



SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

**HUAWEI TECHNOLOGIES CO., LTD
HUAWEI OCEANSTOR 6800 V5**

SPC-1 V3.8

SUBMISSION IDENTIFIER: A31021

SUBMITTED FOR REVIEW: MARCH 25, 2019

First Edition – March 2019

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Benchmark Specification and Glossary

The official SPC Benchmark 1™ (SPC-1™) specification is available on the website of the Storage Performance Council (SPC) at spcresults.org.

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

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AUDIT CERTIFICATION



Zhong Xu
 Huawei Technologies Co., Ltd.
 Huawei Industrial Base, Bantian,
 Longgang, Shenzhen city,
 Guangdong province, China

March 20, 2019

I verified the SPC Benchmark 1™ (SPC-1™ Revision 3.8) test execution and performance results of the following Tested Storage Product:

HUAWEI OCEANSTOR 6800 V5

The results were:

SPC-1 IOPS™	2,700,171
SPC-1 Price-Performance™	\$481.08/SPC-1 KIOPS™
SPC-1 IOPS™ Response Time	0.579 ms
SPC-1 Overall Response Time	0.372 ms
SPC-1 ASU Capacity	61,473 GB
SPC-1 ASU Price	\$21.14/GB
SPC-1 Total System Price	\$1,298,993.24

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

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

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

A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by the Test Sponsor, and can be found at www.spcresults.org under the Submission Identifier **A31021**.

A31021

HUAWEI OCEANSTOR 6800 V5

p.2

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

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

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

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

- None.

Respectfully Yours,



François Raab, Certified SPC Auditor

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LETTER OF GOOD FAITH



Huawei Technologies Co., Ltd.
 Huawei Industrial Base, Bantian, Longgang
 Shenzhen city
 Guangdong province
 China
 Tel: 0086-755-28780808
<http://www.huawei.com/en/>

Date: March 18, 2019

From: Huawei Technologies Co., Ltd.

To: Mr. Francois Raab, Certified SPC Auditor
 InfoSizing
 20 Kreg Lane
 Manitou Springs, CO 80829

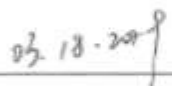
Subject: SPC-1 Letter of Good Faith for the Huawei OceanStor 6800V5

Huawei Technologies Co., Ltd. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V3.8 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: 

 Meng Guangbin
 President of Storage Product Line

Date: 



SPC BENCHMARK 1™

EXECUTIVE SUMMARY

HUAWEI TECHNOLOGIES Co., LTD HUAWEI OCEANSTOR 6800 V5

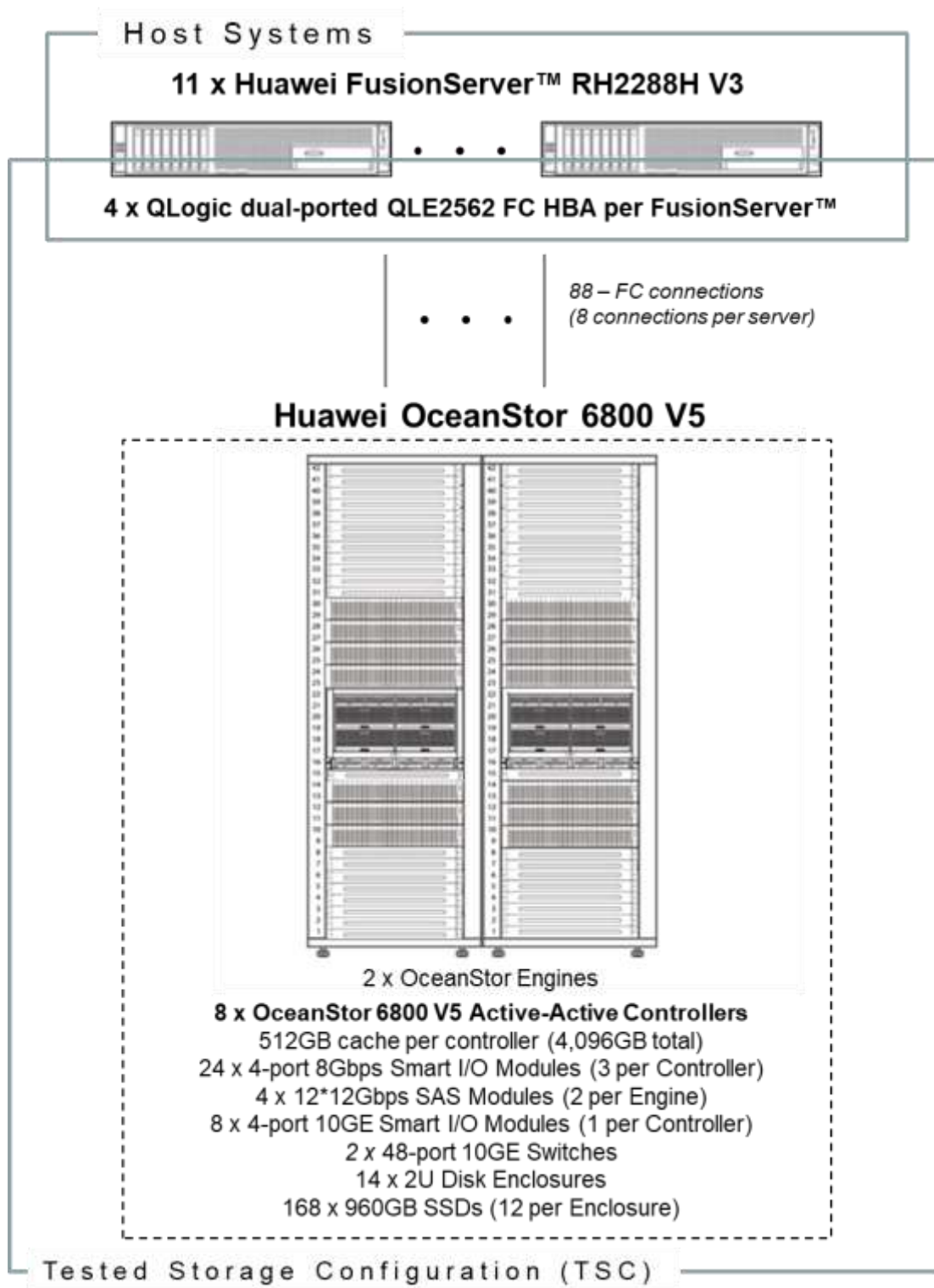
SPC-1 IOPS™	2,700,171
SPC-1 Price-Performance™	\$481.08/SPC-1 KIOPS™
SPC-1 IOPS™ Response Time	0.579 ms
SPC-1 Overall Response Time	0.372 ms
SPC-1 ASU Capacity	61,473 GB
SPC-1 ASU Price	\$21.14/GB
SPC-1 Total System Price	\$1,298,993.24
Data Protection Level	Protected 2 (RAID-10 and full redundancy)
Physical Storage Capacity	161,280 GB
Pricing Currency / Target Country	U.S. Dollars / USA

SPC-1 V3.8

SUBMISSION IDENTIFIER: A31021

SUBMITTED FOR REVIEW: MARCH 25, 2019

Benchmark Configuration Diagram



Tested Storage Product Description

The new generation of mid-range hybrid flash storage, dedicated to providing the reliable and efficient data services for enterprises.

Cloud-ready operating system, flash-enabled performance, and intelligent management software, delivering top-of-the-line functionality, performance, efficiency, reliability, and ease of use.

Satisfies the data storage requirements of large-database OLTP/OLAP, cloud computing, and many other applications, making it a perfect choice for sectors such as government, finance, telecommunications, and manufacturing.

For more details, visit:

<http://e.huawei.com/en/products/cloud-computing-dc/storage/massive-storage/6800-v5>

Priced Storage Configuration Components

44 x QLogic dual-ported QLE2562 FC HBA
2 x System enclosures, each with:
4 x OceanStor 6800 V5 Active-Active Controllers (8 total), each with:
512 GB cache (4,096 GB total)
3 x 4-port 8Gbps Smart I/O Modules (24 total)
1 x 4-port 10GE Smart I/O Modules (8 total)
2 x 12-port 12Gbps SAS I/O Modules (4 total)
14 x 2U Disk enclosures, each with:
12 x 960 GB SSDs (168 total)
2 x 48-port 10GE Switches

Storage Configuration Pricing

	Description	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
Hardware & Software						
02351NPT 68V5-4C2048G-AC	OceanStor 6800 V5 Engine(6U, Four Controller, AC\240HVDC, 2048GB Cache, SPE73C0600)	2	625,481.00	1,250,962.00	68%	400,307.84
SMARTIO8FC	4 port SmartIO I/O module (SFP+,8Gb FC)	24	3,192.00	76,608.00	68%	24,514.56
SMARTIO10ETH	4 port SmartIO I/O module (SFP+, 10Gb Eth/FCoE(VN2VF)/Scale-out)	8	6,288.00	50,304.00	68%	16,097.28
LPU4S12V5	12 port 4*12Gb SAS shared I/O module (MiniSAS HD)	4	4,963.00	19,852.00	68%	6,352.64
HSSD-960G2S-A9	960GB SSD SAS Disk Unit (2.5")	168	10,176.00	1,709,568.00	70%	512,870.40
DAE52525U2-AC-A2	Disk Enclosure (2U, AC\240HVDC, 2.5", Expansion Module, 25 Disk Slots, without Disk Unit, DAE52525U2)	14	10,584.00	148,176.00	68%	47,416.32
RACK-42U-1	42U Storage AC Cabinet (With Power Distribution Unit)	2	10,158.00	20,316.00	0%	20,316.00
ND8GOLC00	Qlogic, FC HBA, 8Gb(QLE2562), 2-Port, SFP+(with 2x Multi-mode Optical Transceiver), PCIe 2.0 x4	44	1,698.00	74,712.00	0%	74,712.00
SN2F01FCPC	Patch Cord, DLC/PC, DLC/PC, Multi-mode, 3m, A1a.2, 2mm, 42mm DLC, OM3 bending insensitive	104	14.00	1,456.00	0%	1,456.00
LIC-68V5-BS	Basic Software License(Including DeviceManager, SmartThin, SmartMulti-tenant, SmartMigration, SmartErase, SmartMotion, SystemReporter, SmartQuota, NFS, CIFS, NDMP, eService)	1	30,744.00	30,744.00	70%	9,223.20
CE6855-HI-F-B0A	CE6855-48S6Q-HI Switch (48-Port 10G SFP+, 6-Port 40GE QSFP+, 2*AC Power Module, 2*FAN Box, Port-side Exhaust)	2	13,738.00	27,476.00	0%	27,476.00
Hardware & Software Subtotal						1,140,742.24
Support & Maintenance						
02351LWK-88134ULF-36	OceanStor 6800 V5 Engine (6U, Four Controller, AC\240HVDC, 2048GB Cache, SPE73C0600&7*Disk Enclosure-2U, AC\240HVDC, 2.5", DAE52525U2&84*960GB SSD SAS Disk Unit) Hi-Care Onsite Premier 24x7x4H Engineer Onsite Service-36Month(s)	2	56,085.00	112,170.00	0%	112,170.00
88034JNY-88134UHK-36	Basic Software License (Including DeviceManager, SmartThin, SmartMulti-tenant, SmartMigration, SmartErase, SmartMotion, SystemReporter, eService, SmartQuota, NFS, CIFS, NDMP) Hi-Care Application Software Upgrade Support Service-36Month(s)	1	4,323.00	4,323.00	0%	4,323.00
02350RTB-88134UFJ-36	CE6855-48S6Q-HI Switch (48-Port 10G SFP+, 6-Port 40GE QSFP+, 2*AC Power Module, 2*FAN Box,Port-side Exhaust) Hi-Care Onsite Standard 9x5xNBD Service-36Month(s)	2	5,729.00	11,458.00	0%	11,458.00
8812099164	OceanStor 6800 V5 Installation Service - Engineering	1	30,300.00	30,300.00	0%	30,300.00
Support & Maintenance Subtotal						158,251.00
SPC-1 Total System Price						1,298,993.24
SPC-1 IOPS™						2,700,171
SPC-1 Price-Performance™ (\$/SPC-1 KIOPS™)						481.08
SPC-1 ASU Capacity (GB)						61,473
SPC-1 ASU Price (\$/GB)						21.14

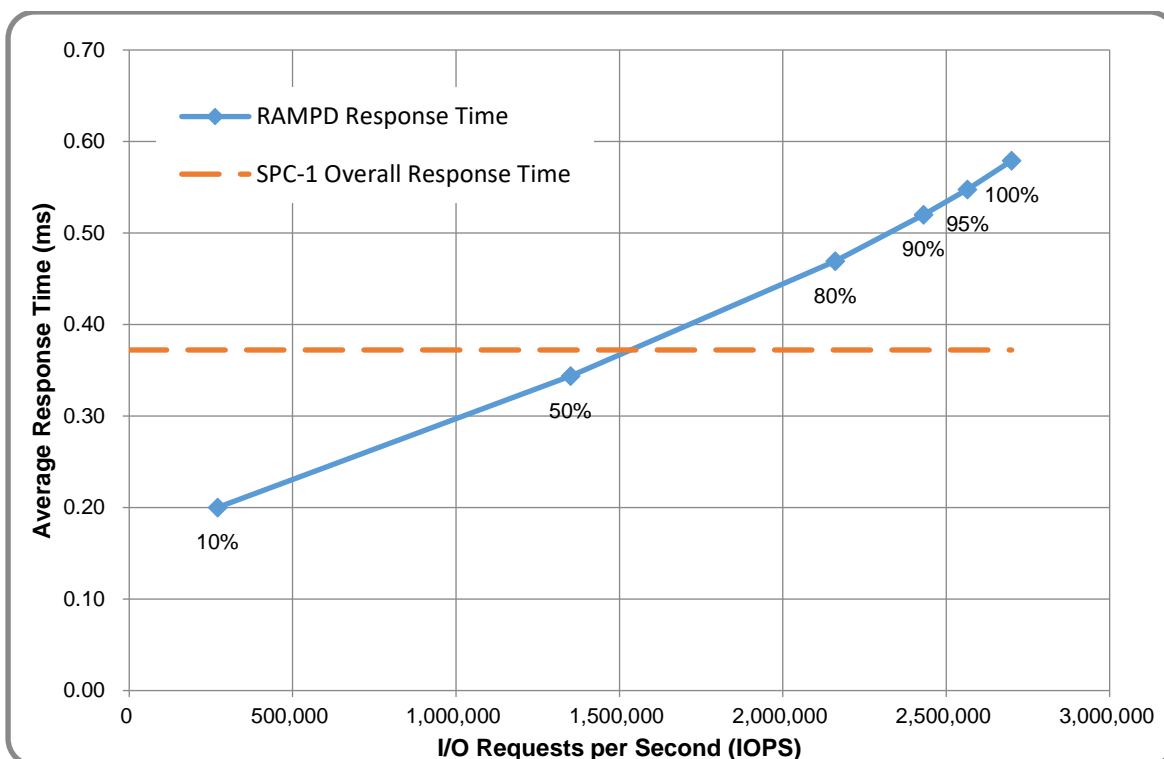
Third-Party Reseller: Huawei Technologies Co., Ltd. only sells its products to third-party resellers who, in turn, sell those products to U.S. customers. The above reflects the pricing quoted by one of those third-party resellers. See Appendix B of the Full Disclosure Report for a copy of the third-party reseller's quotation.

Discount Details: The discounts shown are based on the storage capacity purchased and are generally available.

Warranty: Hi-Care Premier On-Site Service include: 7x24 Technical Assistance Center Access. Access to all new software updates and Online Support. 24x7 with 4-hour On-site Hardware Replacement.

Availability Date: Currently available.

Response Time and Throughput Graph



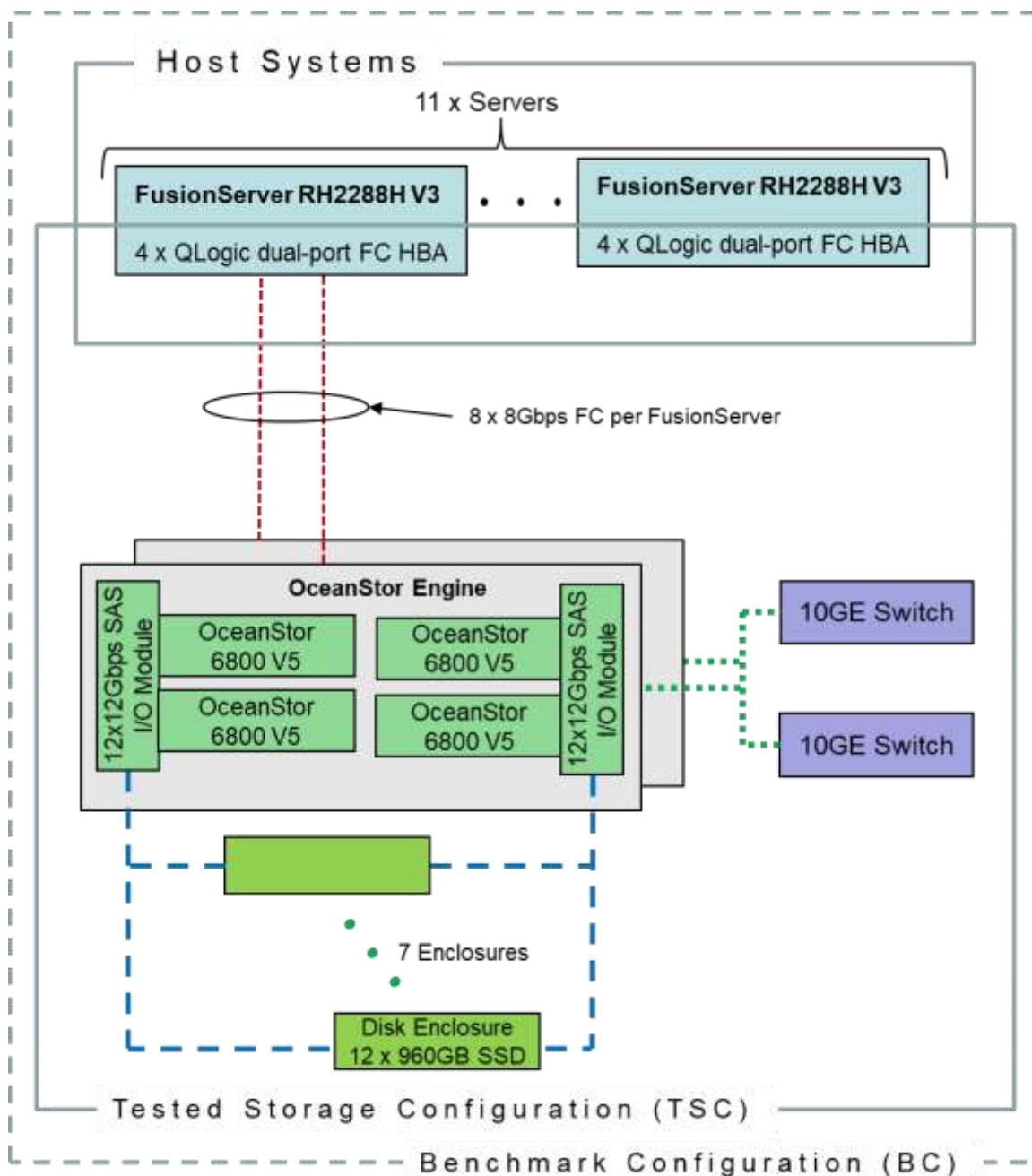
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Test Sponsor Primary Contact	Huawei Technologies Co., Ltd. – www.huawei.com Zhong Xu – xuzhong@huawei.com
SPC Auditor	InfoSizing – www.sizing.com Francois Raab – francois@sizing.com

Revision Information	
SPC Benchmark 1™ Revision	V3.8.0
SPC-1 Workload Generator Revision	V3.0.2-1 build g823a
Publication Revision History	First Edition

CONFIGURATION INFORMATION

Benchmark Configuration and Tested Storage Configuration

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



Storage Network Configuration

The Tested Storage Configuration (TSC) involved an external storage subsystem made of 8 Huawei OceanStor 6800 V5 Controllers, driven by 11 host systems (Huawei FusionServer RH2288H V3). The OceanStor Controllers were grouped in sets of 4 in 2 System Enclosures, forming 2 OceanStor Engines. Each FusionServer host system connected one-to-one to each OceanStor Controllers. That connection was established via a port from 1 of the 4 dual-port Fibre Chanel HBAs on the FusionServer; and a port from 1 of the 3 4-port Smart I/O Modules on the OceanStor Controllers, leaving 1 of these ports inactive in each Controller. These Fibre Chanel paths operated at 8Gbps.

Host System and Tested Storage Configuration Components

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

Host Systems
11 x Huawei FusionServer™ RH2288H V3 2 x Intel® Xeon® E5-2680 v3 (2.7 GHz, 8 Cores, 20 MB L3) 128 GB Main Memory Red Hat Enterprise Linux 7.1
Priced Storage Configuration
44 x QLogic dual-ported QLE2562 FC HBA 2 x System enclosures, each with: 4 x OceanStor 6800 V5 Active-Active Controllers (8 total), each with: 512 GB cache (4,096 GB total) 3 x 4-port 8Gbps Smart I/O Modules (24 total) 1 x 4-port 10GE Smart I/O Modules (8 total) 2 x 12-port 12Gbps SAS I/O Modules (4 total) 14 x 2U Disk enclosures, each with: 12 x 960 GB SSDs (168 total) 2 x 48-port 10GE Switches

Differences Between Tested and Priced Storage Configurations

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

Component Changes in Revised Full Disclosure Report

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

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

Benchmark Configuration Creation Process

Customer Tuning Parameters and Options

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

Tested Storage Configuration Creation

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

Tested Storage Configuration Inventory

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

Workload Generator Storage Configuration

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

Logical Volume Capacity and ASU Mapping

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

	LV per ASU	LV Capacity	Used per LV	Total per ASU	% ASU Capacity
ASU-1	18	1,536.9	1,536.8	27,662.9	45.00%
ASU-2	18	1,536.9	1,536.8	27,662.9	45.00%
ASU-3	2	3,073.5	3,073.4	6,146.8	10.00%
SPC-1 ASU Capacity				61,472.6	

Physical Storage Capacity and Utilization

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

Devices	Count	Physical Capacity	Total Capacity
960GB SSD	168	960.0	161,280.0
Total Physical Capacity			161,280.0
Physical Capacity Utilization			38.11%

Data Protection

The data protection level used for all logical volumes was **Protected 2**, which was accomplished by configuring 14 pools of 12 drives into 14 RAID-10 arrays and providing redundancy for all TSC components.

BENCHMARK EXECUTION RESULTS

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

Benchmark Execution Overview

Workload Generator Input Parameters

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

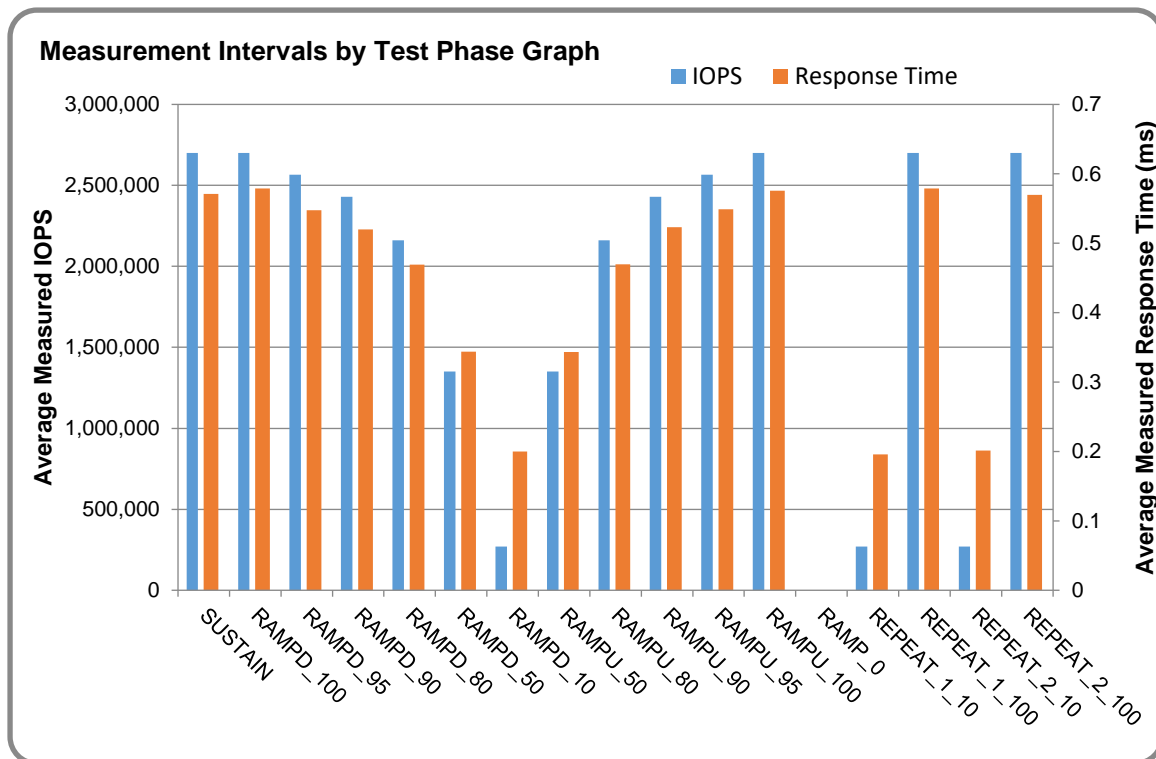
Primary Metrics Test Phases

The benchmark execution consists of the Primary Metrics Test Phases, including the Test Phases SUSTAIN, RAMPD_100 to RAMPD_10, RAMP_50 to RAMP_100, RAMP_0, REPEAT_1 and REPEAT_2.

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

Measurement Intervals by Test Phase Graph

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



Exception and Waiver

None.

SUSTAIN Test Phase

SUSTAIN – Results File

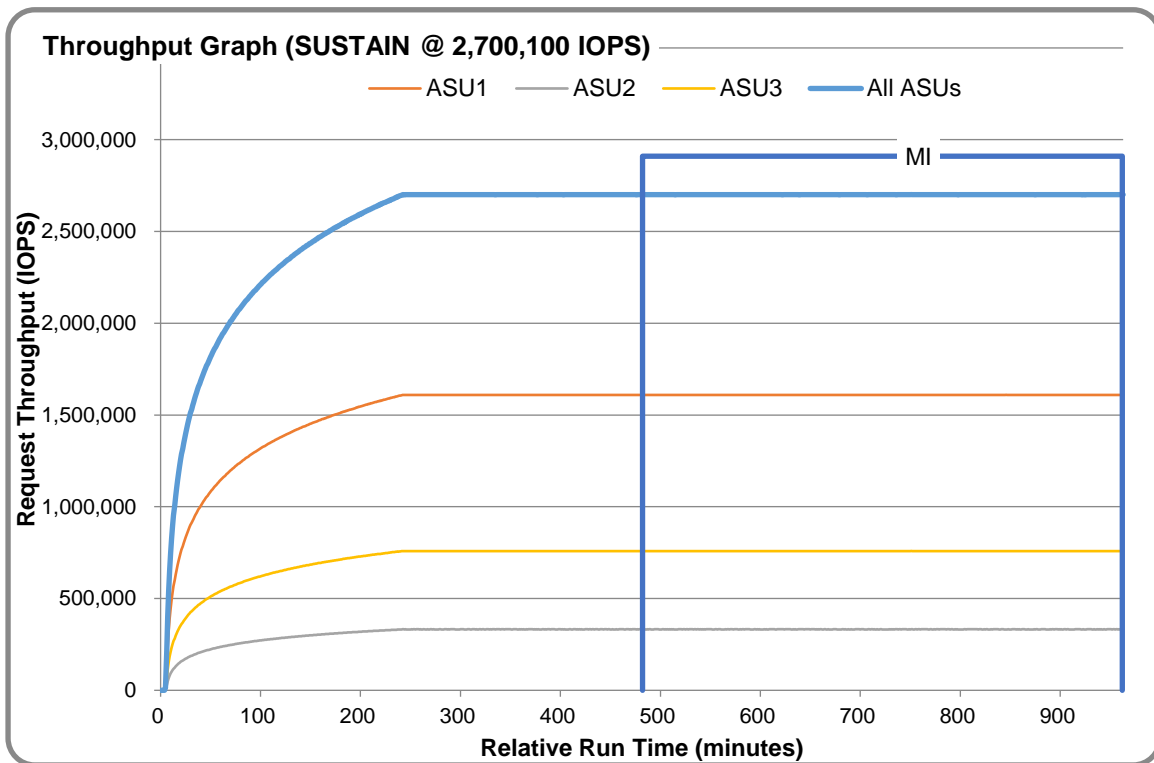
The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

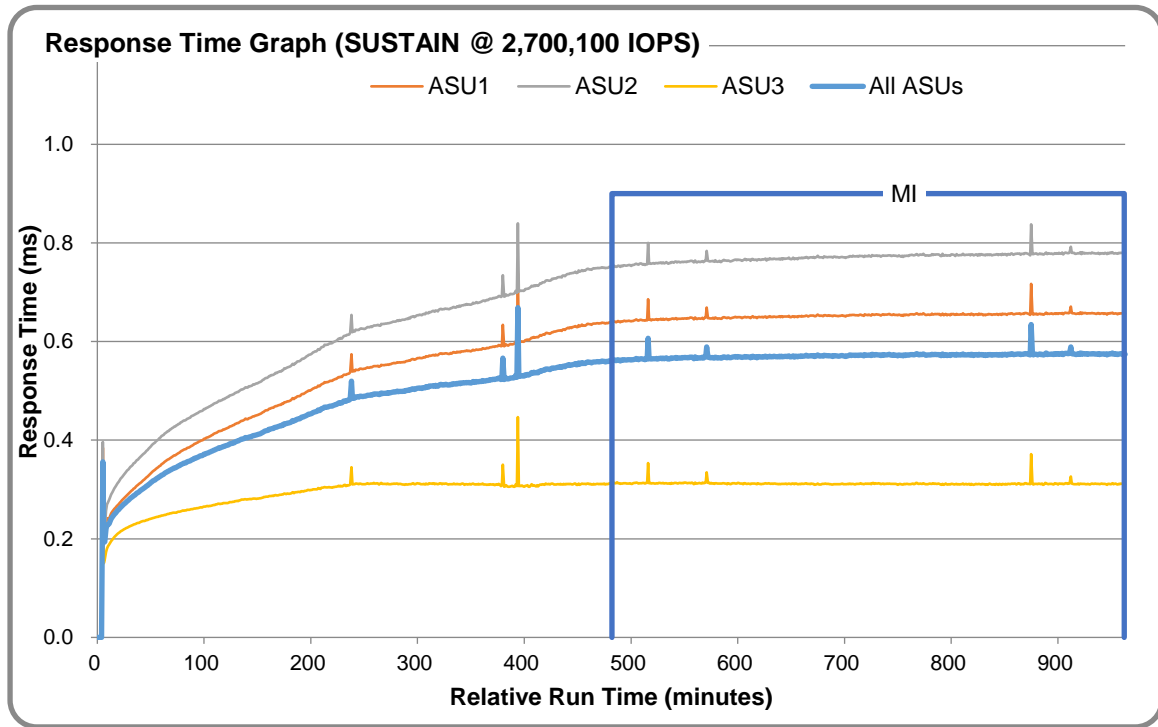
SUSTAIN – Execution Times

Interval	Start Time	End Time	Duration
Transition Period	12-Mar-19 17:44:24	13-Mar-19 01:44:24	8:00:00
Measurement Interval	13-Mar-19 01:44:24	13-Mar-19 09:44:25	8:00:01

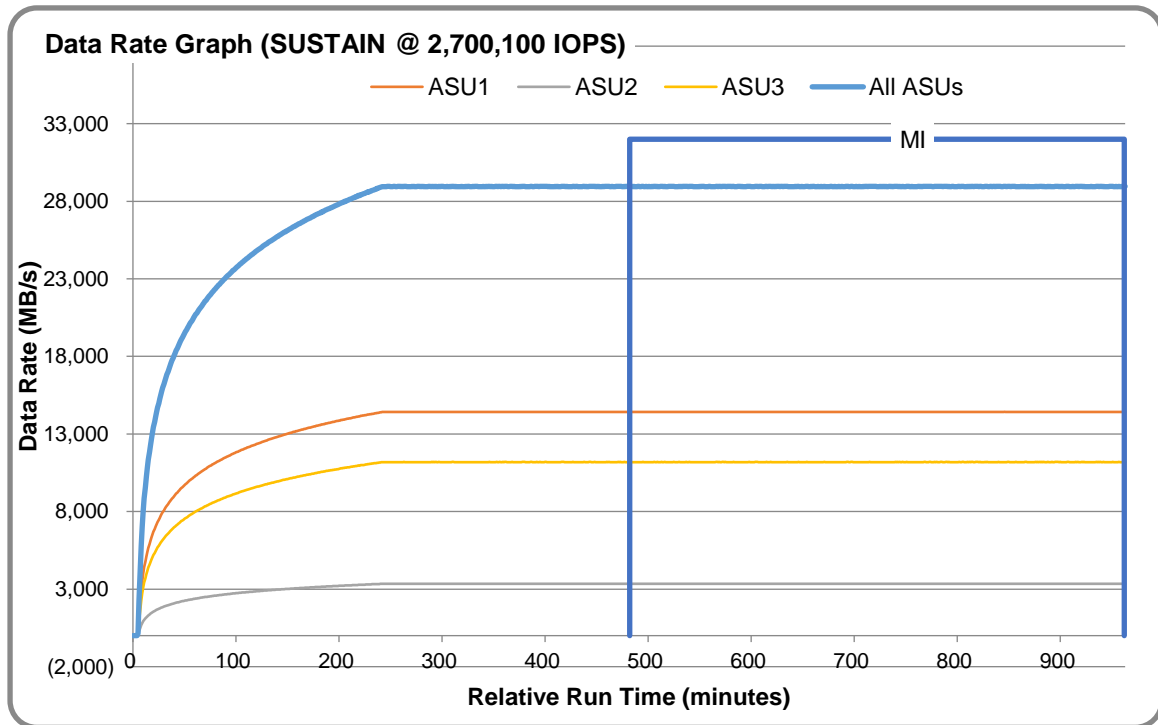
SUSTAIN – Throughput Graph



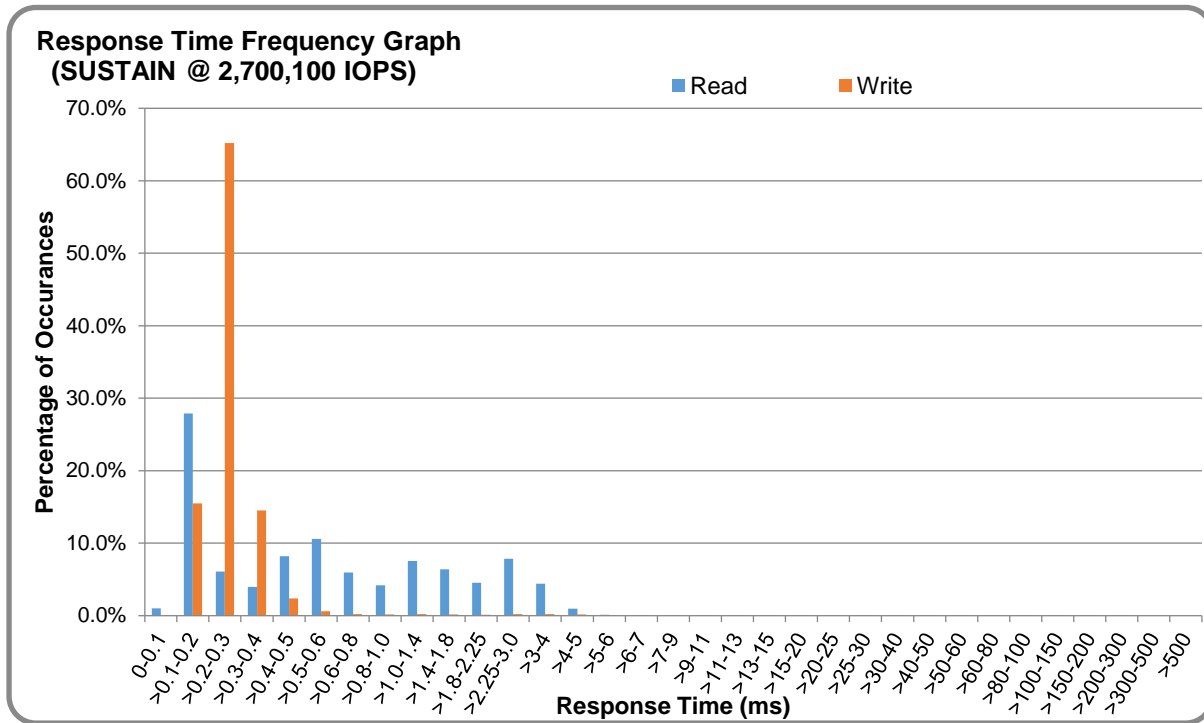
SUSTAIN – Response Time Graph



SUSTAIN – Data Rate Graph



SUSTAIN – Response Time Frequency Graph



SUSTAIN – Intensity Multiplier

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0004	0.0001	0.0003	0.0002	0.0006	0.0003	0.0004	0.0001
Difference	0.004%	0.001%	0.005%	0.000%	0.007%	0.003%	0.005%	0.003%

RAMPD_100 Test Phase

RAMPD 100 – Results File

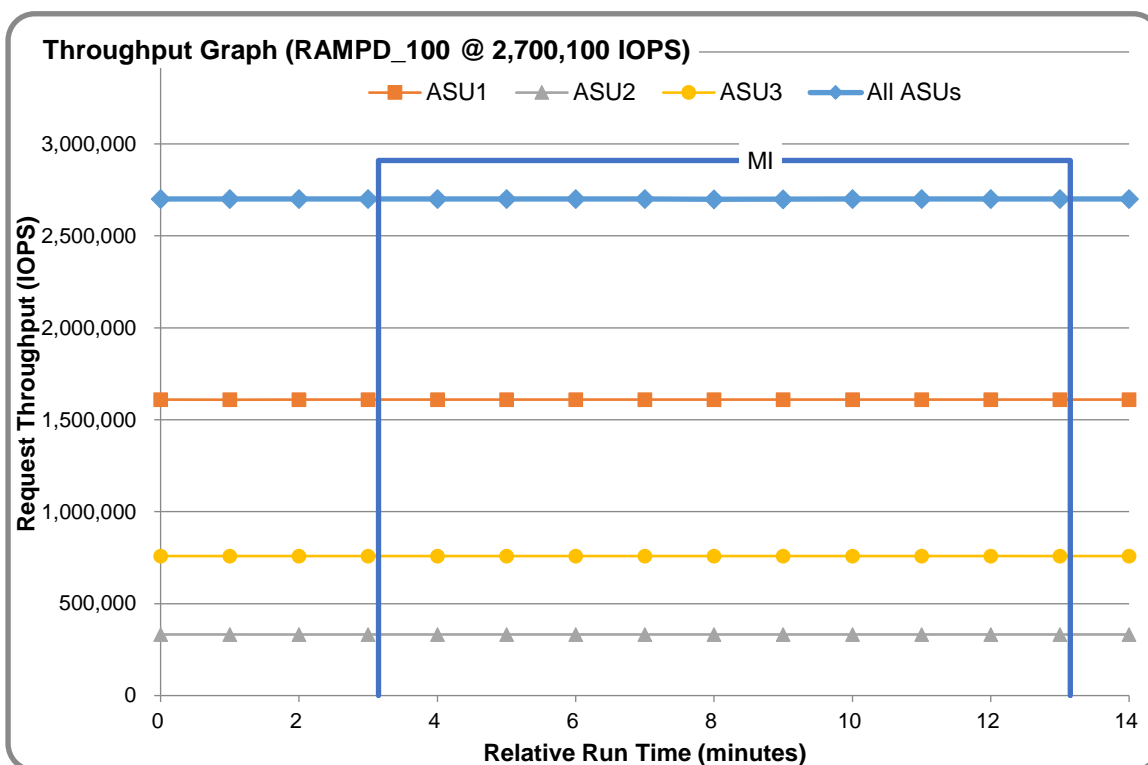
The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

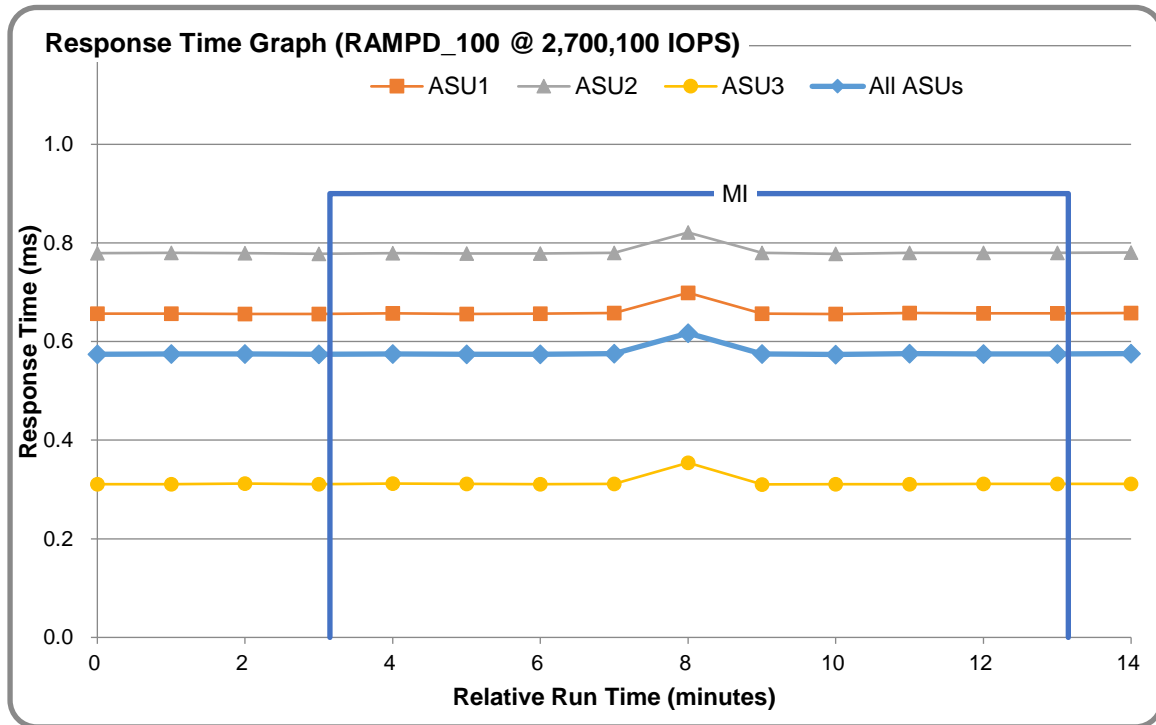
RAMPD 100 – Execution Times

Interval	Start Time	End Time	Duration
Transition Period	13-Mar-19 09:45:24	13-Mar-19 09:48:24	0:03:00
Measurement Interval	13-Mar-19 09:48:24	13-Mar-19 09:58:25	0:10:01

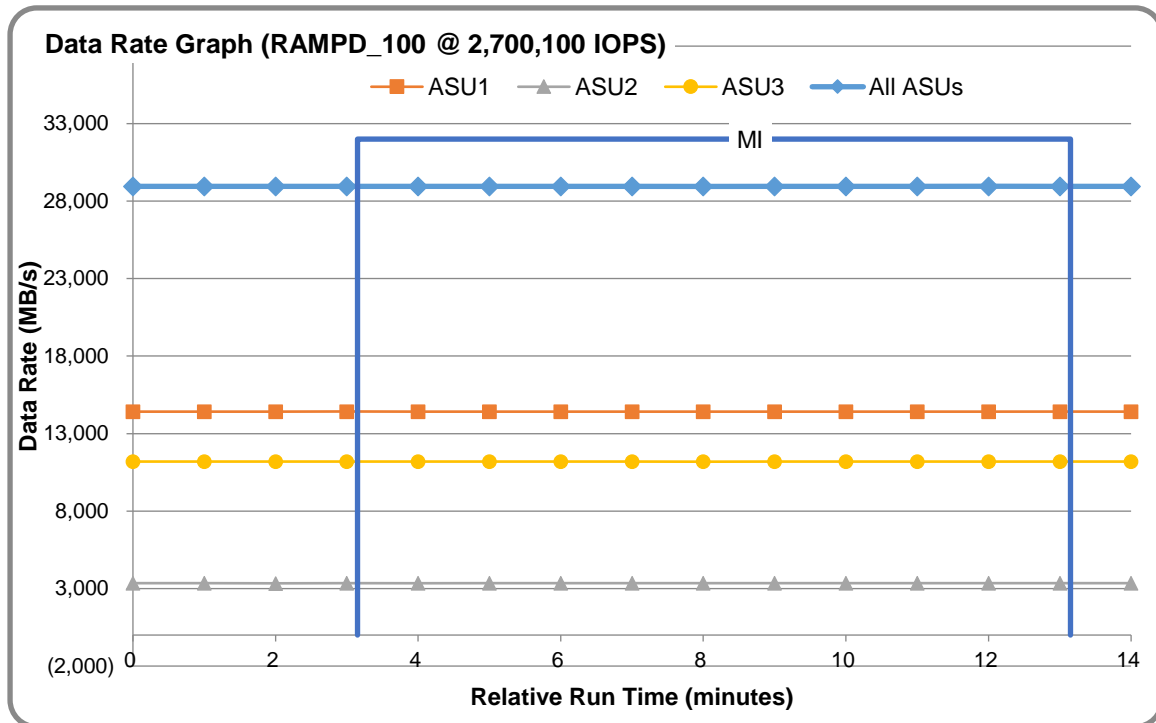
RAMPD 100 – Throughput Graph



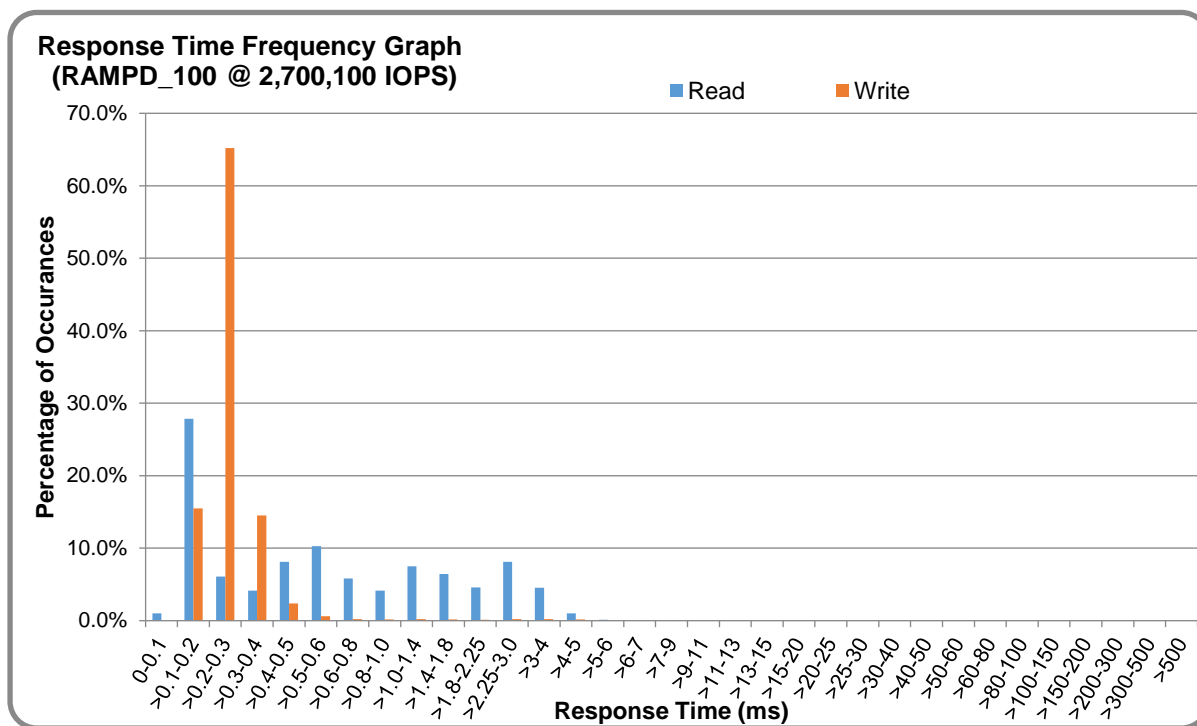
RAMPD 100 – Response Time Graph



RAMPD 100 – Data Rate Graph



RAMPD 100 – Response Time Frequency Graph



RAMPD 100 – Intensity Multiplier

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

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0004	0.0001	0.0003	0.0001	0.0008	0.0002	0.0003	0.0001
Difference	0.007%	0.005%	0.007%	0.005%	0.006%	0.015%	0.002%	0.008%

RAMPD 100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	1,620,135,322
I/O Requests Completed with Response Time <= 30 ms	1,620,075,696
I/O Requests Completed with Response Time > 30 ms	59,626

Response Time Ramp Test

Response Time Ramp Test – Results File

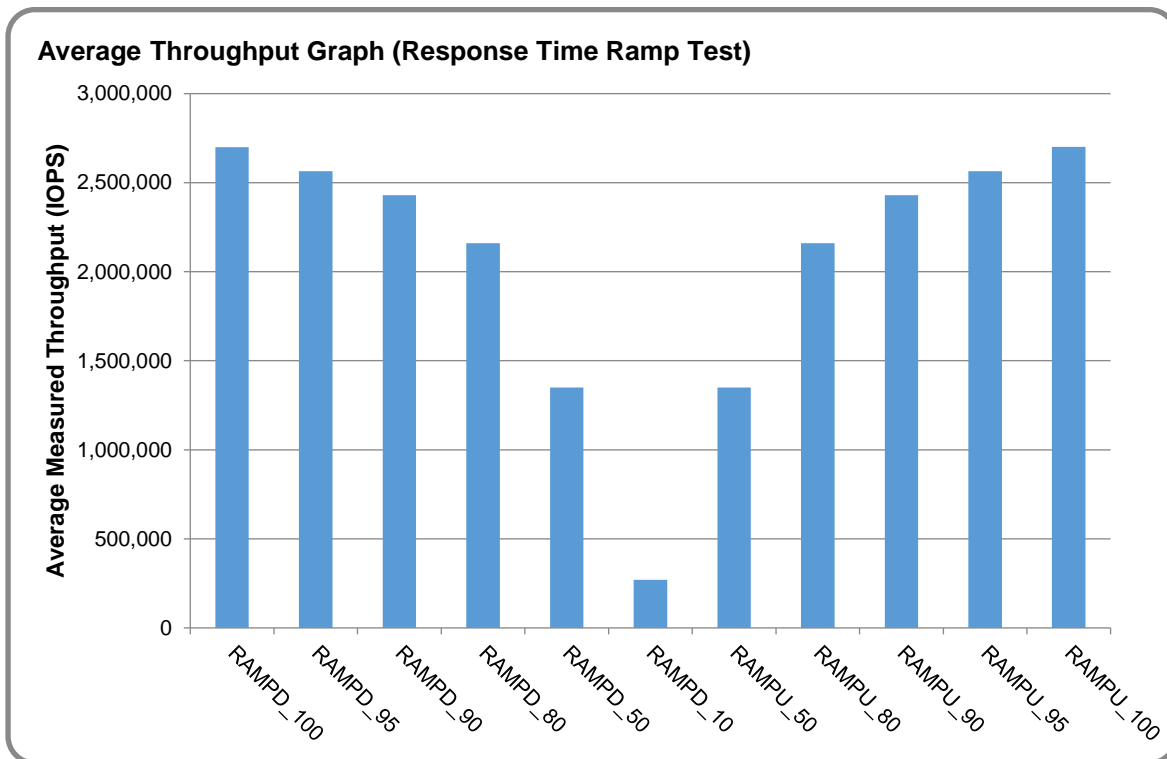
The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

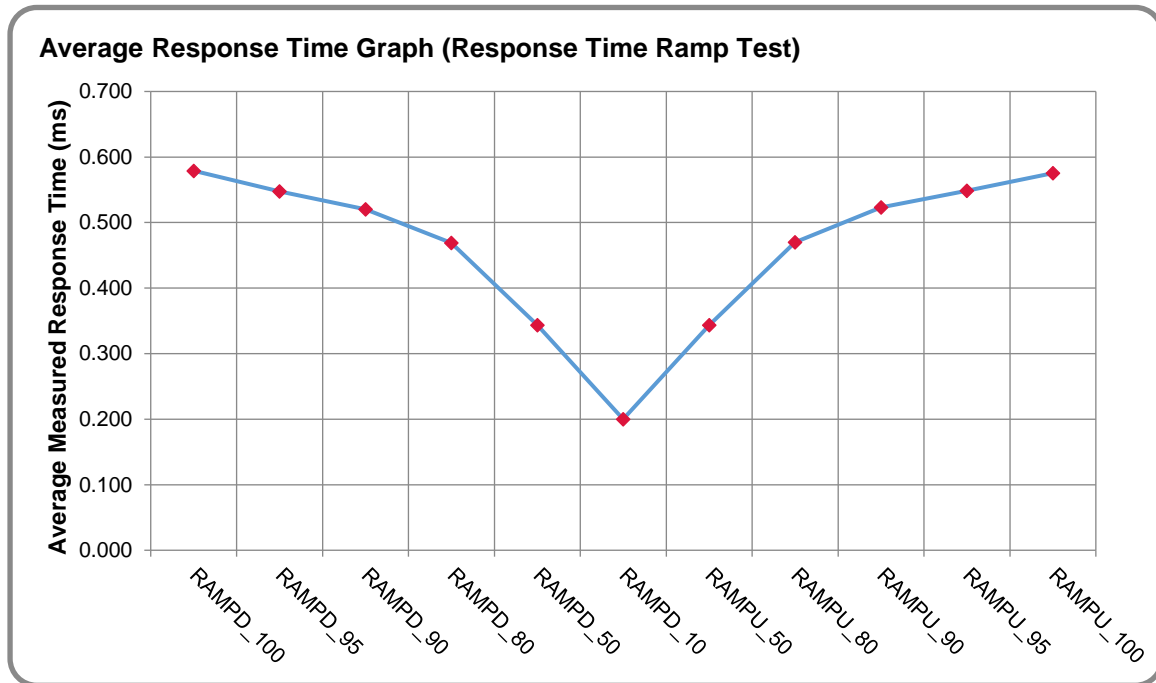
Response Time Ramp Test – Phases

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

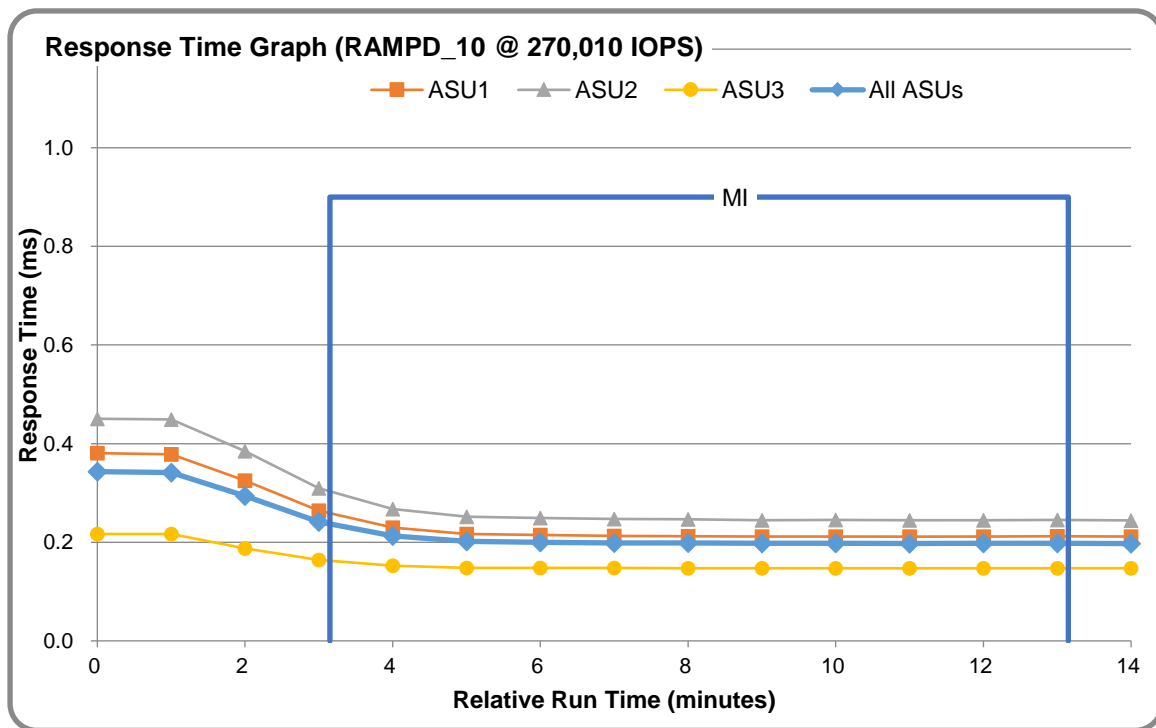
Response Time Ramp Test – Average Throughput Graph



Response Time Ramp Test – Average Response Time Graph



Response Time Ramp Test – RAMPD 10 Response Time Graph



Repeatability Test

Repeatability Test Results File

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

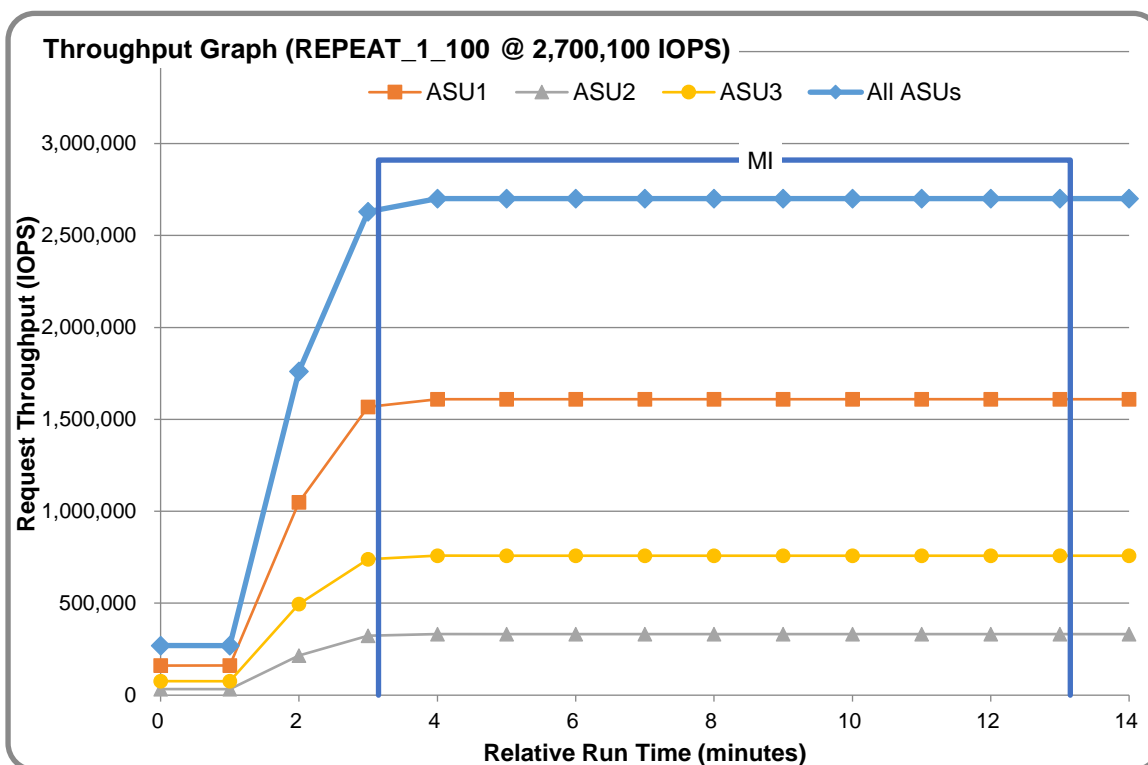
- SPC1_METRICS_0_Raw_Results.xlsx

Repeatability Test Results

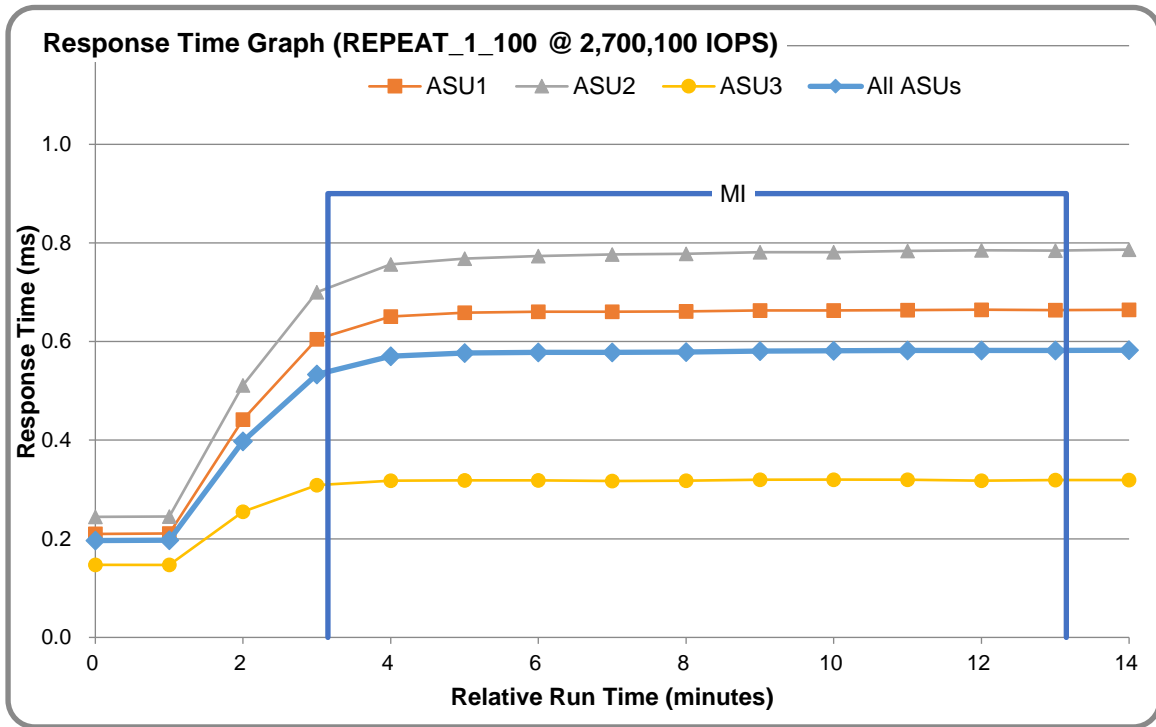
The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the tables below.

Test Phase	100% IOPS	10% IOPS
RAMPD	2,700,171.5	270,028.9
REPEAT_1	2,700,215.7	270,040.5
REPEAT_2	2,700,329.8	270,000.8

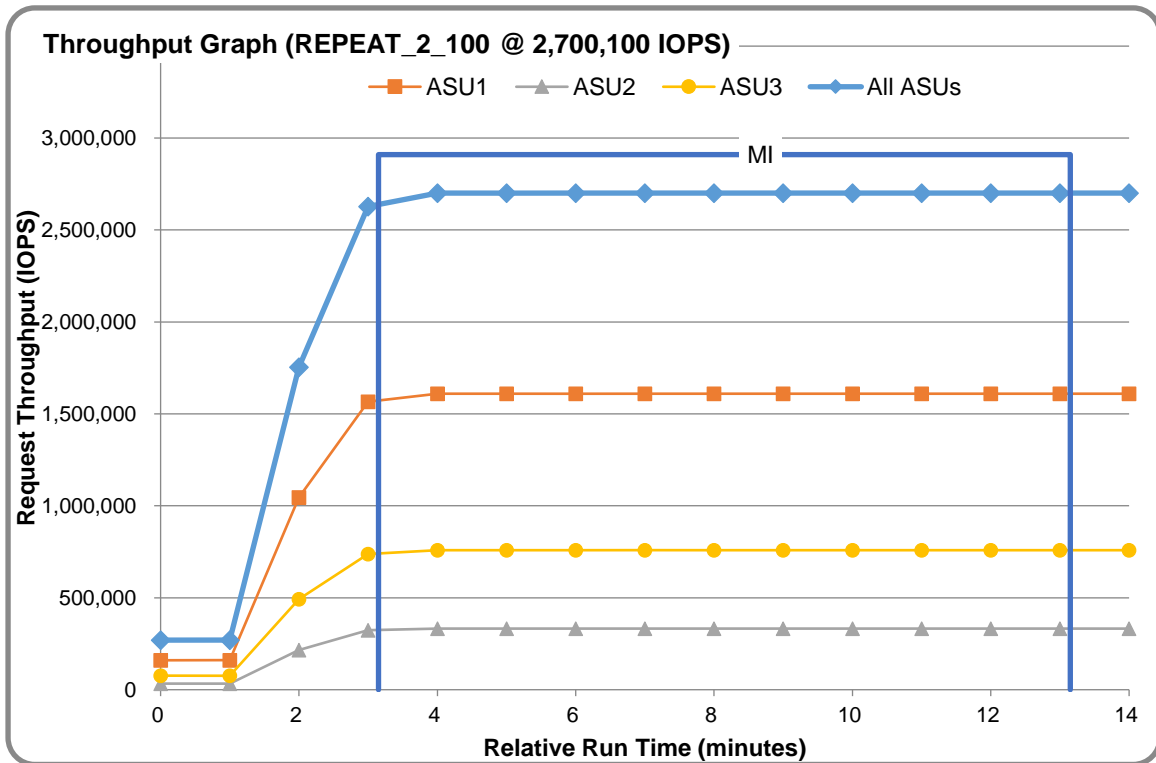
REPEAT 1 100 – Throughput Graph



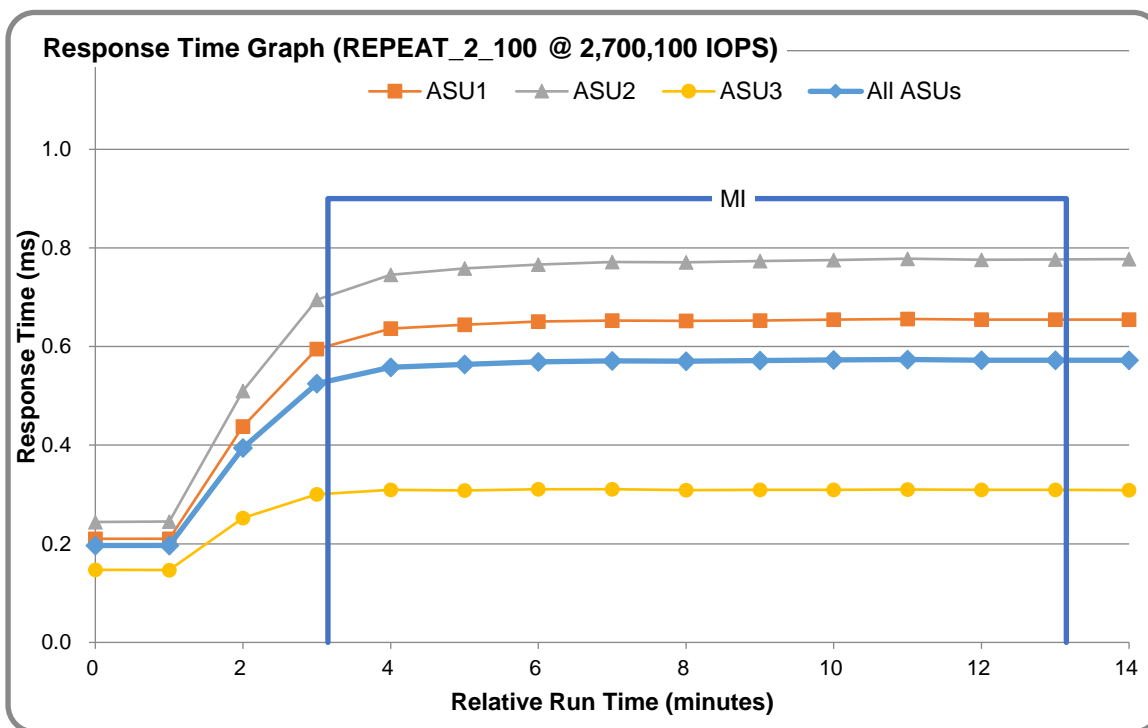
REPEAT 1 100 – Response Time Graph



REPEAT 2 100 – Throughput Graph



REPEAT 2 100 – Response Time Graph



Repeatability Test – Intensity Multiplier

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

REPEAT_1_100 Test Phase

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0004	0.0002	0.0004	0.0002	0.0007	0.0002	0.0005	0.0001
Difference	0.027%	0.003%	0.004%	0.001%	0.024%	0.011%	0.018%	0.003%

REPEAT_2_100 Test Phase

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0005	0.0001	0.0003	0.0002	0.0003	0.0001	0.0003	0.0001
Difference	0.017%	0.000%	0.009%	0.000%	0.001%	0.007%	0.028%	0.005%

Space Optimization Reporting

Description of Utilized Techniques

No space optimization was used for this SPC-1 result.

Physical Free Space Measurements

The following table lists the Physical Free Space as measured at each of the required points during test execution. If space optimization techniques were not used, "NA" is reported.

Physical Free Space Measurement	Free Space (GB)
After Logical Volume Creation	NA
After ASU Pre-Fill	NA
After Repeatability Test Phase	NA

Space Optimization Metrics

The following table lists the required space optimization metrics. If space optimization techniques were not used, "NA" is reported.

Space Optimization Metric	Value
SPC-1 Space Optimization Ratio	NA
SPC-1 Space Effectiveness Ratio	NA

Data Persistence Test

Data Persistence Test Results file

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

- **SPC1_PERSIST_1_0_Raw_Results.xlsx**
- **SPC1_PERSIST_2_0_Raw_Results.xlsx**

Data Persistence Test Execution

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

- The PERSIST_1_0 Test Phase was executed to completion.
- The Benchmark Configuration was taken through an orderly shutdown process and powered off.
- The Benchmark Configuration was powered on and taken through an orderly startup process.
- The PERSIST_2_0 Test Phase was executed to completion.

Data Persistence Test Results

Data Persistence Test Phase: Persist1	
Total Number of Logical Blocks Written	554,824,409
Total Number of Logical Blocks Verified	267,809,907
Total Number of Logical Blocks Overwritten	287,014,502
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks (sec.)	601
Size in bytes of each Logical Block	8,192
Number of Failed I/O Requests in the process of the Test	0

Committed Data Persistence Implementation


The persistency of committed data is implemented at two levels. At the disk level, data loss is prevented through the use of RAID 10 arrays. At the controller level, all caches are mirrored across controllers, where write requests are only completed once the local cache has been successfully mirrored in another controller's cache. In addition, cache content is protected from a loss of power by flushing the cache content to permanent flash memory, as soon as a power loss is detected. The flushing action is powered by a battery backup located in each controller.

APPENDIX A: SUPPORTING FILES

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

File Name	Description	Location
/SPC1_RESULTS	Data reduction worksheets	root
SPC1_INIT_0_Raw_Results.xlsx	Raw results for INIT Test Phase	/SPC1_RESULTS
SPC1_METRICS_0_Quick_Look.xlsx	Quick Look Test Run Overview	/SPC1_RESULTS
SPC1_METRICS_0_Raw_Results.xlsx	Raw results for Primary Metrics Test	/SPC1_RESULTS
SPC1_METRICS_0_Summary_Results.xlsx	Primary Metrics Summary	/SPC1_RESULTS
SPC1_PERSIST_1_0_Raw_Results.xlsx	Raw results for PERSIST1 Test Phase	/SPC1_RESULTS
SPC1_PERSIST_2_0_Raw_Results.xlsx	Raw results for PERSIST2 Test Phase	/SPC1_RESULTS
SPC1_Run_Set_Overview.xlsx	Run Set Overview Worksheet	/SPC1_RESULTS
SPC1_VERIFY_0_Raw_Results.xlsx	Raw results for first VERIFY Test Phase	/SPC1_RESULTS
SPC1_VERIFY_1_Raw_Results.xlsx	Raw results for second VERIFY Test Phase	/SPC1_RESULTS
/C_Tuning	Tuning parameters and options	root
aio-max-nr.sh	Set maximum asynchronous I/O	/C_Tuning
nr_requests.sh	Increase disk queue depth	/C_Tuning
scheduler.sh	Change the I/O scheduler	/C_Tuning
/D_Creation	Storage configuration creation	root
mklun.txt	Create the storage environment	/D_Creation
mkvolume.sh	Create the Logical Volumes	/D_Creation
/E_Inventory	Configuration inventory	root
profile1_volume.log	List of logical volumes before INIT	/E_Inventory
profile1_storage.log	List of storage devices before INIT	/E_Inventory
profile2_volume.log	List of logical volumes after restart	/E_Inventory
profile2_storage.log	List of storage devices after restart	/E_Inventory
/F_Generator	Workload generator	root
slave_asu.asu	Defining LUNs hosting the ASUs	/F_generator
11host.HST	Host configuration file	/F_generator
full_run.sh	Executing all test phases	/F_generator

APPENDIX B: THIRD PARTY QUOTATION



Address: 32 Broadway, Suite 401
 New York, NY 10004
 Tel: 212-809-6625
 Email: sales@noviant.com

19/03/2019, Quote Valid:90 Days

No.	Model	Description	Qty.	Unit Price (USD)	Disc. (off)	Total Disc. Price (USD)
1	Phase					
1.1	Location					
1.1.1	OceanStor 6800 V5 Main Equipment					
1.1.1	Controller Enclosure					
	02351NPT-88V5-4C2048G-AC	OceanStor 6800 V5 Engine(8U,Four Controller,AC240HVDC,2048GB Cache,SPE73C0600)	2	625461	68%	400,307.84
1.1.2	Expanding Interface Module					
	SMARTIO6FC	4 port SmartIO I/O module(SFP+,8Gb FC)	24	3192	68%	24,514.56
	SMARTIO10ETH	4 port SmartIO I/O module(SFP+,10Gb Eth/FCoE/VN2VF)/Scale-out)	8	6268	68%	16,097.28
	LPU4S12V5	12 port 4*12Gb SAS shared I/O module(MiniSAS HD)	4	4963	68%	6,352.64
1.1.3	Disk Components					
	HSSD-960G2S-A9	960GB SSD SAS Disk Unit(2.5")	168	10176	70%	512,870.40
1.1.4	Disk Enclosure					
	DAE5252SU2-AC-A2	Disk Enclosure(2U,AC240HVDC,2.5",Expansion Module,25 Disk Slots,without Disk Unit,DAE5252SU2)	14	10584	68%	47,416.32
1.1.5	Cabinet					
	RACK-42U-1	42U Storage AC Cabinet(With Power Distribution Unit)	2	10158	0%	20,316.00
1.1.6	HBA					
	ND8GOLC00	Qlogic,FC HBA,8Gb(QLE2562),2-Port,SFP+(with 2x Multi-mode Optical Transceiver),PCIe 2.0 x4	44	1698	0%	74,712.00
1.1.7	Accessory					
	SN2F01FCPC	Patch Cord,DLC/PC,DLC/PC,Multi-mode,3m,A1a,2.2mm,42mm DLC,OM3 bending insensitive	104	14	0%	1,456.00
1.1.8	Storage Software					

	LIC-8BV5-B5	Basic Software License(Including DeviceManager,SmartThin,SmartMulti-tenant,SmartMigration,SmartErase,SmartMotion, SystemReporter,SmartQuota,NFS,CIFS,NDMP,e Service)	1	30744	70%	9,223.20
1.1.9	Switch					
	CE6855-HI-F-80A	CE6855-48S6Q-HI Switch(48-Port 10G SFP+,6-Port 40GE QSFP+,2*AC Power Module,2*FAN Box,Port-side Exhaust)	2	13738	0%	27,476.00
Total of Product						1,140,742.24
1.1.10	Maintenance Support Service					
	02351LWK-88134ULF-36	OceanStor 6800 V5 Engine(6U,Four Controller,AC\240HVDC,2048GB Cache,SPE73C0600&7"Disk Enclosure-2U,AC\240HVDC,2.5",DAE52525U2&84"960GB SSD SAS Disk Unit)-Hi-Care Onsite Premier 24x7x4H Engineer Onsite Service-36Month(s)	2	56085	0%	112,170.00
	88034JNY-88134UHK-36	Basic Software License(Including DeviceManager,SmartThin,SmartMulti-tenant,SmartMigration,SmartErase,SmartMotion, SystemReporter,eService,SmartQuota,NFS,CIFS,NDMP)-Hi-Care Application Software Upgrade Support Service-36Month(s)	1	4323	0%	4,323.00
	02350RTB-88134UFJ-36	CE6855-48S6Q-HI Switch(48-Port 10G SFP+,6-Port 40GE QSFP+,2*AC Power Module,2*FAN Box,Port-side Exhaust)-Hi-Care Onsite Standard 9x5xNBD Service-36Month(s)	2	5729	0%	11,458.00
	8812099164	OceanStor 6800 V5 Installation Service - Engineering	1	30300	0%	30,300.00
Total of Service (3 years)						158,251.00
Total Price						1,298,993.24
Notes:Hi-Care Premier On-Site Service include: 7*24 Technical Assistance Center Access. Access to all new software updates and Online Support. 24*7*4 Hours Onsite Hardware Replacement.						
Payment Terms:						
Comments:						
Noviant is an Authorized Value Added reseller (VAR) of networking products. Products sold by NF are factory new unless otherwise specified. All new products sold by NF carry its own Original Equipment Manufacturer's (OEM) Limited Warranty and software licenses. This Quote is valid for 90 days. Prices and availability is subject to change without notice. Installation and configuration costs are not included in the quoted pricing unless specified. A 20% Restocking Fee applies to all cancelled orders and/or returned products. Special Orders are non-returnable. Buyer is responsible for payment of all applicable taxes and freight charges. Issuance of customer PO against this Quote constitutes acceptance of Noviant Sales Terms conditions.						
I agree to the these terms and conditions.						

APPENDIX C: TUNING PARAMETERS AND OPTIONS

The following scripts, listed below, were used to set tuning parameters and options:

- ***aio-max-nr.sh*** to change the maximum number of AIO operations to 1048576
- ***nr_requests.sh*** to change `nr_requests` from 128 to 4096 on each Host System for each device
- ***scheduler.sh*** to change the I/O scheduler from `cfq` to `noop` on each Host System, which will result in all incoming I/O requests inserted into a simple, unordered FIFO queue

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

aio-max-nr.sh

```
echo 10485760 > /proc/sys/fs/aio-max-nr
```

nr_requests.sh

```
echo 4096 >/sys/block/sdb/queue/nr_requests  
echo 4096 >/sys/block/sdc/queue/nr_requests  
echo 4096 >/sys/block/sdd/queue/nr_requests  
echo 4096 >/sys/block/sde/queue/nr_requests  
echo 4096 >/sys/block/sdf/queue/nr_requests  
echo 4096 >/sys/block/sdg/queue/nr_requests  
echo 4096 >/sys/block/sdh/queue/nr_requests  
echo 4096 >/sys/block/sdi/queue/nr_requests  
echo 4096 >/sys/block/sdj/queue/nr_requests  
echo 4096 >/sys/block/sdk/queue/nr_requests  
echo 4096 >/sys/block/sdl/queue/nr_requests  
echo 4096 >/sys/block/sdm/queue/nr_requests  
echo 4096 >/sys/block/sdn/queue/nr_requests  
echo 4096 >/sys/block/sdo/queue/nr_requests  
echo 4096 >/sys/block/sdp/queue/nr_requests  
echo 4096 >/sys/block/sdq/queue/nr_requests  
echo 4096 >/sys/block/sdr/queue/nr_requests  
echo 4096 >/sys/block/sds/queue/nr_requests  
echo 4096 >/sys/block/sdt/queue/nr_requests  
echo 4096 >/sys/block/sdu/queue/nr_requests  
echo 4096 >/sys/block/sdv/queue/nr_requests  
echo 4096 >/sys/block/sdw/queue/nr_requests  
echo 4096 >/sys/block/sdx/queue/nr_requests  
echo 4096 >/sys/block/sdy/queue/nr_requests  
echo 4096 >/sys/block/sdz/queue/nr_requests  
echo 4096 >/sys/block/sdaa/queue/nr_requests  
echo 4096 >/sys/block/sdab/queue/nr_requests  
echo 4096 >/sys/block/sdac/queue/nr_requests  
echo 4096 >/sys/block/sdad/queue/nr_requests  
echo 4096 >/sys/block/sdae/queue/nr_requests  
echo 4096 >/sys/block/sdaf/queue/nr_requests  
echo 4096 >/sys/block/sdag/queue/nr_requests  
echo 4096 >/sys/block/sdah/queue/nr_requests  
echo 4096 >/sys/block/sdai/queue/nr_requests
```

```
echo 4096 >/sys/block/sdaj/queue/nr_requests
echo 4096 >/sys/block/sdak/queue/nr_requests
echo 4096 >/sys/block/sdal/queue/nr_requests
echo 4096 >/sys/block/sdam/queue/nr_requests
echo 4096 >/sys/block/sdan/queue/nr_requests
echo 4096 >/sys/block/sdao/queue/nr_requests
echo 4096 >/sys/block/sdap/queue/nr_requests
echo 4096 >/sys/block/sdaq/queue/nr_requests
echo 4096 >/sys/block/sdar/queue/nr_requests
echo 4096 >/sys/block/sdas/queue/nr_requests
echo 4096 >/sys/block/sdat/queue/nr_requests
echo 4096 >/sys/block/sdau/queue/nr_requests
echo 4096 >/sys/block/sdav/queue/nr_requests
echo 4096 >/sys/block/sdaw/queue/nr_requests
echo 4096 >/sys/block/sdax/queue/nr_requests
echo 4096 >/sys/block/sday/queue/nr_requests
echo 4096 >/sys/block/sdaz/queue/nr_requests
echo 4096 >/sys/block/sdba/queue/nr_requests
echo 4096 >/sys/block/sdbb/queue/nr_requests
echo 4096 >/sys/block/sdbc/queue/nr_requests
echo 4096 >/sys/block/sdbd/queue/nr_requests
echo 4096 >/sys/block/sdbe/queue/nr_requests
```

- ***scheduler.sh***

```
echo noop >/sys/block/sdb/queue/scheduler
echo noop >/sys/block/sdc/queue/scheduler
echo noop >/sys/block/sdd/queue/scheduler
echo noop >/sys/block/sde/queue/scheduler
echo noop >/sys/block/sdf/queue/scheduler
echo noop >/sys/block/sdg/queue/scheduler
echo noop >/sys/block/sdh/queue/scheduler
echo noop >/sys/block/sdi/queue/scheduler
echo noop >/sys/block/sdj/queue/scheduler
echo noop >/sys/block/sdk/queue/scheduler
echo noop >/sys/block/sdl/queue/scheduler
echo noop >/sys/block/sdm/queue/scheduler
echo noop >/sys/block/sdn/queue/scheduler
echo noop >/sys/block/sdo/queue/scheduler
echo noop >/sys/block/sdp/queue/scheduler
echo noop >/sys/block/sdq/queue/scheduler
echo noop >/sys/block/sdr/queue/scheduler
echo noop >/sys/block/sds/queue/scheduler
echo noop >/sys/block/sdt/queue/scheduler
echo noop >/sys/block/sdu/queue/scheduler
echo noop >/sys/block/sdv/queue/scheduler
echo noop >/sys/block/sdw/queue/scheduler
echo noop >/sys/block/sdx/queue/scheduler
echo noop >/sys/block/sdy/queue/scheduler
echo noop >/sys/block/sdz/queue/scheduler
echo noop >/sys/block/sdaa/queue/scheduler
echo noop >/sys/block/sdab/queue/scheduler
echo noop >/sys/block/sdac/queue/scheduler
echo noop >/sys/block/sdad/queue/scheduler
echo noop >/sys/block/sdae/queue/scheduler
echo noop >/sys/block/sdaf/queue/scheduler
echo noop >/sys/block/sdag/queue/scheduler
echo noop >/sys/block/sdah/queue/scheduler
echo noop >/sys/block/sdai/queue/scheduler
echo noop >/sys/block/sdaj/queue/scheduler
echo noop >/sys/block/sdak/queue/scheduler
```

```
echo noop >/sys/block/sdal/queue/scheduler
echo noop >/sys/block/sdam/queue/scheduler
echo noop >/sys/block/sdan/queue/scheduler
echo noop >/sys/block/sdao/queue/scheduler
echo noop >/sys/block/sdap/queue/scheduler
echo noop >/sys/block/sdaq/queue/scheduler
echo noop >/sys/block/sdar/queue/scheduler
echo noop >/sys/block/sdas/queue/scheduler
echo noop >/sys/block/sdat/queue/scheduler
echo noop >/sys/block/sdau/queue/scheduler
echo noop >/sys/block/sdav/queue/scheduler
echo noop >/sys/block/sdaw/queue/scheduler
echo noop >/sys/block/sdax/queue/scheduler
echo noop >/sys/block/sday/queue/scheduler
echo noop >/sys/block/sdaz/queue/scheduler
echo noop >/sys/block/sdba/queue/scheduler
echo noop >/sys/block/sdbb/queue/scheduler
echo noop >/sys/block/sdbc/queue/scheduler
echo noop >/sys/block/sdbd/queue/scheduler
echo noop >/sys/block/sdbe/queue/scheduler
```

APPENDIX D: STORAGE CONFIGURATION CREATION

Environment

First, the CLI commands from the following command file are copied and pasted into the OCEANSTOR 6800 V5 CLI window. These commands are executed on one of the Host Systems.

- ***mklun.txt***

Next, the following shell script is executed on one of the Host Systems.

- ***mkvolume.sh***

Step 1 - Create Disk Domains, Storage Pools, LUNs

The ***mklun.txt*** command file, listed below, includes all the CLI commands to perform the following actions:

- Create 14 disk domains
- Create 14 storage pools
- Create 56 LUNs

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

mklun.txt (part 1)

```
create disk_domain name=dd01 disk_list=DAE000.0-11 tier0_hotspare_strategy=low
disk_domain_id=1
create disk_domain name=dd02 disk_list=DAE010.0-11 tier0_hotspare_strategy=low
disk_domain_id=2
create disk_domain name=dd03 disk_list=DAE020.0-11 tier0_hotspare_strategy=low
disk_domain_id=3
create disk_domain name=dd04 disk_list=DAE030.0-11 tier0_hotspare_strategy=low
disk_domain_id=4
create disk_domain name=dd05 disk_list=DAE040.0-11 tier0_hotspare_strategy=low
disk_domain_id=5
create disk_domain name=dd06 disk_list=DAE050.0-11 tier0_hotspare_strategy=low
disk_domain_id=6
create disk_domain name=dd07 disk_list=DAE060.0-11 tier0_hotspare_strategy=low
disk_domain_id=7
create disk_domain name=dd08 disk_list=DAE100.0-11 tier0_hotspare_strategy=low
disk_domain_id=8
create disk_domain name=dd09 disk_list=DAE110.0-11 tier0_hotspare_strategy=low
disk_domain_id=9
create disk_domain name=dd10 disk_list=DAE120.0-11 tier0_hotspare_strategy=low
disk_domain_id=10
create disk_domain name=dd11 disk_list=DAE130.0-11 tier0_hotspare_strategy=low
disk_domain_id=11
create disk_domain name=dd12 disk_list=DAE140.0-11 tier0_hotspare_strategy=low
disk_domain_id=12
create disk_domain name=dd13 disk_list=DAE150.0-11 tier0_hotspare_strategy=low
disk_domain_id=13
create disk_domain name=dd14 disk_list=DAE160.0-11 tier0_hotspare_strategy=low
disk_domain_id=14
```

```
create storage_pool name=sp1 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=1 disk_domain_id=1
create storage_pool name=sp2 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=2 disk_domain_id=2
create storage_pool name=sp3 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=3 disk_domain_id=3
create storage_pool name=sp4 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=4 disk_domain_id=4
create storage_pool name=sp5 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=5 disk_domain_id=5
create storage_pool name=sp6 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=6 disk_domain_id=6
create storage_pool name=sp7 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=7 disk_domain_id=7
create storage_pool name=sp8 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=8 disk_domain_id=8
create storage_pool name=sp9 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=9 disk_domain_id=9
create storage_pool name=sp10 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=10 disk_domain_id=10
create storage_pool name=sp11 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=11 disk_domain_id=11
create storage_pool name=sp12 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=12 disk_domain_id=12
create storage_pool name=sp13 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=13 disk_domain_id=13
create storage_pool name=sp14 disk_type=SSD capacity=4306GB stripe_depth=64KB
raid_level=RAID10 pool_id=14 disk_domain_id=14
create lun name=lun_sp01 pool_id=1 capacity=1076GB lun_id=1 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp02 pool_id=1 capacity=1076GB lun_id=2 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp03 pool_id=1 capacity=1076GB lun_id=3 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp04 pool_id=1 capacity=1076GB lun_id=4 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp05 pool_id=2 capacity=1076GB lun_id=5 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp06 pool_id=2 capacity=1076GB lun_id=6 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp07 pool_id=2 capacity=1076GB lun_id=7 owner_controller=0A
prefetch_policy=none
create lun name=lun_sp08 pool_id=2 capacity=1076GB lun_id=8 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp09 pool_id=3 capacity=1076GB lun_id=9 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp10 pool_id=3 capacity=1076GB lun_id=10 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp11 pool_id=3 capacity=1076GB lun_id=11 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp12 pool_id=3 capacity=1076GB lun_id=12 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp13 pool_id=4 capacity=1076GB lun_id=13 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp14 pool_id=4 capacity=1076GB lun_id=14 owner_controller=0B
prefetch_policy=none
create lun name=lun_sp15 pool_id=4 capacity=1076GB lun_id=15 owner_controller=0C
prefetch_policy=none
create lun name=lun_sp16 pool_id=4 capacity=1076GB lun_id=16 owner_controller=0C
prefetch_policy=none
create lun name=lun_sp17 pool_id=5 capacity=1076GB lun_id=17 owner_controller=0C
prefetch_policy=none
```

```
create lun name=lun_sp18 pool_id=5 capacity=1076GB lun_id=18 owner_controller=0C
  prefetch_policy=none
create lun name=lun_sp19 pool_id=5 capacity=1076GB lun_id=19 owner_controller=0C
  prefetch_policy=none
create lun name=lun_sp20 pool_id=5 capacity=1076GB lun_id=20 owner_controller=0C
  prefetch_policy=none
create lun name=lun_sp21 pool_id=6 capacity=1076GB lun_id=21 owner_controller=0C
  prefetch_policy=none
create lun name=lun_sp22 pool_id=6 capacity=1076GB lun_id=22 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp23 pool_id=6 capacity=1076GB lun_id=23 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp24 pool_id=6 capacity=1076GB lun_id=24 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp25 pool_id=7 capacity=1076GB lun_id=25 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp26 pool_id=7 capacity=1076GB lun_id=26 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp27 pool_id=7 capacity=1076GB lun_id=27 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp28 pool_id=7 capacity=1076GB lun_id=28 owner_controller=0D
  prefetch_policy=none
create lun name=lun_sp29 pool_id=8 capacity=1076GB lun_id=29 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp30 pool_id=8 capacity=1076GB lun_id=30 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp31 pool_id=8 capacity=1076GB lun_id=31 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp32 pool_id=8 capacity=1076GB lun_id=32 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp33 pool_id=9 capacity=1076GB lun_id=33 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp34 pool_id=9 capacity=1076GB lun_id=34 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp35 pool_id=9 capacity=1076GB lun_id=35 owner_controller=1A
  prefetch_policy=none
create lun name=lun_sp36 pool_id=9 capacity=1076GB lun_id=36 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp37 pool_id=10 capacity=1076GB lun_id=37 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp38 pool_id=10 capacity=1076GB lun_id=38 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp39 pool_id=10 capacity=1076GB lun_id=39 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp40 pool_id=10 capacity=1076GB lun_id=40 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp41 pool_id=11 capacity=1076GB lun_id=41 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp42 pool_id=11 capacity=1076GB lun_id=42 owner_controller=1B
  prefetch_policy=none
create lun name=lun_sp43 pool_id=11 capacity=1076GB lun_id=43 owner_controller=1C
  prefetch_policy=none
create lun name=lun_sp44 pool_id=11 capacity=1076GB lun_id=44 owner_controller=1C
  prefetch_policy=none
create lun name=lun_sp45 pool_id=12 capacity=1076GB lun_id=45 owner_controller=1C
  prefetch_policy=none
create lun name=lun_sp46 pool_id=12 capacity=1076GB lun_id=46 owner_controller=1C
  prefetch_policy=none
create lun name=lun_sp47 pool_id=12 capacity=1076GB lun_id=47 owner_controller=1C
  prefetch_policy=none
create lun name=lun_sp48 pool_id=12 capacity=1076GB lun_id=48 owner_controller=1C
  prefetch_policy=none
```

```
create lun name=lun_sp49 pool_id=13 capacity=1076GB lun_id=49 owner_controller=1C
  prefetch_policy=none
create lun name=lun_sp50 pool_id=13 capacity=1076GB lun_id=50 owner_controller=1D
  prefetch_policy=none
create lun name=lun_sp51 pool_id=13 capacity=1076GB lun_id=51 owner_controller=1D
  prefetch_policy=none
create lun name=lun_sp52 pool_id=13 capacity=1076GB lun_id=52 owner_controller=1D
  prefetch_policy=none
create lun name=lun_sp53 pool_id=14 capacity=1076GB lun_id=53 owner_controller=1D
  prefetch_policy=none
create lun name=lun_sp54 pool_id=14 capacity=1076GB lun_id=54 owner_controller=1D
  prefetch_policy=none
create lun name=lun_sp55 pool_id=14 capacity=1076GB lun_id=55 owner_controller=1D
  prefetch_policy=none
create lun name=lun_sp56 pool_id=14 capacity=1076GB lun_id=56 owner_controller=1D
  prefetch_policy=none
```

Step 2 - Create Mapping View, Host Group and Host

The *mk1un.txt* command file, listed below, includes all the CLI commands to perform the following actions:

- Create 11 hosts
- Add the FC port's WWN to the 11 hosts
- Create a host group for the 11 hosts.
- Create one LUN group
- Add the 56 LUNs to the LUN group
- Create a mapping view

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

mk1un.txt (part 2)

```
create host name=host01 operating_system=Linux host_id=1
create host name=host02 operating_system=Linux host_id=2
create host name=host03 operating_system=Linux host_id=3
create host name=host04 operating_system=Linux host_id=4
create host name=host05 operating_system=Linux host_id=5
create host name=host06 operating_system=Linux host_id=6
create host name=host07 operating_system=Linux host_id=7
create host name=host09 operating_system=Linux host_id=9
create host name=host10 operating_system=Linux host_id=10
create host name=host11 operating_system=Linux host_id=11
create host name=host12 operating_system=Linux host_id=12

add host initiator host_id=12 initiator_type=FC wwn=21000024ff7f431a
add host initiator host_id=12 initiator_type=FC wwn=21000024ff7f431b
add host initiator host_id=12 initiator_type=FC wwn=21000024ff7f78fe
add host initiator host_id=12 initiator_type=FC wwn=21000024ff7f78ff
add host initiator host_id=12 initiator_type=FC wwn=2100f4e9d453359a
add host initiator host_id=12 initiator_type=FC wwn=2100f4e9d453359b
add host initiator host_id=12 initiator_type=FC wwn=2100f4e9d45340dc
add host initiator host_id=12 initiator_type=FC wwn=2100f4e9d45340dd
add host initiator host_id=11 initiator_type=FC wwn=21000024ff17dff5
add host initiator host_id=11 initiator_type=FC wwn=21000024ff17df38
add host initiator host_id=11 initiator_type=FC wwn=21000024ff17df39
```

```
add host initiator host_id=11 initiator_type=FC wwn=21000024ff1be660
add host initiator host_id=11 initiator_type=FC wwn=21000024ff1be661
add host initiator host_id=11 initiator_type=FC wwn=21000024ff54523c
add host initiator host_id=11 initiator_type=FC wwn=21000024ff54523d
add host initiator host_id=11 initiator_type=FC wwn=21000024ff17dff4
add host initiator host_id=10 initiator_type=FC wwn=21000024ff17e0bb
add host initiator host_id=10 initiator_type=FC wwn=21000024ff28ea5c
add host initiator host_id=10 initiator_type=FC wwn=21000024ff28ea5d
add host initiator host_id=10 initiator_type=FC wwn=2100f4e9d4533ae0
add host initiator host_id=10 initiator_type=FC wwn=2100f4e9d4533ae1
add host initiator host_id=10 initiator_type=FC wwn=21000024ff17e0ba
add host initiator host_id=10 initiator_type=FC wwn=2100f4e9d4533738
add host initiator host_id=10 initiator_type=FC wwn=2100f4e9d4533739
add host initiator host_id=9 initiator_type=FC wwn=21000024ff7fb903
add host initiator host_id=9 initiator_type=FC wwn=21000024ff7fb716
add host initiator host_id=9 initiator_type=FC wwn=21000024ff7fb717
add host initiator host_id=9 initiator_type=FC wwn=2100f4e9d45340cc
add host initiator host_id=9 initiator_type=FC wwn=2100f4e9d45340cd
add host initiator host_id=9 initiator_type=FC wwn=2100f4e9d4533742
add host initiator host_id=9 initiator_type=FC wwn=2100f4e9d4533743
add host initiator host_id=9 initiator_type=FC wwn=21000024ff7fb902
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d45340c9
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d45198b0
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d45198b1
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d452e9d8
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d452e9d9
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d4533aea
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d4533aeb
add host initiator host_id=7 initiator_type=FC wwn=2100f4e9d45340c8
add host initiator host_id=6 initiator_type=FC wwn=21000024ff8f9d71
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4b81b0
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4b81b1
add host initiator host_id=6 initiator_type=FC wwn=2100f4e9d452f08c
add host initiator host_id=6 initiator_type=FC wwn=2100f4e9d452f08d
add host initiator host_id=6 initiator_type=FC wwn=21000024ff1be9e6
add host initiator host_id=6 initiator_type=FC wwn=21000024ff1be9e7
add host initiator host_id=6 initiator_type=FC wwn=21000024ff8f9d70
add host initiator host_id=5 initiator_type=FC wwn=21000024ff1be9e0
add host initiator host_id=5 initiator_type=FC wwn=21000024ff1be9e1
add host initiator host_id=5 initiator_type=FC wwn=21000024ff1bea2a
add host initiator host_id=5 initiator_type=FC wwn=21000024ff1bea2b
add host initiator host_id=5 initiator_type=FC wwn=2100f4e9d45340b4
add host initiator host_id=5 initiator_type=FC wwn=2100f4e9d45340b5
add host initiator host_id=5 initiator_type=FC wwn=21000024ff4b82b0
add host initiator host_id=5 initiator_type=FC wwn=21000024ff4b82b1
add host initiator host_id=4 initiator_type=FC wwn=21000024ff3a3d5d
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5c364e
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5c364f
add host initiator host_id=4 initiator_type=FC wwn=2100f4e9d452f03e
add host initiator host_id=4 initiator_type=FC wwn=2100f4e9d452f03f
add host initiator host_id=4 initiator_type=FC wwn=2100f4e9d45340e8
add host initiator host_id=4 initiator_type=FC wwn=2100f4e9d45340e9
add host initiator host_id=4 initiator_type=FC wwn=21000024ff3a3d5c
add host initiator host_id=3 initiator_type=FC wwn=21000024ff545061
add host initiator host_id=3 initiator_type=FC wwn=21000024ff178584
add host initiator host_id=3 initiator_type=FC wwn=21000024ff178585
add host initiator host_id=3 initiator_type=FC wwn=21000024ff7f4322
add host initiator host_id=3 initiator_type=FC wwn=21000024ff7f4323
add host initiator host_id=3 initiator_type=FC wwn=2100f4e9d45340ce
add host initiator host_id=3 initiator_type=FC wwn=2100f4e9d45340cf
add host initiator host_id=3 initiator_type=FC wwn=21000024ff545060
add host initiator host_id=2 initiator_type=FC wwn=21000024ff36cf44
```



```
add host initiator host_id=2 initiator_type=FC wwn=21000024ff36cf45
add host initiator host_id=2 initiator_type=FC wwn=21000024ff369d90
add host initiator host_id=2 initiator_type=FC wwn=21000024ff369d91
add host initiator host_id=2 initiator_type=FC wwn=2100f4e9d453385a
add host initiator host_id=2 initiator_type=FC wwn=2100f4e9d453385b
add host initiator host_id=2 initiator_type=FC wwn=2100f4e9d4533746
add host initiator host_id=2 initiator_type=FC wwn=2100f4e9d4533747
add host initiator host_id=1 initiator_type=FC wwn=2100f4e9d45340b3
add host initiator host_id=1 initiator_type=FC wwn=21000024ff3cc4ca
add host initiator host_id=1 initiator_type=FC wwn=21000024ff3cc4cb
add host initiator host_id=1 initiator_type=FC wwn=2100f4e9d4533628
add host initiator host_id=1 initiator_type=FC wwn=2100f4e9d4533629
add host initiator host_id=1 initiator_type=FC wwn=21000024ff1bdfe2
add host initiator host_id=1 initiator_type=FC wwn=21000024ff1bdfe3
add host initiator host_id=1 initiator_type=FC wwn=2100f4e9d45340b2

create host_group name=hg0 host_group_id=0 host_id_list=1-12
create lun_group name=lg0 lun_group_id=0
add lun_group lun lun_group_id=0 lun_id_list=1-56
create mapping_view name=mv1 mapping_view_id=1 lun_group_id=0 host_group_id=0
```

Step 3 - Create Volumes on the Master Host Systems

The *mkvolume.sh* shell script, listed below, is invoked on the master Host Systems to perform the following actions:

- Create 56 physical volumes
- Create a volume group for the 56 physical volumes
- Create 18 Logical Volumes for ASU-1
- Create 18 Logical Volumes for ASU-2
- Create 2 Logical Volumes for ASU-3

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

mkvolume.sh

```
pvcreate /dev/sdb
pvcreate /dev/sdc
pvcreate /dev/sdd
pvcreate /dev/sde
pvcreate /dev/sdf
pvcreate /dev/sg
pvcreate /dev/sgd
pvcreate /dev/sdh
pvcreate /dev/sdi
pvcreate /dev/sdj
pvcreate /dev/sdk
pvcreate /dev/sdl
pvcreate /dev/sdm
pvcreate /dev/sdn
pvcreate /dev/sdo
pvcreate /dev/sdp
pvcreate /dev/sdq
pvcreate /dev/sdr
pvcreate /dev/sds
pvcreate /dev/sdt
pvcreate /dev/sdu
pvcreate /dev/sdv
```

```
pvcreeate /dev/sdw  
pvcreeate /dev/sdx  
pvcreeate /dev/sdy  
pvcreeate /dev/sdz  
pvcreeate /dev/sdaa  
pvcreeate /dev/sdab  
pvcreeate /dev/sdac  
pvcreeate /dev/sdad  
pvcreeate /dev/sdae  
pvcreeate /dev/sdaf  
pvcreeate /dev/sdag  
pvcreeate /dev/sdah  
pvcreeate /dev/sdai  
pvcreeate /dev/sdaj  
pvcreeate /dev/sdak  
pvcreeate /dev/sdal  
pvcreeate /dev/sdam  
pvcreeate /dev/sdan  
pvcreeate /dev/sdao  
pvcreeate /dev/sdap  
pvcreeate /dev/sdaq  
pvcreeate /dev/sdar  
pvcreeate /dev/sdas  
pvcreeate /dev/sdat  
pvcreeate /dev/sdau  
pvcreeate /dev/sdav  
pvcreeate /dev/sdaw  
pvcreeate /dev/sdax  
pvcreeate /dev/sday  
pvcreeate /dev/sdaz  
pvcreeate /dev/sdba  
pvcreeate /dev/sdbb  
pvcreeate /dev/sdbc  
pvcreeate /dev/sdbd  
pvcreeate /dev/sdbe
```

```
vgcreate vg1 /dev/sdb /dev/sdc /dev/sdd /dev/sde /dev/sdf /dev/sdg /dev/sdh  
/dev/sdi /dev/sdj /dev/sdk /dev/sdl /dev/sdm /dev/sdn /dev/sdo /dev/sdp  
/dev/sdq /dev/sdr /dev/sds /dev/sdt /dev/sdu /dev/sdv /dev/sdw /dev/sdx  
/dev/sdy /dev/sdz /dev/sdaa /dev/sdab /dev/sdac /dev/sdad /dev/sdae /dev/sdaf  
/dev/sdag /dev/sdah /dev/sdai /dev/sdaj /dev/sdak /dev/sdal /dev/sdam  
/dev/sdan /dev/sdao /dev/sdap /dev/sdaq /dev/sdar /dev/sdas /dev/sdat  
/dev/sdau /dev/sdav /dev/sdaw /dev/sdax /dev/sday /dev/sdaz /dev/sdba  
/dev/sdbb /dev/sdbc /dev/sdbd /dev/sdbe
```

```
lvcreate -n asu101 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu102 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu103 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu104 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu105 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu106 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu107 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu108 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu109 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu110 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu111 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu112 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu113 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu114 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu115 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu116 -i 56 -I 512 -C y -L 1431.08g vg1  
lvcreate -n asu117 -i 56 -I 512 -C y -L 1431.08g vg1
```

```
lvcreate -n asu118 -i 56 -I 512 -C y -L 1431.08g vg1

lvcreate -n asu201 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu202 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu203 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu204 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu205 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu206 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu207 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu208 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu209 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu210 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu211 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu212 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu213 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu214 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu215 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu216 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu217 -i 56 -I 512 -C y -L 1431.08g vg1
lvcreate -n asu218 -i 56 -I 512 -C y -L 1431.08g vg1

lvcreate -n asu301 -i 56 -I 512 -C y -L 2862.16g vg1
lvcreate -n asu302 -i 56 -I 512 -C y -L 2862.16g vg1
```

APPENDIX E: CONFIGURATION INVENTORY

An inventory of the Tested Storage Configuration was collected during the execution the script *full_run.sh*. It generated the following log file:

- ***profile1_volume.log*** List of configured volumes before the INIT Phase.
- ***profile1_storage.log*** List of configured storage before the INIT Phase.
- ***Profile2_volume.log*** List of configured volumes after TSC restart.
- ***Profile2_storage.log*** List of configured storage after TSC restart.

The above log files are included in the Supporting Files (see Appendix A).

APPENDIX F: WORKLOAD GENERATOR

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

The phases of the benchmark are executed using the script ***full_run.sh***. The script pauses at the end of the PERSIST_1 test phase. Once the TSC has been restarted, the PERSIST_2 test phase is executed by pressing ENTER from the console where the script has been invoked.

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

slave_asu.asu

```
ASU=1
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu101
DEVICE=/dev/vg1/asu102
DEVICE=/dev/vg1/asu103
DEVICE=/dev/vg1/asu104
DEVICE=/dev/vg1/asu105
DEVICE=/dev/vg1/asu106
DEVICE=/dev/vg1/asu107
DEVICE=/dev/vg1/asu108
DEVICE=/dev/vg1/asu109
DEVICE=/dev/vg1/asu110
DEVICE=/dev/vg1/asu111
DEVICE=/dev/vg1/asu112
DEVICE=/dev/vg1/asu113
DEVICE=/dev/vg1/asu114
DEVICE=/dev/vg1/asu115
DEVICE=/dev/vg1/asu116
DEVICE=/dev/vg1/asu117
DEVICE=/dev/vg1/asu118

--
ASU=2
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu201
DEVICE=/dev/vg1/asu202
DEVICE=/dev/vg1/asu203
DEVICE=/dev/vg1/asu204
DEVICE=/dev/vg1/asu205
DEVICE=/dev/vg1/asu206
DEVICE=/dev/vg1/asu207
DEVICE=/dev/vg1/asu208
DEVICE=/dev/vg1/asu209
DEVICE=/dev/vg1/asu210
DEVICE=/dev/vg1/asu211
DEVICE=/dev/vg1/asu212
DEVICE=/dev/vg1/asu213
DEVICE=/dev/vg1/asu214
DEVICE=/dev/vg1/asu215
DEVICE=/dev/vg1/asu216
DEVICE=/dev/vg1/asu217
```

```
DEVICE=/dev/vg1/asu218  
  
--  
ASU=3  
OFFSET=0  
SIZE=0  
DEVICE=/dev/vg1/asu301  
DEVICE=/dev/vg1/asu302
```

full_run.sh

```
#!/bin/sh  
expect shstorage.tcl > profile1_storage.log  
  
date > profile1_volume.log  
lvdisplay >> profile1_volume.log  
date >> profile1_volume.log  
  
/root/SPCv302_2017504/spc1 -run SPC1_INIT -iops 6000 -storage slave_asu.asu -  
output ./newtool/spc1_INIT_6000_iops -master 11host.HST  
sleep 600  
/root/SPCv302_2017504/spc1 -run SPC1_VERIFY -iops 1000 -storage slave_asu.asu -  
output ./newtool/spc1_VERIFY1_1000_iops -master 11host.HST  
/root/SPCv302_2017504/spc1 -run SPC1_METRICS -iops 2700100 -storage slave_asu.asu  
-output ./newtool/spc1_METRICS_2700100_iops -master 11host.HST  
/root/SPCv302_2017504/spc1 -run SPC1_VERIFY -iops 1000 -storage slave_asu.asu -  
output ./newtool/spc1_VERIFY2_1000_iops -master 11host.HST  
/root/SPCv302_2017504/spc1 -run SPC1_PERSIST_1 -iops 675025 -storage  
slave_asu.asu -output ./newtool/spc1_PERSIST_675025_iops -master 11host.HST  
echo "Power cycle TSC, then Enter to continue"  
read  
  
expect shstorage.tcl > profile2_storage.log  
  
date > profile2_volume.log  
lvdisplay >> profile2_volume.log  
date >> profile2_volume.log  
/root/SPCv302_2017504/spc1 -run SPC1_PERSIST_2 -iops 675025 -storage  
slave_asu.asu -output ./newtool/spc1_PERSIST_675025_iops -master 11host.HST
```