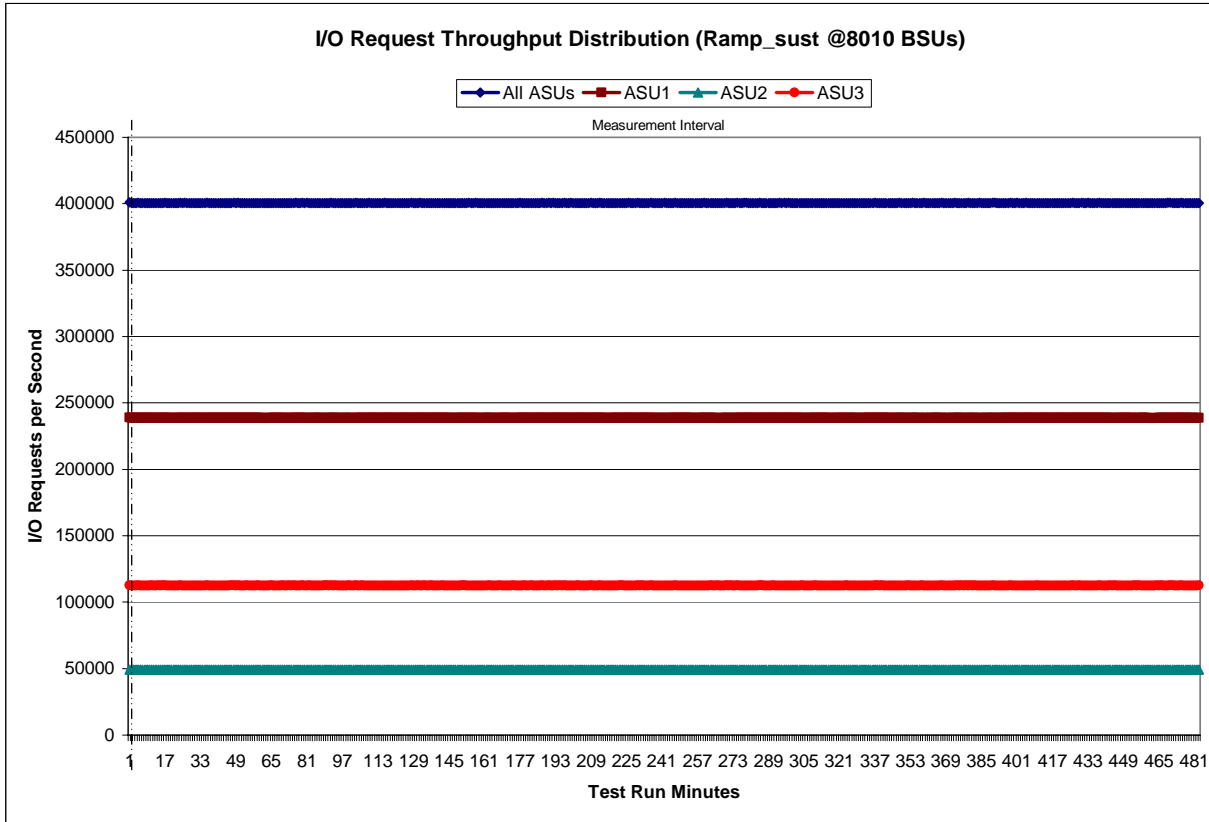
Sustainability – Average Response Time (ms) Distribution Data

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 Data Rate Tables

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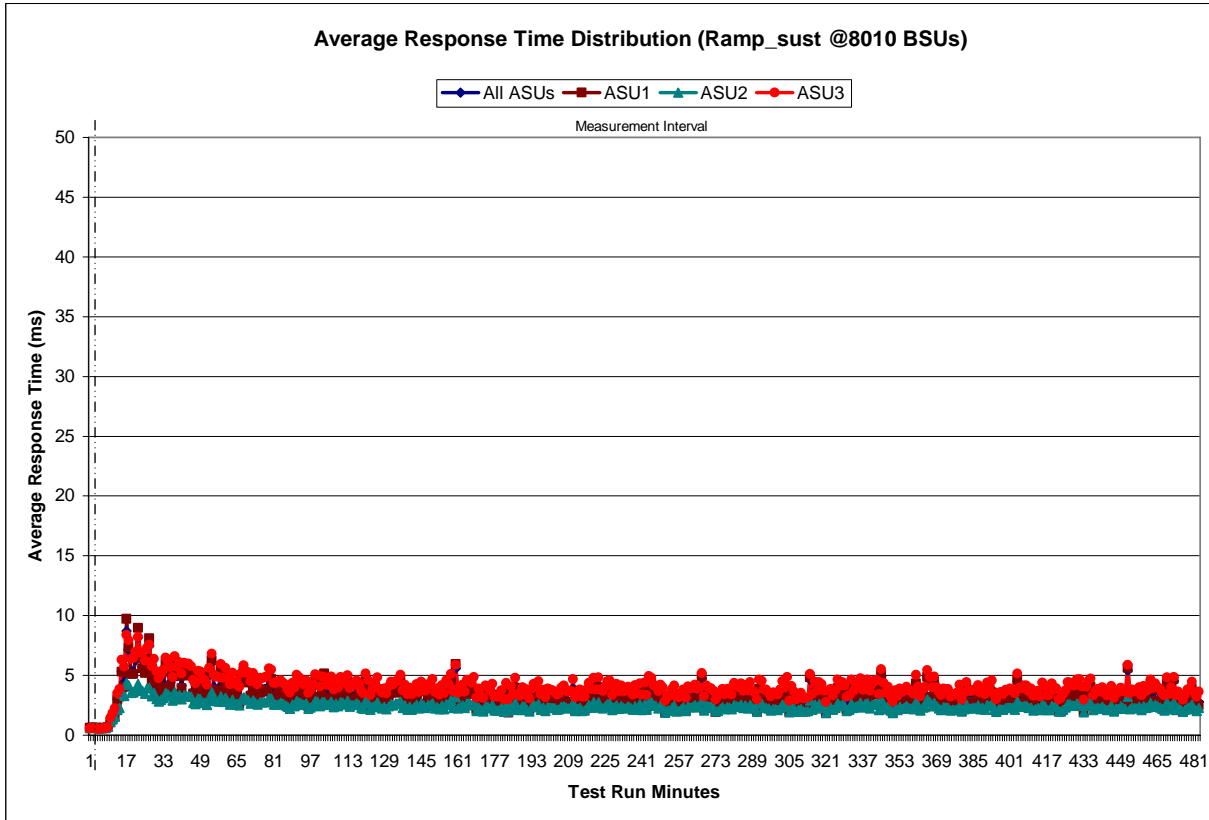
Sustainability – Response Time Frequency Distribution Data

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	-	563,463,611	1,304,794,247	901,736,502	584,166,565	302,403,136	247,653,821	152,630,333
Write	451,590,870	1,440,434,915	1,259,370,755	531,601,923	257,207,246	162,580,465	139,171,812	105,260,677
All ASUs	451,590,870	2,003,898,526	2,564,165,002	1,433,338,425	841,373,811	464,983,601	386,825,633	257,891,010
ASU1	220,187,507	1,140,071,738	1,646,374,792	973,764,295	591,439,880	316,666,430	263,663,800	169,741,765
ASU2	51,394,230	230,839,429	318,573,745	192,737,614	122,200,853	68,806,305	56,892,961	38,751,157
ASU3	180,009,133	632,987,359	599,216,465	266,836,516	127,733,078	79,510,866	66,268,872	49,398,088

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	196,427,075	65,773,993	19,854,122	10,658,624	8,022,554	5,969,608	9,686,318	8,855,397
Write	213,078,571	189,979,997	178,465,135	158,556,462	142,951,862	133,037,656	231,476,316	186,075,151
All ASUs	409,505,646	255,753,990	198,319,257	169,215,086	150,974,416	139,007,264	241,162,634	194,930,548
ASU1	246,446,409	131,184,255	89,694,733	75,802,736	66,831,652	62,238,295	108,099,694	88,050,835
ASU2	61,888,593	35,651,435	24,299,190	19,321,804	16,407,441	14,590,141	24,235,613	19,186,157
ASU3	101,170,644	88,918,300	84,325,334	74,090,546	67,735,323	62,178,828	108,827,327	87,693,556

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	8,510,145	8,170,328	7,867,934	32,450,453	23,590,901	18,100,844	15,595,803	52,817,364
Write	151,894,935	121,172,581	99,363,296	302,628,270	177,477,296	120,073,123	76,929,697	154,913,091
All ASUs	160,405,080	129,342,909	107,231,230	335,078,723	201,068,197	138,173,967	92,525,500	207,730,455
ASU1	73,274,036	59,745,531	50,225,670	159,502,427	82,609,736	57,081,276	45,353,870	156,575,691
ASU2	15,635,177	12,456,748	10,240,674	31,485,352	28,260,967	16,683,796	6,224,495	1,964,398
ASU3	71,495,867	57,140,630	46,764,886	144,090,944	90,197,494	64,408,895	40,947,135	49,190,366

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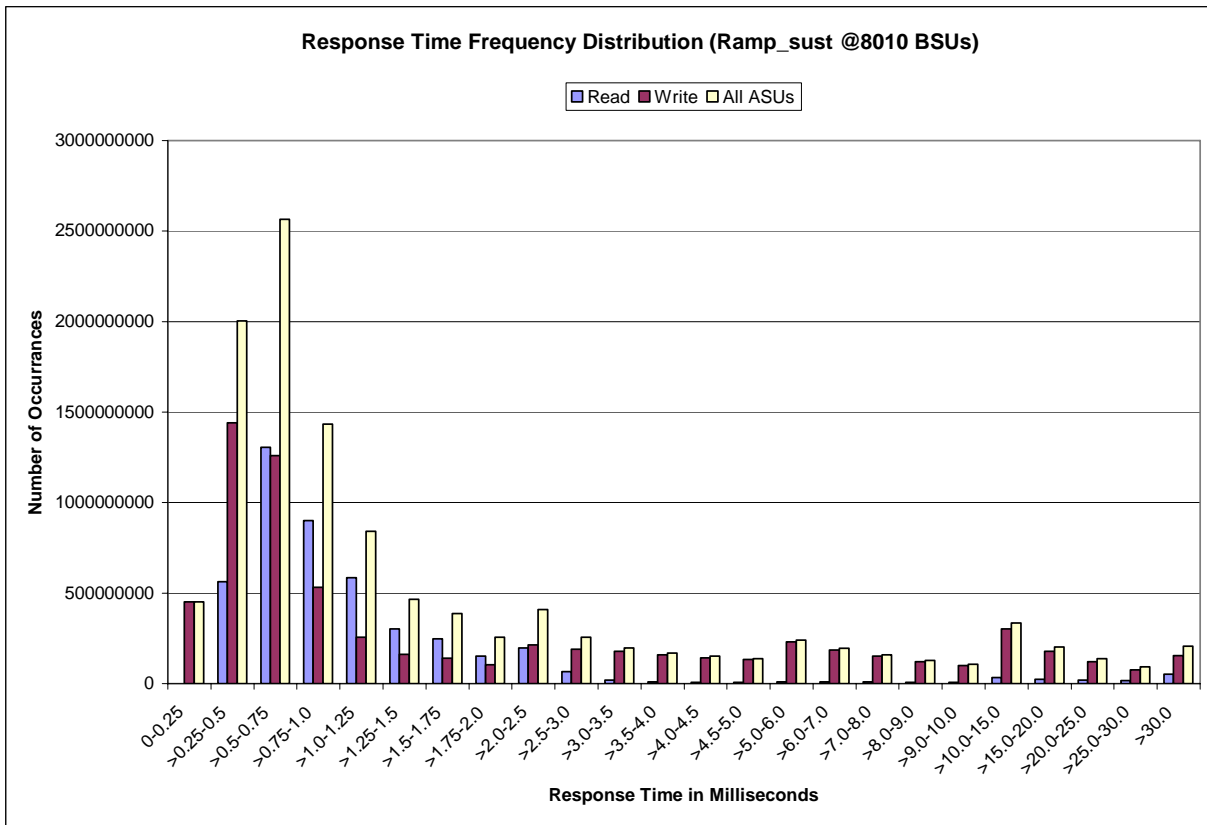
Sustainability – Measured Intensity Multiplier and Coefficient of Variation

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	0.02100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.002	0.001	0.001	0.000

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 62.

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

8010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:36:38	16:39:39	0-2	0:03:01
Measurement Interval	16:39:39	16:49:39	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	400,796.77	238,922.00	49,256.57	112,618.20
1	400,616.22	238,799.18	49,238.75	112,578.28
2	400,607.13	238,781.53	49,269.10	112,556.50
3	400,561.18	238,751.08	49,232.58	112,577.52
4	400,485.97	238,706.83	49,265.88	112,513.25
5	400,605.07	238,724.23	49,309.88	112,570.95
6	400,423.95	238,620.45	49,223.95	112,579.55
7	400,420.53	238,638.05	49,273.80	112,508.68
8	400,503.40	238,739.08	49,243.23	112,521.08
9	400,462.57	238,662.73	49,234.02	112,565.82
10	400,743.57	238,879.53	49,332.37	112,531.67
11	400,522.60	238,670.48	49,285.13	112,566.98
12	400,303.78	238,550.70	49,263.45	112,489.63
Average	*400,503.26*	*238,694.32*	*49,266.43*	*112,542.51*

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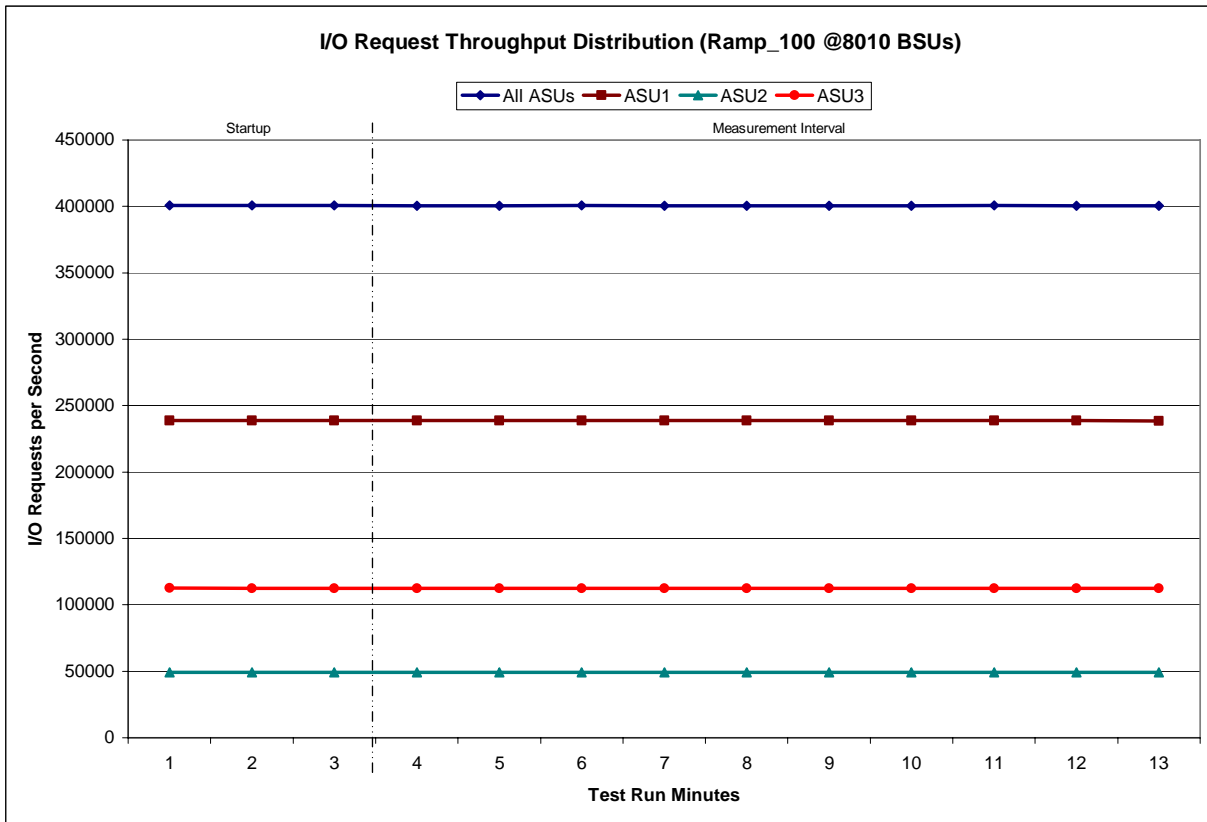
IOPS Test Run – Average Response Time (ms) Distribution Data

8010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:36:38	16:39:39	0-2	0:03:01
Measurement Interval	16:39:39	16:49:39	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.85	0.86	0.75	0.87
1	1.24	1.11	1.17	1.54
2	9.78	10.97	4.86	9.41
3	7.36	7.63	4.30	8.11
4	7.28	7.54	4.30	8.03
5	6.17	6.13	3.91	7.25
6	8.93	9.85	4.63	8.88
7	6.24	6.26	3.90	7.22
8	7.59	7.77	4.49	8.58
9	8.46	9.08	4.63	8.82
10	7.32	7.65	4.24	7.96
11	9.38	10.47	4.72	9.13
12	8.36	9.06	4.48	8.56
Average	*7.71*	*8.14*	*4.36*	*8.25*

IOPS Test Run – Average Response Time (ms) Distribution Graph
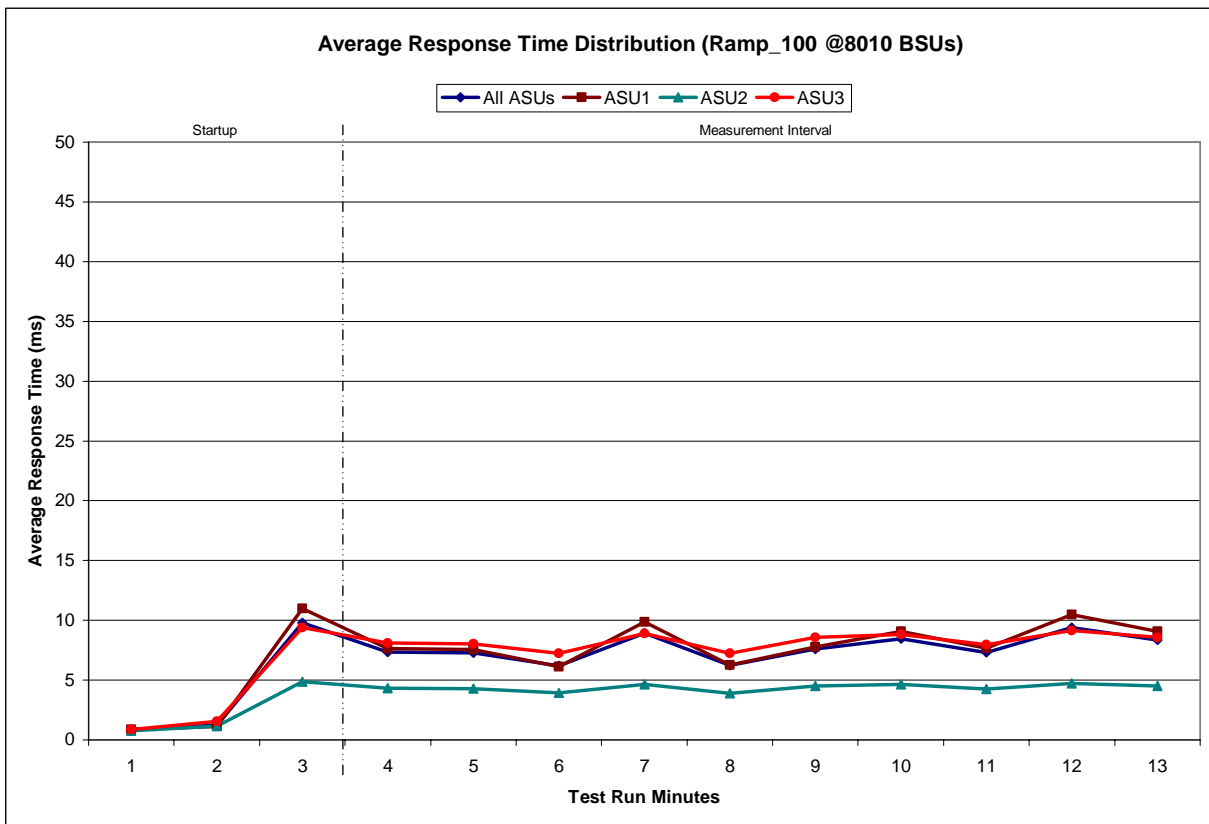
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Texas Memory Systems, Inc.   Submitted for Review: MAY 10, 2011
Texas Memory Systems RamSan-630

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	0	7,753,896	20,021,156	16,473,772	12,318,944	6,976,095	5,509,215	3,511,654
Write	6,461,681	21,261,490	18,985,109	8,328,413	4,208,631	2,658,148	2,080,689	1,474,085
All ASUs	6,461,681	29,015,386	39,006,265	24,802,185	16,527,575	9,634,243	7,589,904	4,985,739
ASU1	3,148,589	16,343,669	25,141,436	17,230,746	11,944,780	6,800,614	5,329,737	3,355,004
ASU2	734,218	3,344,941	4,876,846	3,407,349	2,478,593	1,514,355	1,252,213	931,195
ASU3	2,578,874	9,326,776	8,987,983	4,164,090	2,104,202	1,319,274	1,007,954	699,540

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	5,115,583	2,083,526	770,635	439,902	352,371	271,452	423,627	375,038
Write	2,913,298	2,627,811	2,564,768	2,454,920	2,374,089	2,407,153	4,760,394	4,495,383
All ASUs	8,028,881	4,711,337	3,335,403	2,894,822	2,726,460	2,678,605	5,184,021	4,870,421
ASU1	4,986,814	2,516,459	1,533,743	1,320,040	1,245,496	1,243,078	2,435,734	2,303,057
ASU2	1,655,212	968,247	600,423	436,888	371,217	323,203	536,997	472,829
ASU3	1,386,855	1,226,631	1,201,237	1,137,894	1,109,747	1,112,324	2,211,290	2,094,535

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	361,000	350,777	340,686	1,475,819	1,284,750	1,143,463	1,083,437	6,340,920
Write	4,228,660	3,779,819	3,346,826	11,492,352	9,393,443	6,675,881	4,472,251	12,078,578
All ASUs	4,589,660	4,130,596	3,687,512	12,968,171	10,678,193	7,819,344	5,555,688	18,419,498
ASU1	2,181,060	1,970,139	1,774,643	6,261,935	3,864,099	2,881,886	2,452,409	14,951,213
ASU2	439,262	390,600	344,211	1,203,571	1,634,721	1,072,990	455,041	114,685
ASU3	1,969,338	1,769,857	1,568,658	5,502,665	5,179,373	3,864,468	2,648,238	3,353,600

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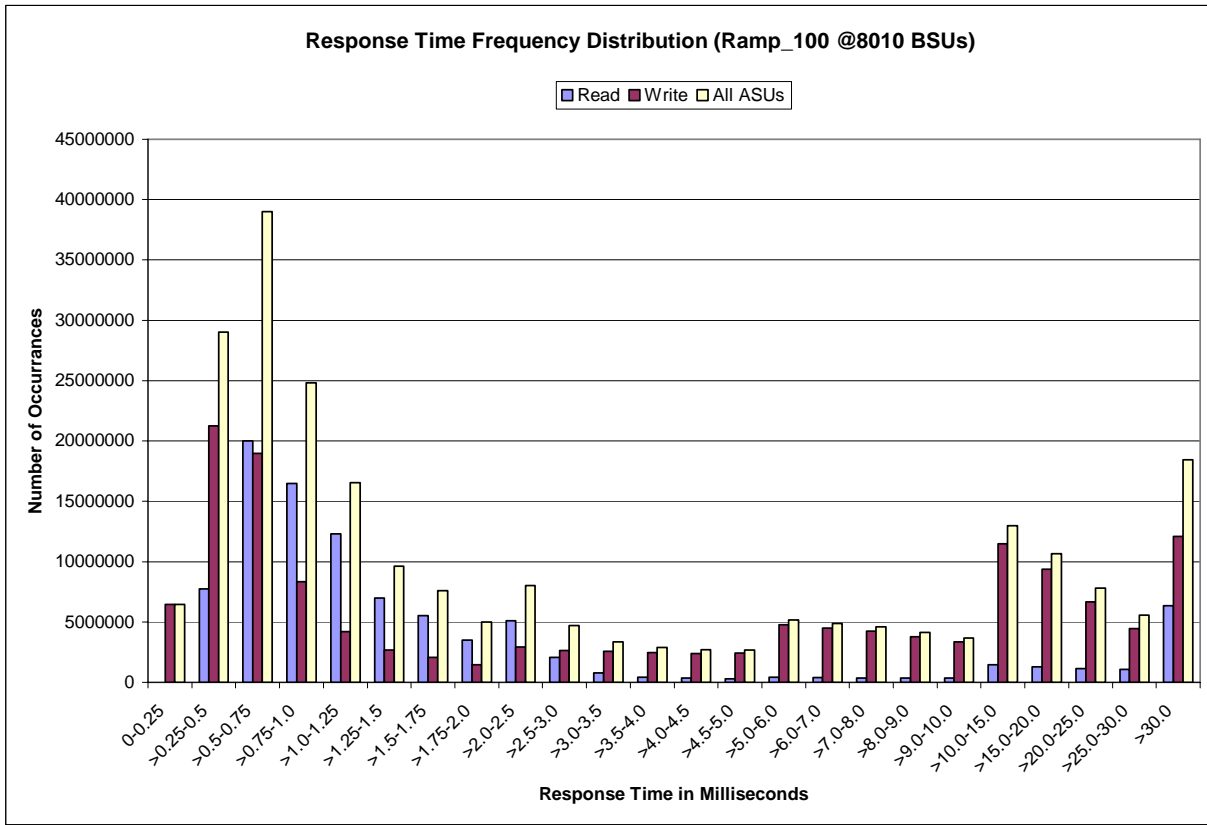
IOPS Test Run – I/O Request Information

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
240,301,590	221,882,092	18,419,498

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	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.002	0.001	0.001	0.000

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Texas Memory Systems, Inc.   Submitted for Review: MAY 10, 2011
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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 62.

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 - 8010 BSUs	Start	Stop	Interval	Duration	95% Load Level - 7609 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	16:36:38	16:39:39	0-2	0:03:01	Start-Up/Ramp-Up	16:50:44	16:53:45	0-2	0:03:01
Measurement Interval	16:39:39	16:49:39	3-12	0:10:00	Measurement Interval	16:53:45	17:03:45	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	400,796.77	238,922.00	49,256.57	112,618.20	0	380,590.90	226,876.23	46,824.88	106,889.78
1	400,616.22	238,799.18	49,238.75	112,578.28	1	380,388.45	226,669.93	46,775.92	106,942.60
2	400,607.13	238,781.53	49,269.10	112,556.50	2	380,535.17	226,813.75	46,805.15	106,916.27
3	400,561.18	238,751.08	49,232.58	112,577.52	3	380,404.57	226,743.97	46,783.82	106,876.78
4	400,485.97	238,706.83	49,265.88	112,513.25	4	380,477.08	226,727.33	46,812.02	106,937.73
5	400,605.07	238,724.23	49,309.88	112,570.95	5	380,395.98	226,674.67	46,804.32	106,917.00
6	400,423.95	238,620.45	49,223.95	112,579.55	6	380,434.53	226,749.52	46,829.88	106,855.13
7	400,420.53	238,638.05	49,273.80	112,508.68	7	380,496.20	226,767.85	46,782.33	106,946.02
8	400,503.40	238,739.08	49,243.23	112,521.08	8	380,529.97	226,861.07	46,829.95	106,838.95
9	400,462.57	238,662.73	49,234.02	112,565.82	9	380,459.70	226,704.98	46,794.00	106,960.72
10	400,743.57	238,879.53	49,332.37	112,531.67	10	380,427.88	226,741.53	46,799.50	106,886.85
11	400,522.60	238,670.48	49,285.13	112,566.98	11	380,464.32	226,696.25	46,838.48	106,929.58
12	400,303.78	238,550.70	49,263.45	112,489.63	12	380,413.33	226,705.05	46,780.12	106,928.17
Average	400,503.26	238,694.32	49,266.43	112,542.51	Average	380,450.36	226,737.22	46,805.44	106,907.69

90% Load Level - 7209 BSUs	Start	Stop	Interval	Duration	80% Load Level - 6408 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:04:48	17:07:49	0-2	0:03:01	Start-Up/Ramp-Up	17:18:48	17:21:49	0-2	0:03:01
Measurement Interval	17:07:49	17:17:49	3-12	0:10:00	Measurement Interval	17:21:49	17:31:50	3-12	0:10:01
(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3	(60 second intervals)	All ASUs	ASU-1	ASU-2	ASU-3
0	360,401.18	214,822.65	44,306.68	101,271.85	0	320,575.67	191,035.50	39,447.70	90,092.47
1	360,547.93	214,816.42	44,377.12	101,354.40	1	320,358.88	190,929.88	39,376.58	90,052.42
2	360,413.28	214,812.73	44,322.15	101,278.40	2	320,351.13	191,010.37	39,405.97	89,934.80
3	360,372.08	214,777.85	44,341.62	101,252.62	3	320,336.13	190,935.95	39,376.28	90,023.90
4	360,472.35	214,828.18	44,344.47	101,299.70	4	320,349.90	190,911.13	39,418.33	90,020.43
5	360,297.00	214,677.78	44,298.60	101,320.62	5	320,410.65	190,986.75	39,412.00	90,011.90
6	360,454.33	214,858.87	44,365.22	101,230.25	6	320,370.78	190,983.90	39,398.77	89,988.12
7	360,416.20	214,848.08	44,297.40	101,270.72	7	320,324.22	190,954.10	39,408.77	89,961.35
8	360,480.53	214,911.25	44,326.08	101,243.20	8	320,388.35	190,871.43	39,414.05	90,102.87
9	360,443.22	214,882.05	44,302.65	101,258.52	9	320,474.48	190,966.08	39,431.17	90,077.23
10	360,468.05	214,900.42	44,295.90	101,271.73	10	320,336.78	190,911.32	39,388.30	90,037.17
11	360,492.50	214,814.25	44,323.17	101,355.08	11	320,443.10	190,972.45	39,404.38	90,066.27
12	360,358.17	214,810.42	44,320.95	101,226.80	12	320,325.53	190,909.85	39,409.98	90,005.70
Average	360,425.44	214,830.92	44,321.61	101,272.92	Average	320,375.99	190,940.30	39,406.20	90,029.49

50% Load Level - 4005 BSUs	Start	Stop	Interval	Duration	10% Load Level - 801 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:32:36	17:35:37	0-2	0:03:01	Start-Up/Ramp-Up	17:46:08	17:49:09	0-2	0:03:01
Measurement Interval	17:35:37	17:45:37	3-12	0:10:00	Measurement Interval	17:49:09	17:59:09	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	200,191.05	119,288.85	24,655.20	56,247.00	0	40,076.67	23,882.02	4,943.08	11,251.57
1	200,293.73	119,372.75	24,664.05	56,256.93	1	40,051.42	23,845.00	4,924.17	11,282.25
2	200,183.40	119,294.00	24,654.65	56,234.75	2	40,039.92	23,865.72	4,923.00	11,251.20
3	200,157.12	119,275.00	24,602.13	56,279.98	3	40,048.75	23,884.58	4,930.05	11,234.12
4	200,289.77	119,347.37	24,681.38	56,261.02	4	40,026.07	23,838.02	4,927.40	11,260.65
5	200,229.42	119,302.48	24,628.28	56,298.65	5	40,058.45	23,867.80	4,953.23	11,237.42
6	200,300.48	119,326.60	24,648.52	56,325.37	6	40,054.83	23,874.75	4,926.15	11,253.93
7	200,303.53	119,406.17	24,622.28	56,275.08	7	40,016.83	23,853.02	4,922.47	11,241.35
8	200,243.95	119,375.18	24,621.07	56,247.70	8	40,091.03	23,879.53	4,919.13	11,292.37
9	200,248.17	119,381.42	24,641.22	56,225.53	9	40,028.27	23,824.50	4,914.27	11,289.50
10	200,237.28	119,364.27	24,627.67	56,245.35	10	40,050.42	23,874.08	4,932.70	11,243.63
11	200,218.82	119,254.10	24,684.75	56,279.97	11	40,030.47	23,866.35	4,915.70	11,248.42
12	200,275.33	119,350.60	24,640.67	56,284.07	12	40,051.97	23,880.02	4,919.55	11,252.40
Average	200,250.39	119,338.32	24,639.80	56,272.27	Average	40,045.71	23,864.27	4,926.07	11,255.38

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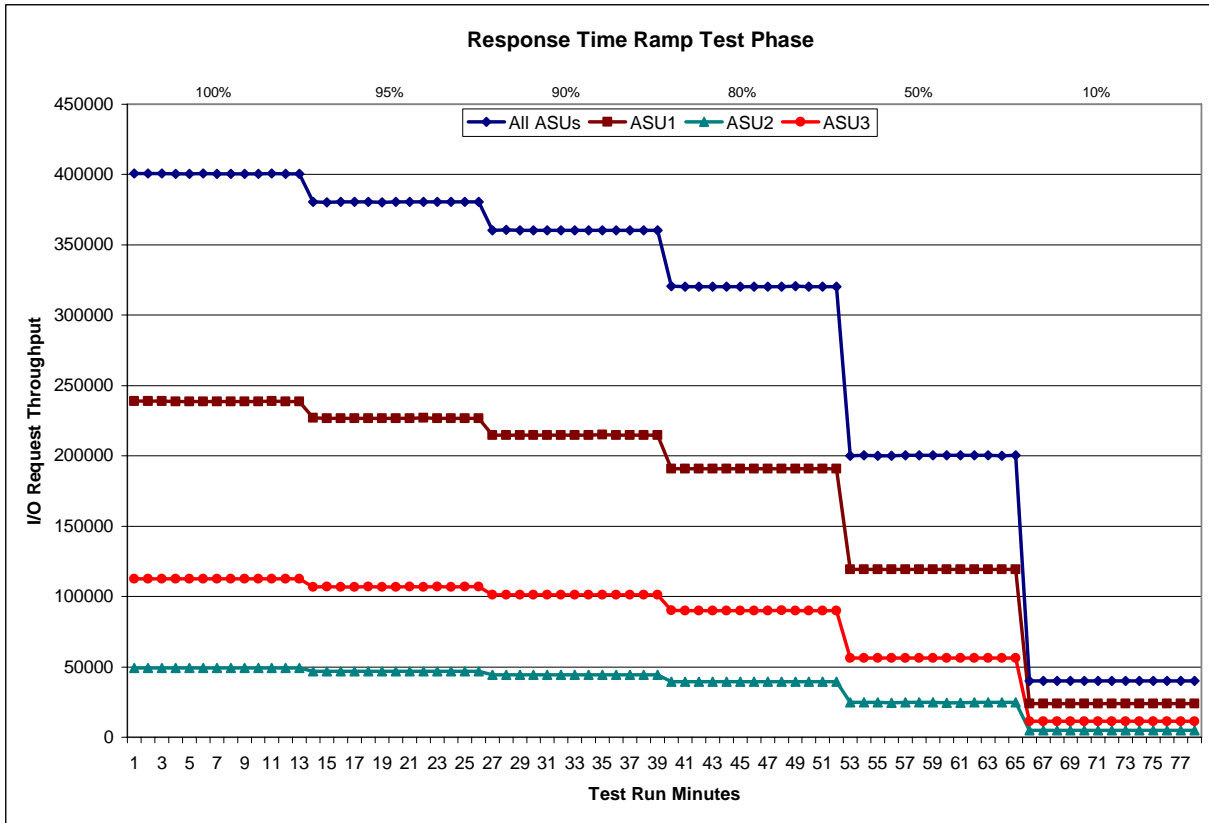
SPC-1 LRT™ Average Response Time (ms) Distribution Data

801 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	17:46:08	17:49:09	0-2	0:03:01
Measurement Interval	17:49:09	17:59:09	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.24	0.26	0.25	0.17
1	0.22	0.25	0.24	0.15
2	0.22	0.25	0.24	0.15
3	0.22	0.25	0.24	0.15
4	0.22	0.25	0.24	0.15
5	0.22	0.25	0.24	0.15
6	0.22	0.25	0.24	0.15
7	0.22	0.25	0.24	0.15
8	0.22	0.25	0.24	0.15
9	0.22	0.25	0.24	0.15
10	0.22	0.25	0.24	0.15
11	0.22	0.25	0.24	0.15
12	0.22	0.25	0.24	0.15
Average	*0.22*	*0.25*	*0.24*	*0.15*

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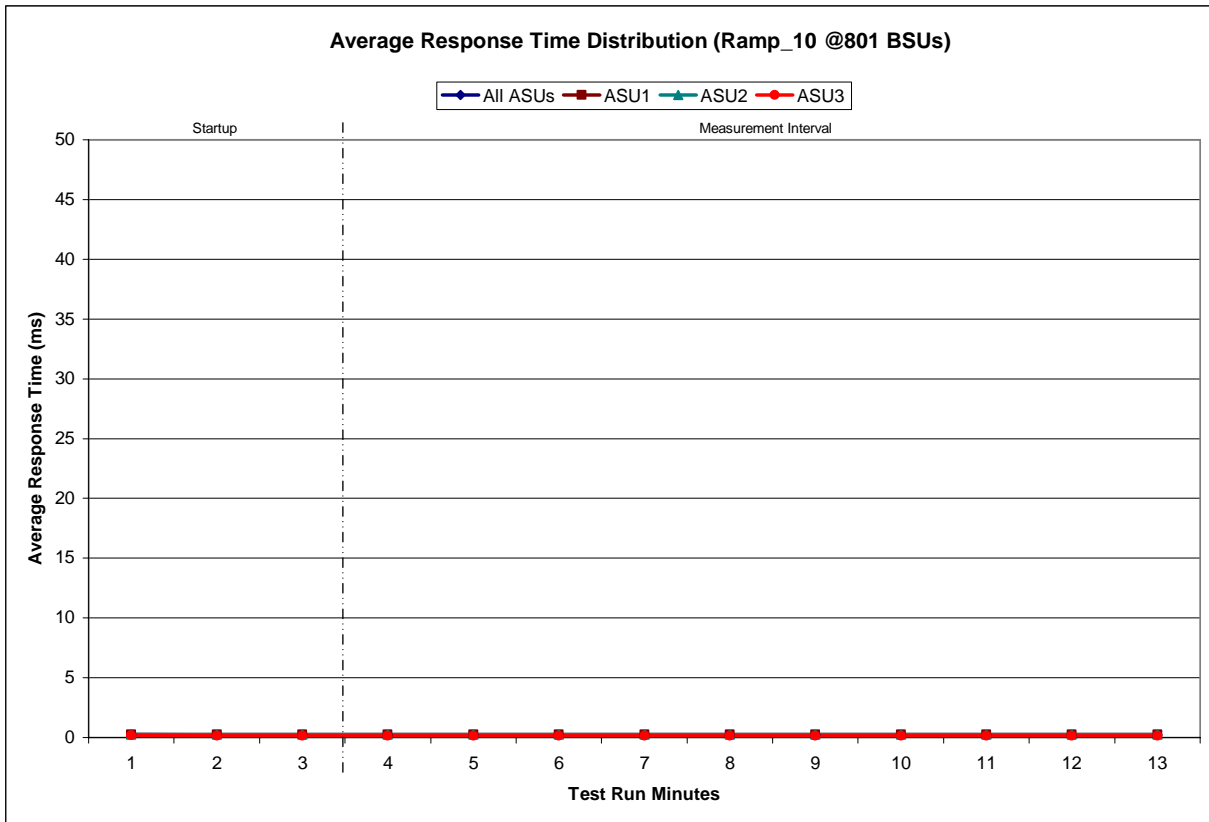
SPC-1 LRT™ (10%) – Measured Intensity Multiplier and Coefficient of Variation

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	0.0349	0.2809	0.0700	0.2101	0.0180	0.0700	0.0350	0.2811
COV	0.003	0.001	0.002	0.002	0.005	0.003	0.002	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 62.

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	*400,503.26*
Repeatability Test Phase 1	400,472.35
Repeatability Test Phase 2	400,481.20

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	*0.22 ms*
Repeatability Test Phase 1	0.22 ms
Repeatability Test Phase 2	0.22 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

801 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:00:18	18:03:18	0-2	0:03:00
Measurement Interval	18:03:18	18:13:18	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	40,052.82	23,879.78	4,914.22	11,258.82
1	40,064.38	23,877.62	4,931.53	11,255.23
2	40,053.77	23,890.97	4,919.68	11,243.12
3	40,070.37	23,890.88	4,929.25	11,250.23
4	40,116.78	23,903.42	4,922.32	11,291.05
5	40,049.33	23,844.28	4,928.88	11,276.17
6	40,037.37	23,882.73	4,900.70	11,253.93
7	40,038.77	23,883.73	4,912.93	11,242.10
8	40,088.62	23,887.43	4,928.52	11,272.67
9	40,017.18	23,856.07	4,925.22	11,235.90
10	40,044.57	23,863.50	4,934.33	11,246.73
11	40,036.05	23,838.17	4,945.40	11,252.48
12	40,045.62	23,867.72	4,908.95	11,268.95
Average	*40,054.47*	*23,871.79*	*4,923.65*	*11,259.02*

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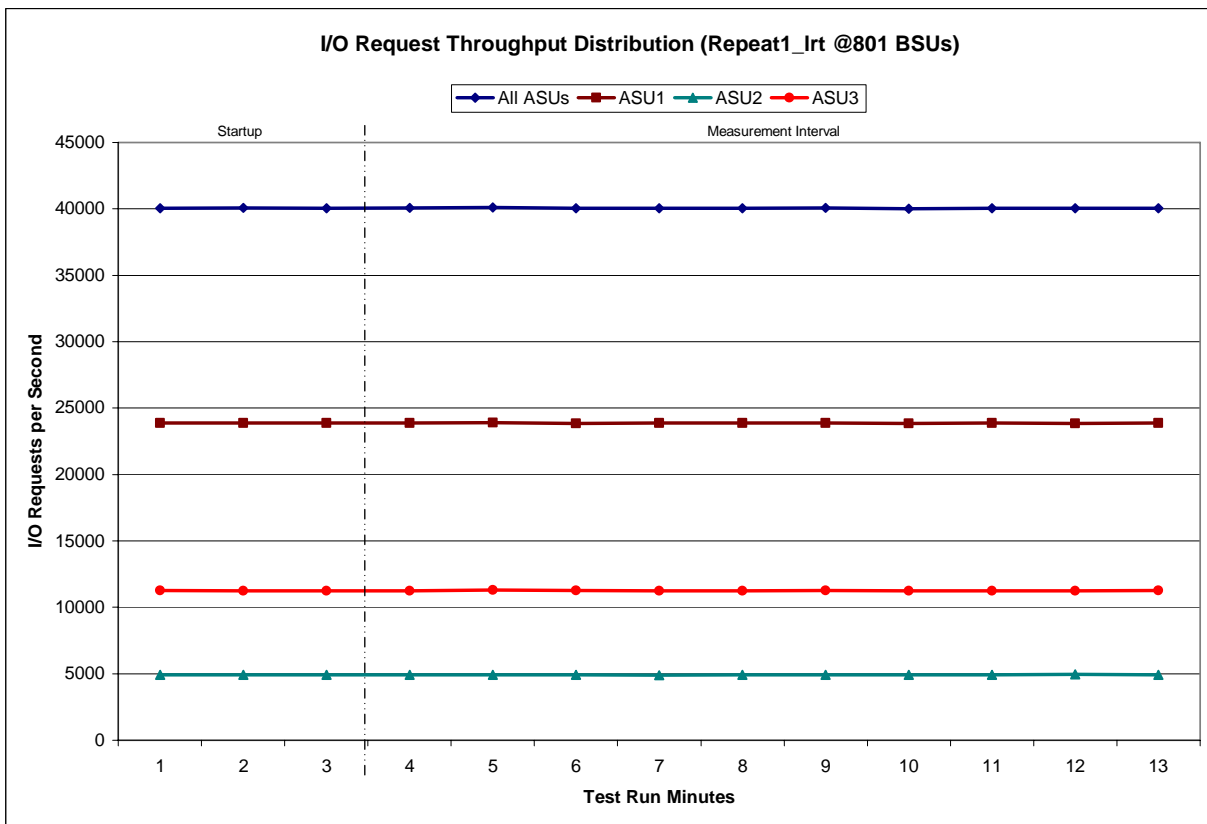
Repeatability 1 LRT –Average Response Time (ms) Distribution Data

801 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:00:18	18:03:18	0-2	0:03:00
Measurement Interval	18:03:18	18:13:18	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.24	0.27	0.26	0.17
1	0.22	0.25	0.24	0.15
2	0.22	0.25	0.24	0.15
3	0.22	0.25	0.24	0.15
4	0.22	0.25	0.24	0.15
5	0.22	0.25	0.24	0.15
6	0.22	0.25	0.24	0.15
7	0.22	0.25	0.24	0.15
8	0.22	0.25	0.24	0.15
9	0.22	0.25	0.24	0.15
10	0.22	0.25	0.24	0.15
11	0.22	0.25	0.24	0.15
12	0.22	0.25	0.24	0.15
Average	*0.22*	*0.25*	*0.24*	*0.15*

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

Repeatability 1 IOPS – I/O Request Throughput Distribution Data

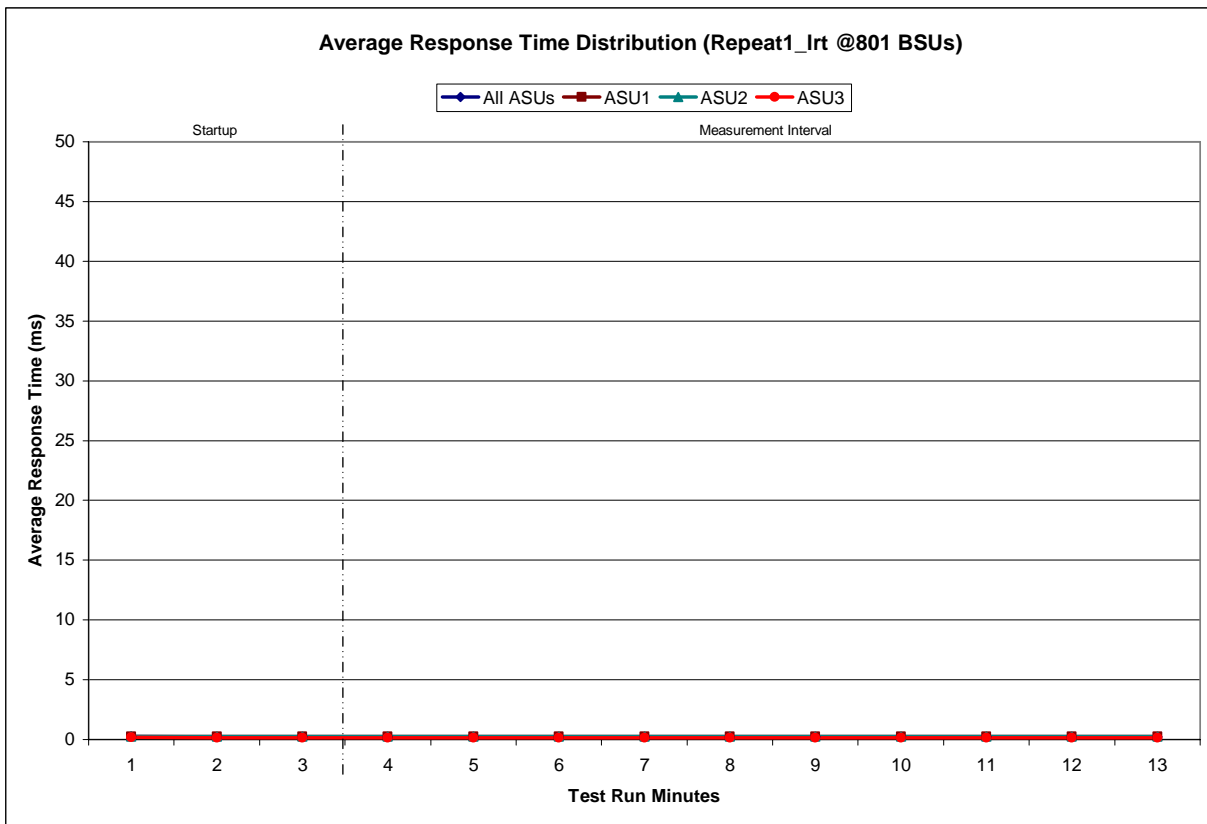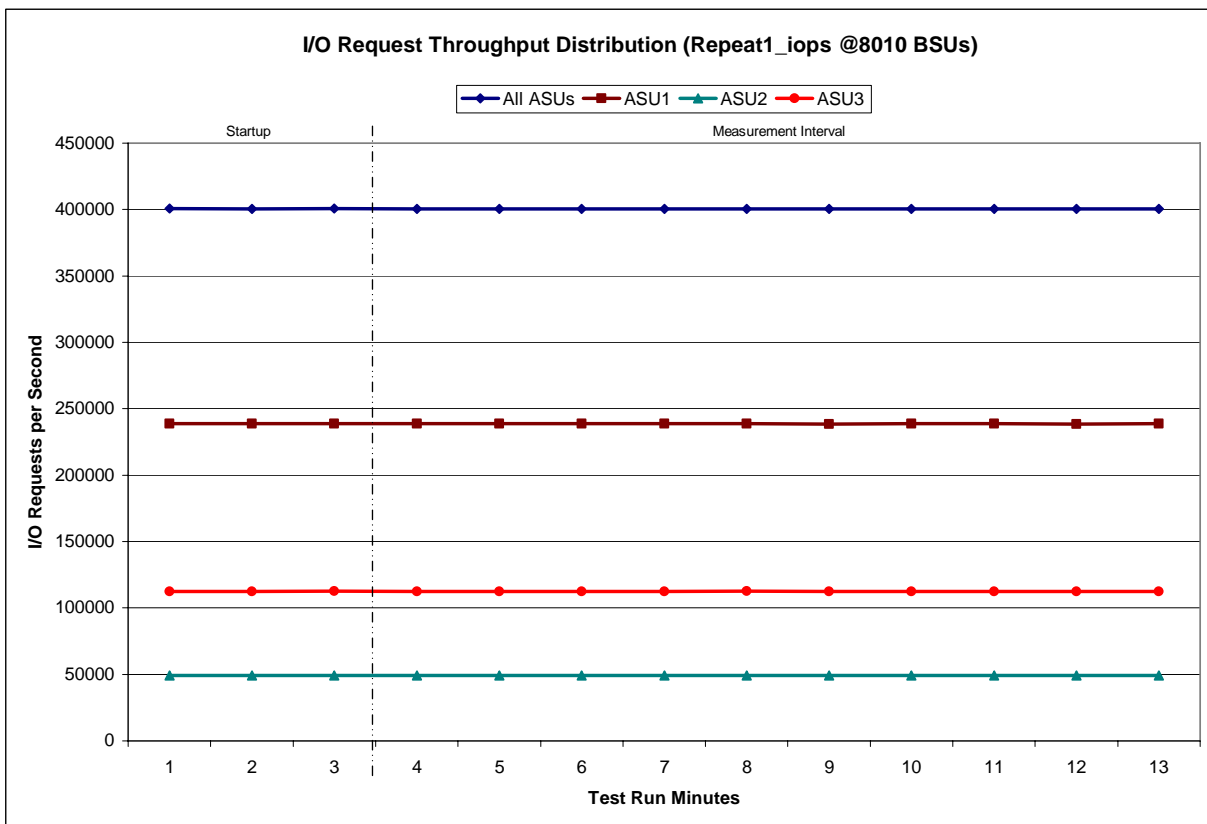| 8010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:14:26	18:17:27	0-2	0:03:01
Measurement Interval	18:17:27	18:27:27	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	400,602.88	238,719.50	49,315.10	112,568.28
1	400,480.87	238,721.30	49,292.07	112,467.50
2	400,632.97	238,720.05	49,290.78	112,622.13
3	400,514.33	238,726.18	49,251.67	112,536.48
4	400,438.10	238,701.72	49,259.03	112,477.35
5	400,465.57	238,723.17	49,269.43	112,472.97
6	400,422.18	238,652.70	49,250.73	112,518.75
7	400,513.65	238,644.68	49,222.73	112,646.23
8	400,455.28	238,594.40	49,293.10	112,567.78
9	400,581.92	238,722.83	49,299.80	112,559.28
10	400,428.77	238,666.47	49,235.90	112,526.40
11	400,427.90	238,586.95	49,274.20	112,566.75
12	400,475.82	238,717.00	49,188.85	112,569.97
Average	*400,472.35*	*238,673.61*	*49,254.55*	*112,544.20*

Repeatability 1 IOPS – I/O Request Throughput Distribution Graph

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

8010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:14:26	18:17:27	0-2	0:03:01
Measurement Interval	18:17:27	18:27:27	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.84	0.84	0.77	0.88
1	1.59	1.39	1.46	2.09
2	8.74	9.48	4.70	8.96
3	10.96	12.30	5.42	10.54
4	6.44	6.68	3.88	7.08
5	9.70	10.69	5.10	9.61
6	9.79	10.64	5.15	10.02
7	8.82	9.53	4.68	9.12
8	7.22	7.33	4.31	8.24
9	8.24	8.88	4.45	8.54
10	6.38	6.45	3.95	7.29
11	5.97	5.87	3.82	7.13
12	5.22	5.01	3.56	6.39
Average	*7.87*	*8.34*	*4.43*	*8.40*

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

Repeatability 2 LRT – I/O Request Throughput Distribution Data

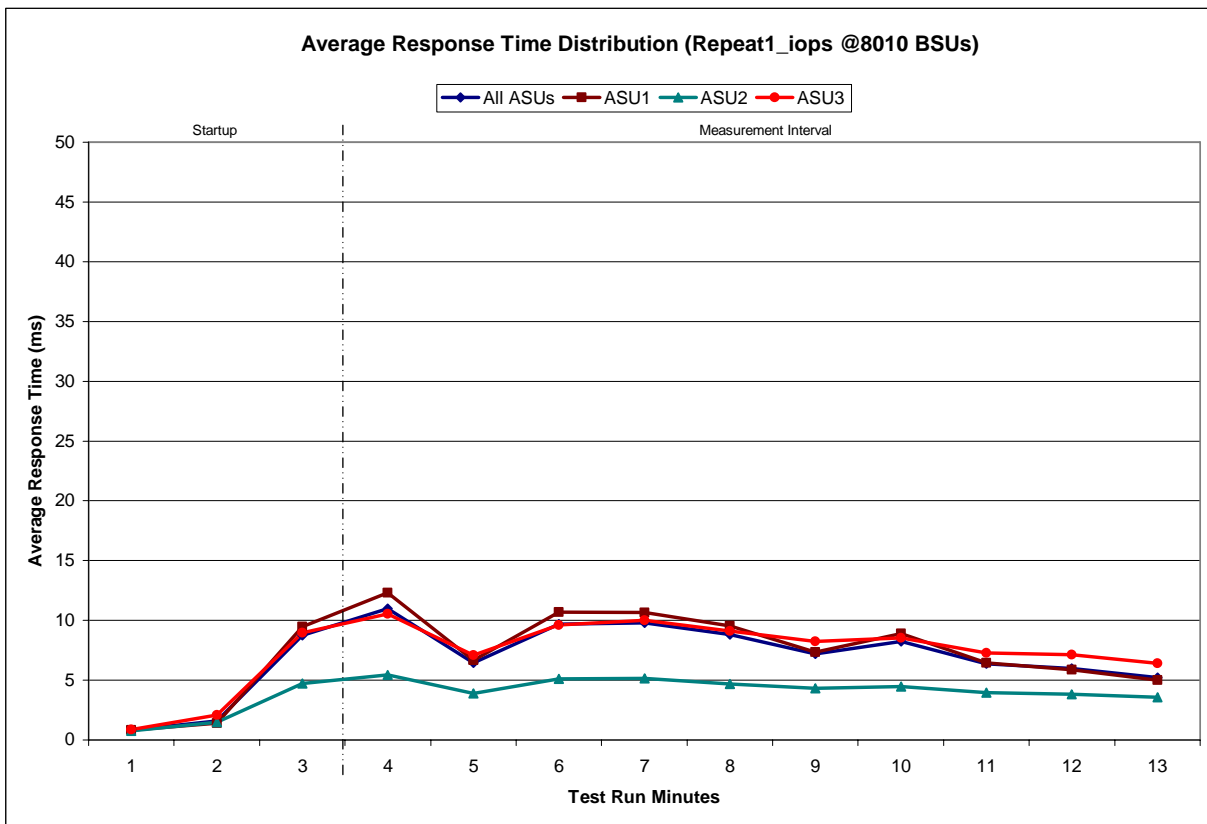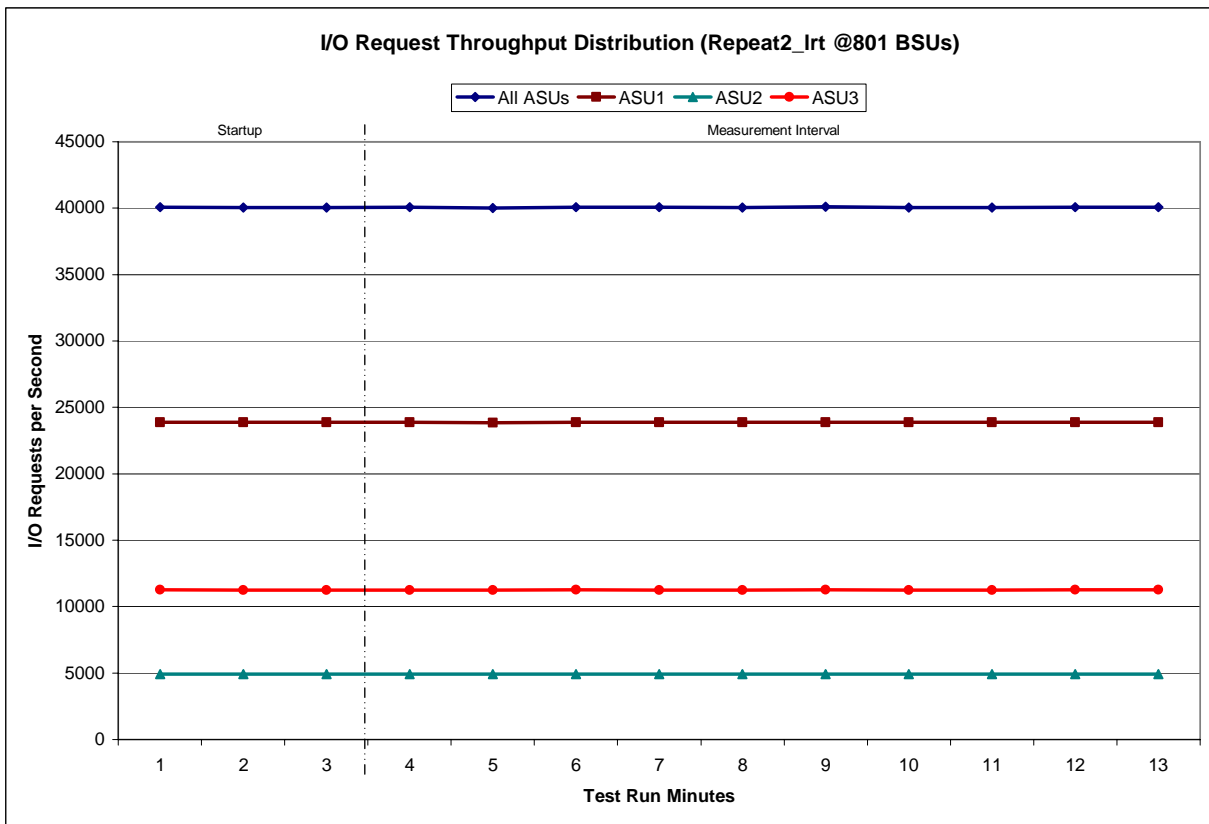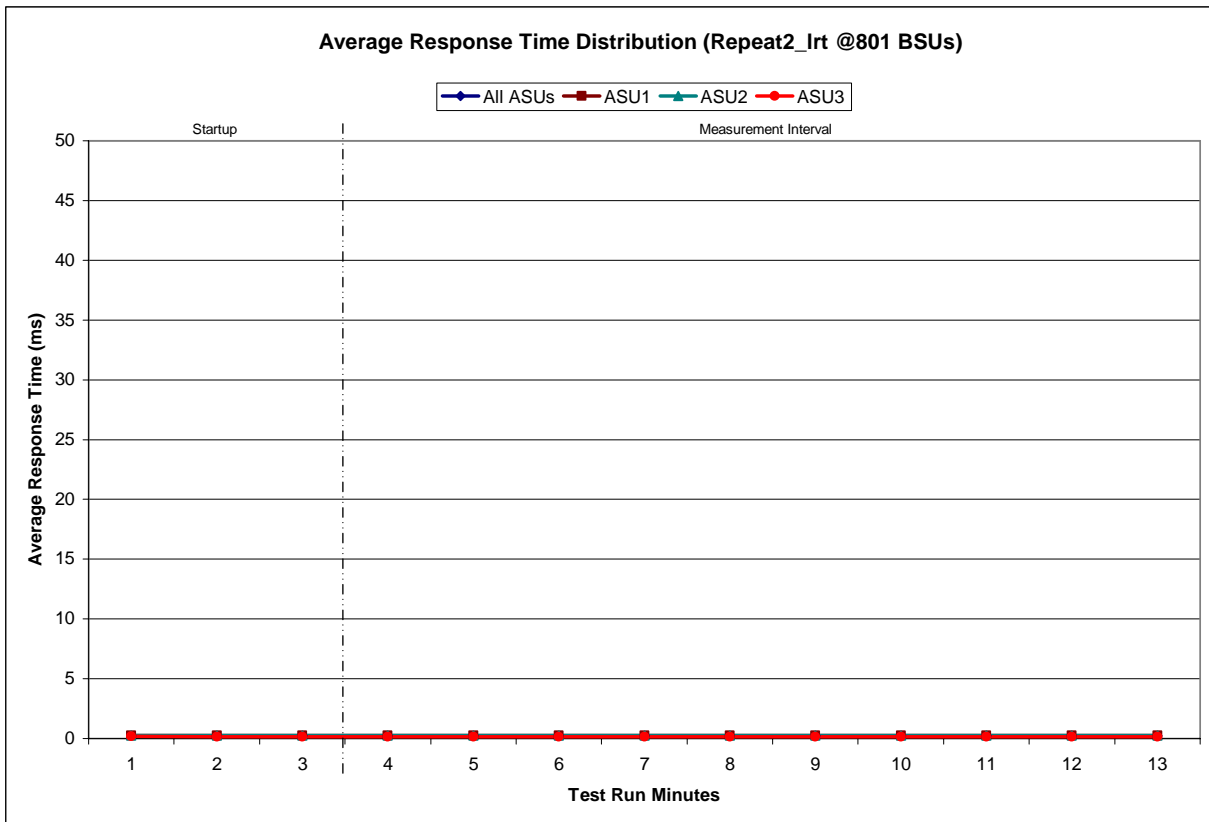| 801 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:28:34	18:31:34	0-2	0:03:00
Measurement Interval	18:31:34	18:41:34	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	40,081.03	23,875.00	4,926.37	11,279.67
1	40,048.93	23,874.70	4,926.68	11,247.55
2	40,034.83	23,888.08	4,917.60	11,229.15
3	40,076.17	23,885.83	4,932.93	11,257.40
4	40,001.93	23,847.65	4,911.48	11,242.80
5	40,069.02	23,864.28	4,932.02	11,272.72
6	40,067.08	23,890.83	4,929.80	11,246.45
7	40,047.90	23,883.57	4,923.08	11,241.25
8	40,103.45	23,890.35	4,937.38	11,275.72
9	40,038.15	23,869.62	4,917.30	11,251.23
10	40,045.73	23,887.43	4,929.08	11,229.22
11	40,064.70	23,874.12	4,916.22	11,274.37
12	40,064.75	23,873.60	4,921.83	11,269.32
Average	*40,057.89*	*23,876.73*	*4,925.11*	*11,256.05*

Repeatability 2 LRT – I/O Request Throughput Distribution Graph

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

801 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:28:34	18:31:34	0-2	0:03:00
Measurement Interval	18:31:34	18:41:34	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	0.23	0.26	0.25	0.16
1	0.22	0.25	0.24	0.15
2	0.22	0.25	0.24	0.15
3	0.22	0.25	0.24	0.15
4	0.22	0.25	0.24	0.15
5	0.22	0.25	0.24	0.15
6	0.22	0.25	0.24	0.15
7	0.22	0.25	0.24	0.15
8	0.22	0.25	0.24	0.15
9	0.22	0.25	0.24	0.15
10	0.22	0.25	0.24	0.15
11	0.22	0.25	0.24	0.15
12	0.22	0.25	0.24	0.15
Average	*0.22*	*0.25*	*0.24*	*0.15*

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

Average Response Time Distribution (Repeat2_lrt @801 BSUs)

Repeatability 2 IOPS – I/O Request Throughput Distribution Data

| 8010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:42:40	18:45:41	0-2	0:03:01
Measurement Interval	18:45:41	18:55:41	3-12	0:10:00
60 second intervals	**All ASUs**	**ASU1**	**ASU2**	**ASU3**
0	400,521.92	238,745.75	49,242.83	112,533.33
1	400,540.77	238,690.28	49,276.50	112,573.98
2	400,484.12	238,683.87	49,274.37	112,525.88
3	400,343.53	238,603.87	49,249.65	112,490.02
4	400,419.18	238,699.32	49,240.03	112,479.83
5	400,615.83	238,782.07	49,280.15	112,553.62
6	400,453.65	238,657.92	49,277.73	112,518.00
7	400,484.78	238,671.00	49,246.35	112,567.43
8	400,591.95	238,744.43	49,271.10	112,576.42
9	400,399.93	238,617.27	49,248.68	112,533.98
10	400,622.27	238,742.65	49,266.80	112,612.82
11	400,500.08	238,653.20	49,279.02	112,567.87
12	400,380.80	238,595.38	49,223.08	112,562.33
Average	*400,481.20*	*238,676.71*	*49,258.26*	*112,546.23*

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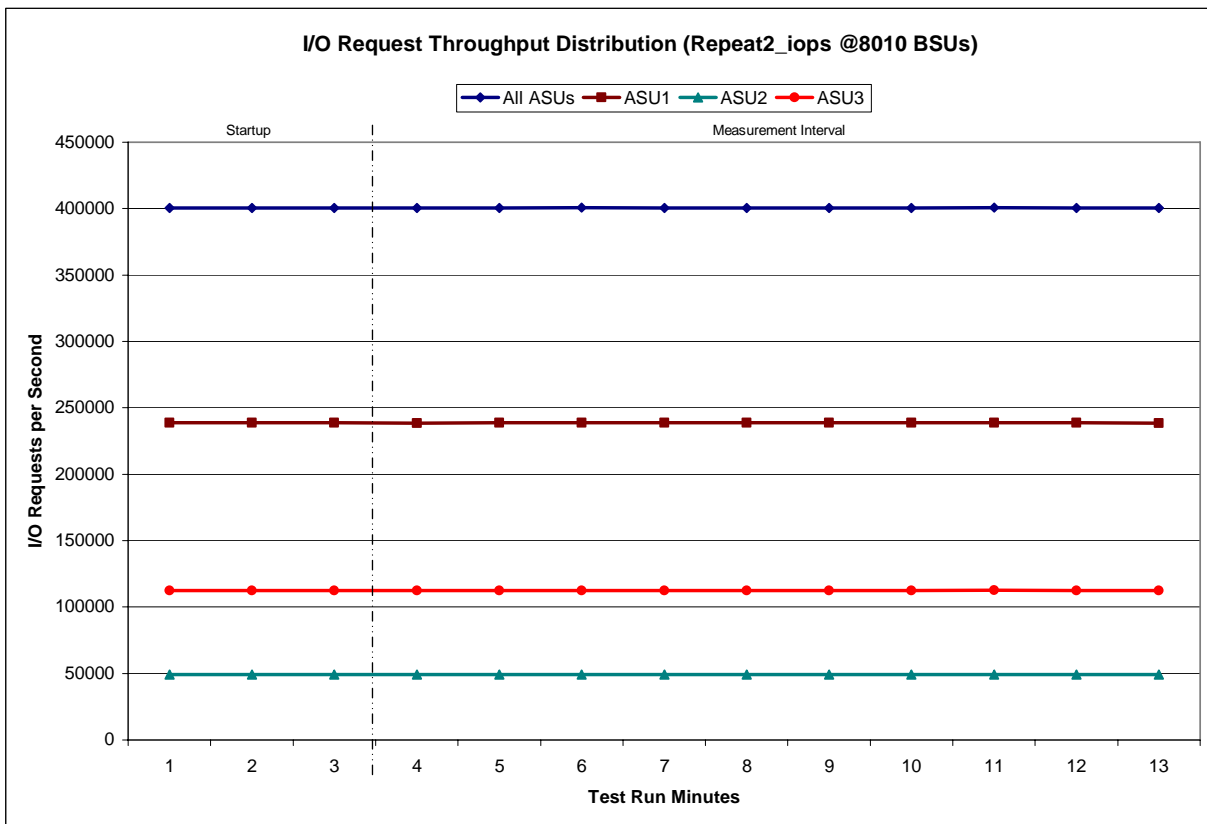
Repeatability 2 IOPS –Average Response Time (ms) Distribution Data

8010 BSUs	Start	Stop	Interval	Duration
Start-Up/Ramp-Up	18:42:40	18:45:41	0-2	0:03:01
Measurement Interval	18:45:41	18:55:41	3-12	0:10:00
60 second intervals	All ASUs	ASU1	ASU2	ASU3
0	0.86	0.85	0.77	0.91
1	3.97	4.16	2.46	4.23
2	8.10	8.35	4.72	9.05
3	7.10	7.08	4.41	8.33
4	9.03	9.76	4.81	9.35
5	6.28	6.30	3.95	7.26
6	11.28	12.78	5.54	10.63
7	8.31	8.85	4.62	8.78
8	4.83	4.53	3.42	6.09
9	8.09	8.48	4.64	8.78
10	6.73	7.17	3.81	7.06
11	7.90	8.76	4.11	7.73
12	5.38	5.15	3.70	6.61
Average	*7.49*	*7.89*	*4.30*	*8.06*

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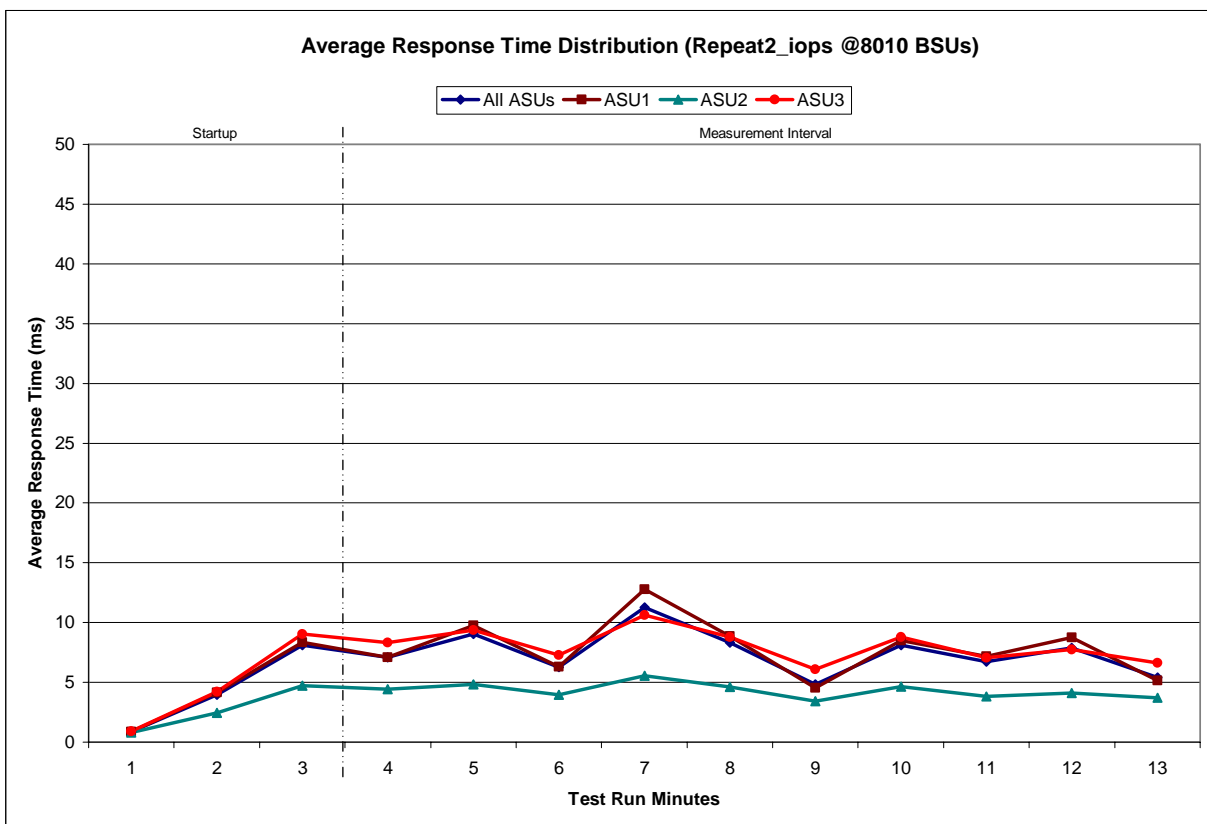
Repeatability 1 (LRT)
Measured Intensity Multiplier and Coefficient of Variation

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	0.2100	0.0180	0.0699	0.0350	0.2811
COV	0.004	0.001	0.003	0.001	0.006	0.003	0.005	0.001

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	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.000	0.002	0.001	0.001	0.000

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	0.2810	0.0700	0.2101	0.0180	0.0699	0.0350	0.2810
COV	0.003	0.001	0.001	0.001	0.004	0.002	0.003	0.001

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	0.2810	0.0700	0.02100	0.0180	0.0700	0.0350	0.2810
COV	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000

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 62.

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	375,954
Total Number of Logical Blocks Verified	365,346
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

If approved by the SPC Auditor, the SPC-2 Persistence Test may be used to meet the SPC-1 persistence requirements. Both the SPC-1 and SPC-2 Persistence Tests provide the same level of functionality and verification of data integrity. The SPC-2 Persistence Test may be easily configured to address an SPC-1 storage configuration. The SPC-2 Persistence Test extends the size of storage configurations that may be tested and significantly reduces the test duration of such configurations.

The SPC-2 Persistence Test was approved for use in this set of audited measurements.

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 Texas Memory Systems RamSan-630 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 Onsite Audit of the Texas Memory Systems RamSan-630 .

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
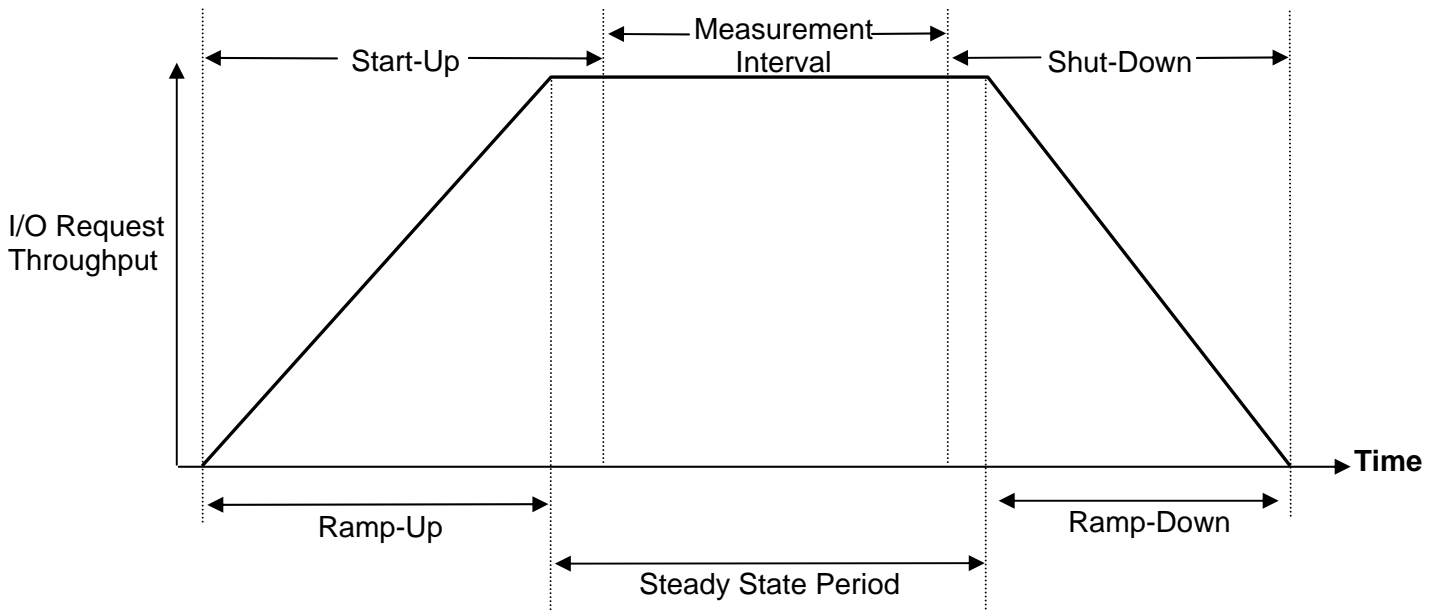
period, Shut-Down period, and Ramp-Down period as illustrated in the "SPC-1 Test Run Components" below. All SPC-1 Test Runs shall have a Steady State period and a Measurement Interval.

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
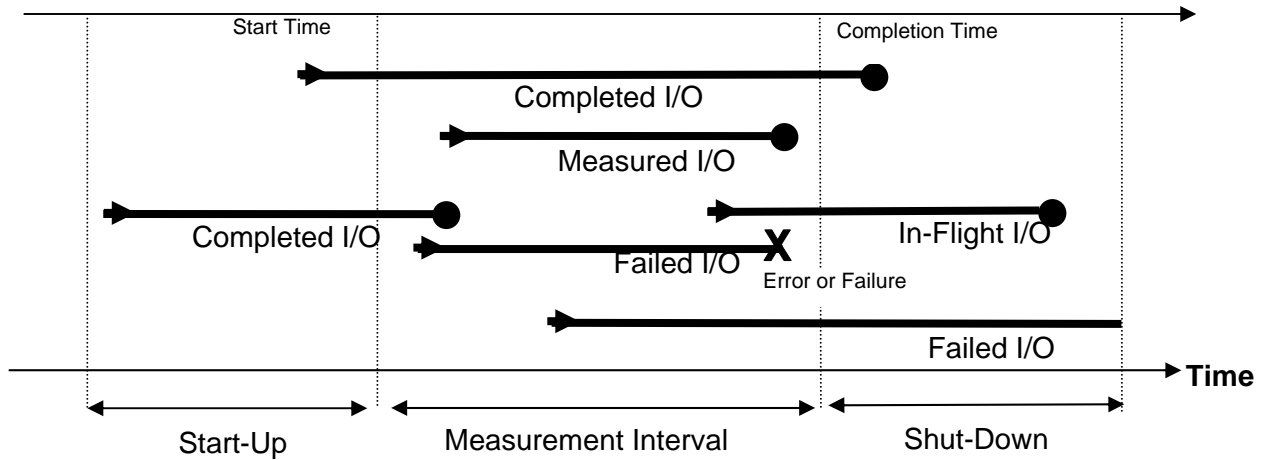
SPC-1 Test Run Components

APPENDIX B: CUSTOMER TUNABLE PARAMETERS AND OPTIONS

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

APPENDIX C: TESTED STORAGE CONFIGURATION (TSC) CREATION

ASU Pre-Fill

The following command was issued in a Windows command session to invoke the script listed below. The script will fill the Total Application Storage Unit (ASU) Capacity with random data using Vdbench 5.03 Beta.

> ***vdbench –f prepssd.txt –o ssdprep***

prepssd.txt

```
*
* This will produce a random data pattern of the entire LBA range using LSFR 32bit
*
pattern=random


sd=sd1,lun=\\.\PhysicalDrive1,threads=32
sd=sd2,lun=\\.\PhysicalDrive2,threads=32
sd=sd3,lun=\\.\PhysicalDrive3,threads=32

wd=wd1,sd=sd*,rdpct=0,seek=-1,xfersize=1m




*==================================
* Use 10 hours as a max elapse time
*==================================
*
rd=PREPSSD,wd=wd*,iorate=max,elapsed=36000,interval=10
```

Create the SPC-1 Logical Volumes

The SPC-1 Logical Volumes are created by using either the Web GUI on the RamSan-630 for wizard-based configuration or by logging into the CLI through Serial, Telnet, or SSH protocols.

Using the CLI, the SPC-1 Logical Volumes are created by the following commands:

- ***lu create asu1 3483254M 0***
- ***lu create asu2 3483254M 1***
- ***lu create asu3 774065M 2***

Configure Access Policies

After the SPC-1 Logical Volumes have been created, access policies are used to grant access through each of the 10 available 8Gb FC ports. These access policies are applied with the following CLI commands:

- ***lu access add asu_1_1 asu1 fc-1a open***
- ***lu access add asu_1_2 asu1 fc-2a open***
- ***lu access add asu_1_3 asu1 fc-3a open***
- ***lu access add asu_1_4 asu1 fc-4a open***

- *lu access add asu_1_5 asu1 fc-5a open*
- *lu access add asu_1_6 asu1 fc-1b open*
- *lu access add asu_1_7 asu1 fc-2b open*
- *lu access add asu_1_8 asu1 fc-3b open*
- *lu access add asu_1_9 asu1 fc-4b open*
- *lu access add asu_1_10 asu1 fc-5b open*
- *lu access add asu_2_1 asu2 fc-1a open*
- *lu access add asu_2_2 asu2 fc-2a open*
- *lu access add asu_2_3 asu2 fc-3a open*
- *lu access add asu_2_4 asu2 fc-4a open*
- *lu access add asu_2_5 asu2 fc-5a open*
- *lu access add asu_2_6 asu2 fc-1b open*
- *lu access add asu_2_7 asu2 fc-2b open*
- *lu access add asu_2_8 asu2 fc-3b open*
- *lu access add asu_2_9 asu2 fc-4b open*
- *lu access add asu_2_10 asu2 fc-5b open*
- *lu access add asu_3_1 asu3 fc-1a open*
- *lu access add asu_3_2 asu3 fc-2a open*
- *lu access add asu_3_3 asu3 fc-3a open*
- *lu access add asu_3_4 asu3 fc-4a open*
- *lu access add asu_3_5 asu3 fc-5a open*
- *lu access add asu_3_6 asu3 fc-1b open*
- *lu access add asu_3_7 asu3 fc-2b open*
- *lu access add asu_3_8 asu3 fc-3b open*
- *lu access add asu_3_9 asu3 fc-4b open*
- *lu access add asu_3_10 asu3 fc-5b open*

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

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

```
host=master

slaves=(g000,g001,g002,g003,g004,g005,g006,g007,g008,g009,g010,g011,g012,g013,g014,g
015,g016,g017,g018,g019,g020,g021,g022,g023,g024,g025,g026,g027,g028,g029,g030,g031,
g032,g033,g034,g035,g036,g037,g038,g039,g040,g041,g042,g043,g044,g045,g046,g047,g048
,g049,g050,g051,g052,g053,g054,g055,g056,g057,g058,g059,g060,g061,g062,g063,g064,g06
5,g066,g067,g068,g069,g070,g071,g072,g073,g074,g075,g076,g077,g078,g079,g080,g081,g0
82,g083,g084,g085,g086,g087,g088,g089,g090,g091,g092,g093,g094,g095,g096,g097,g098,g
099)

sd=asu1_1,lun=\\.\PHYSICALDRIVE1
sd=asu2_1,lun=\\.\PHYSICALDRIVE2
sd=asu3_1,lun=\\.\PHYSICALDRIVE3
```

Persistence Test

The content of SPC-2 Workload Generator command and parameter file, used in this benchmark to execute the Persistence Test, is listed below.

Persistence Test Run 1 (write phase)

```
host=localhost,jvms=8,maxstreams=300

sd=sd1,lun=\\.\PHYSICALDRIVE1,size=3652457000000
sd=sd2,lun=\\.\PHYSICALDRIVE2,size=3652457000000
sd=sd3,lun=\\.\PHYSICALDRIVE3,size=81166600000

maxlatestart=1
reportinginterval=5
segmentlength=512m
rd=default,rampup=180,periods=90,measurement=300,runout=0,rampdown=0,buffers=1
rd=default,rdpct=0,xfersize=1024k
rd=TR1-270s_SPC-2-persist-w,streams=270
```

Persistence Test Run 2 (read phase)

```
host=localhost,jvms=8,maxstreams=300

sd=sd1,lun=\\.\PHYSICALDRIVE1,size=3652457000000
sd=sd2,lun=\\.\PHYSICALDRIVE2,size=3652457000000
sd=sd3,lun=\\.\PHYSICALDRIVE3,size=81166600000

maxlatestart=1
reportinginterval=5
segmentlength=512m
maxpersistenceerrors=10
rd=default,buffers=1,rdpct=100,xfersize=1024k
rd=TR1-270s_SPC-2-persist-r
```

APPENDIX E: SPC-1 WORKLOAD GENERATOR INPUT PARAMETERS

Primary Metrics Test, Repeatability Test, and Persistence Test Run 1

The following scripts was used to execute the Primary Metrics Test *(Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase)*, **Repeatability Test** *(Repeatability Test Phase 1 and Repeatability Test Phase 2)*, **and Persistence Test Run 1 in an uninterrupted sequence.**

startslaves.bat

```
start \\nas-c10\share\spc1\slave.bat 0
start \\nas-c10\share\spc1\slave.bat 1
start \\nas-c10\share\spc1\slave.bat 2
start \\nas-c10\share\spc1\slave.bat 3
start \\nas-c10\share\spc1\slave.bat 4
start \\nas-c10\share\spc1\slave.bat 5
start \\nas-c10\share\spc1\slave.bat 6
start \\nas-c10\share\spc1\slave.bat 7
start \\nas-c10\share\spc1\slave.bat 8
start \\nas-c10\share\spc1\slave.bat 9
```

slave.bat

```
cd \spc1\spc1
SET LD_LIBRARY_PATH=c:\spc1\spc1
java -Xmx512m -Xss64k spc1 -fslave%1.txt
exit
```

spc1.bat

```
java -Xmx512M -Xss64K metrics -b 8010 -t 28800
java -Xmx512M -Xss64K repeat1 -b 8010
java -Xmx512M -Xss64K repeat2 -b 8010
cd c:\spc2\
call spc2.bat -f spc1_persist_WRITE.conf -o init -init
call spc2.bat -f spc1_persist_WRITE.conf -o spc1_persist_write
```

Persistence Test Run 2

The following script was used to execute Persistence Test Run 2.

```
cd c:\spc2\
spc2.bat -f spc1_persist_READ.conf -o spc1_persist_read
```

APPENDIX F: THIRD PARTY QUOTATION

Qlogic 8Gb PCIe x8 Fibre Channel 2-port HBAs

Multimode duplex Fibre Channel LC/LC 2m cables