SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

FUJITSU LIMITED
ETERNUS DX8900 S4

SPC-1 V3.8

SUBMISSION IDENTIFIER: A32009

SUBMITTED FOR REVIEW: MARCH 23, 2019

First Edition – March 2019

Trademarks

Benchmark Specification and Glossary

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

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

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AUDIT CERTIFICATION

InfoSizing
The Right Metric For Sizing IT

Storage Performance Council

Mr. Kun Katsumata
Fujitsu Limited
1250 East Arques Ave.
PO box 3470
Sunnyvale, CA 94088-3470

March 22, 2019

I verified the SPC Benchmark 1™ (SPC-1™ V3.8) test execution and performance results of the following Tested Storage Product:

ETERNUS DX8900 S4

The results were:

SPC-1 IOPS™	**10,001,522**
SPC-1 Price-Performance™	**$644.16/SPC-1 KIOPS™**
SPC-1 IOPS™ Response Time	0.418 ms
SPC-1 Overall Response Time	0.249 ms
SPC-1 ASU Capacity	90,452 GB
SPC-1 ASU Price	$71.23/GB
SPC-1 Total System Price	$6,442,522.88

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 v3.0.2-1-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 A32009.

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

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 each 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 in accordance with the SPC Policies:

> The Tested Storage Configuration (TSC) used eight sparsely populated racks to hold the DX8900 S4 components. The Priced Storage Configuration consolidates the DX8900 S4 components into two racks. If the TSC had been configured with just two racks, there would not have been a difference in the reported SPC-1 performance.

Respectfully Yours,

Doug Johnson, Certified SPC Auditor

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

LETTER OF GOOD FAITH

FUJITSU

Kanagawa-ken,Kawasaki-shi,Nakahara-ku,Kamikodanaka,4-1-1,JAPAN211-8588
Phone: 044-754-3423

March 8, 2019
From: Yoshinori Terao, Fujitsu Limited

To:Doug Johnson, SPC Auditor
PerfLabs, Inc. DBA InfoSizing
63 Lourdes Drive
Leominster, MA 01453-6709 USA

Contact Information: Kun Katsumata
Fujitsu America, Inc.
1250 East Arques Ave. PO Box 3470
Sunnyvale, CA 94088, U.S.A.

Subject: SPC-1 Letter of Good Faith for the FUJITSU Storage ETERNUS DX8900 S4

Fujitsu Limited 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: Date:

Yoshinori Terao March 8, 2019

Yoshinori Terao
Vice President, System Development Div.

SPC BENCHMARK 1™

EXECUTIVE SUMMARY

FUJITSU LIMITED
ETERNUS DX8900 S4

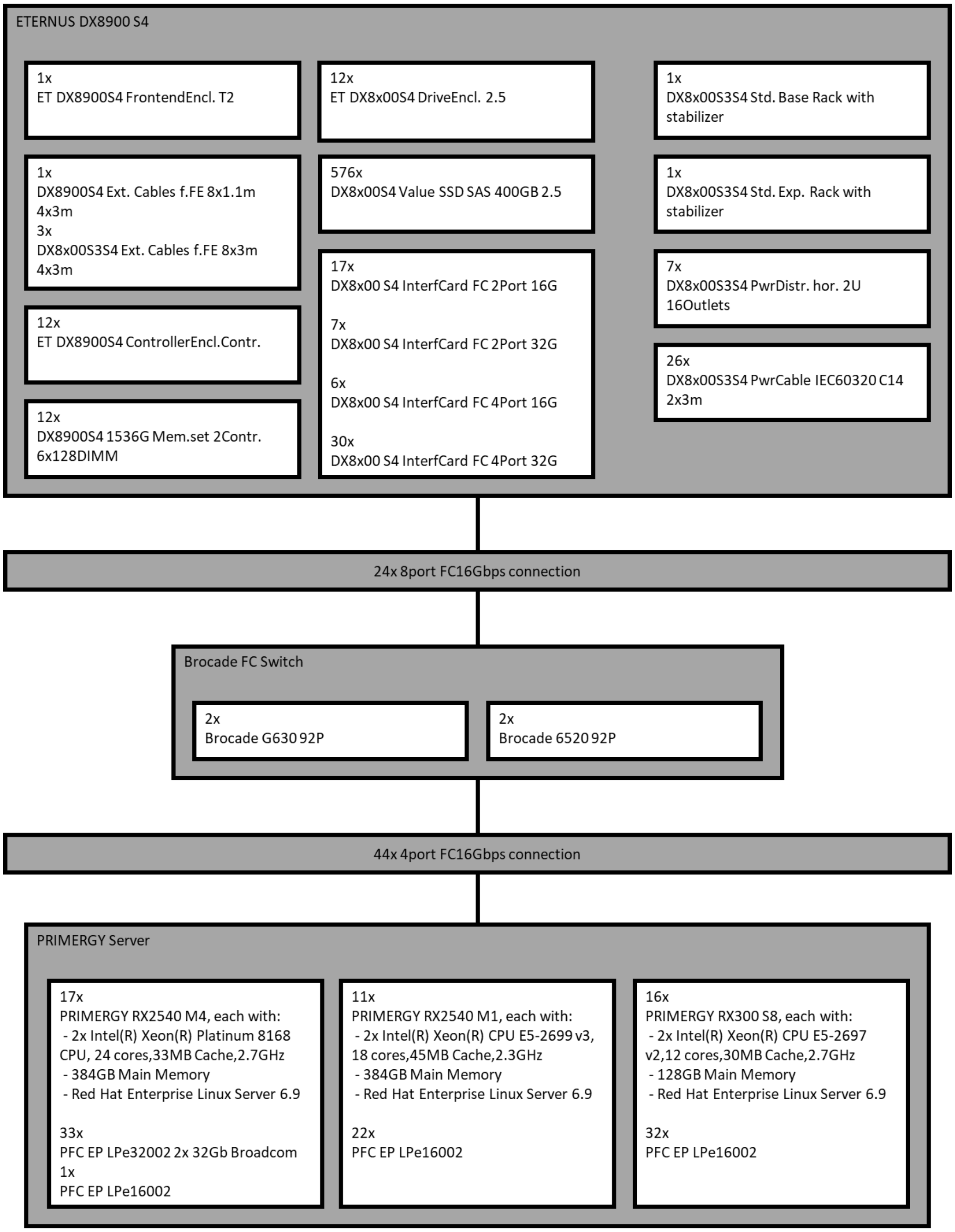
SPC-1 IOPS™	**10,001,522**
SPC-1 Price-Performance™	**$644.16/SPC-1 KIOPS™**
SPC-1 IOPS™ Response Time	0.418 ms
SPC-1 Overall Response Time	0.249 ms
SPC-1 ASU Capacity	90,452 GB
SPC-1 Space Effectiveness Ratio	NA
SPC-1 ASU Price	$71.23/GB
SPC-1 Total System Price	$6,442,522.88
Data Protection Level	Protected 2 (RAID1)
Physical Storage Capacity	230,400 GB
Pricing Currency / Target Country	U.S. Dollars / USA

SPC-1 V3.8

SUBMISSION IDENTIFIER: A32009

SUBMITTED FOR REVIEW: MARCH 23, 2019

Benchmark Configuration Diagram



Tested Storage Product Description

FUJITSU Storage ETERNUS DX8900 S4 is the perfect platform to consolidate storage in data centers by providing leading performance headroom, business continuity and automated operation capabilities. It facilities the transition to full flash-configurations and allows the efficient management of flexible data service levels in terms of capacity, speed and costs.

For more details, visit:

http://www.fujitsu.com/global/products/computing/storage/disk/eternus-dx/dx8900/

Priced Storage Configuration Components

2x Emulex LPe16002 dual port 16Gb Fiber Channel HBAs per Host System **(used in PRIMERGY RX2540 M1, PRIMERGY RX300 S8)** **2x Emulex LPe32002 dual port 32Gb Fiber Channel HBAs per Host System** **(used in 16 of the PRIMERGY RX2540 M4)** **1x Emulex LPe16002 dual port 16Gb Fiber Channel HBA** **1x Emulex LPe32002 dual port 32Gb Fiber Channel HBA** **(used in 1 of the PRIMERGY RX2540 M4)** **All LPe16002s and LPe32002s were connected at a link speed of 16Gbps (176 ports total)**
1x DS8900 S4, with: **12x Controller Module Enclosures– 2.5'' – 2RU, each with:** **24x 400GB SSD Storage Devices** **2x Control Modules (CM), each with:** **768 GB cache (1,536 GB total)** **2x Channel Adapters (CA) with 4x 16Gbps or 32Gbps host ports** **Or** **4x Channel Adapters (CA) with 2x 16Gbps or 32Gbps host ports** **All CMs have 8 ports linked at 16 Gbps (192 ports total)** **12x Drive Enclosures, each with:** **24x 400GB SSD Storage Devices** **(576 SSDs total)**
2x Brocade G630 Fiber Channel Switches, each with: **96 FC ports of which 92 ports are populated with 16Gbps SFP** **2x Brocade 6520 Fiber Channel Switches, each with:** **96 FC ports of which 92 ports are populated with 16Gbps SFP** **(368 16Gbps ports total)**

Storage Configuration Pricing

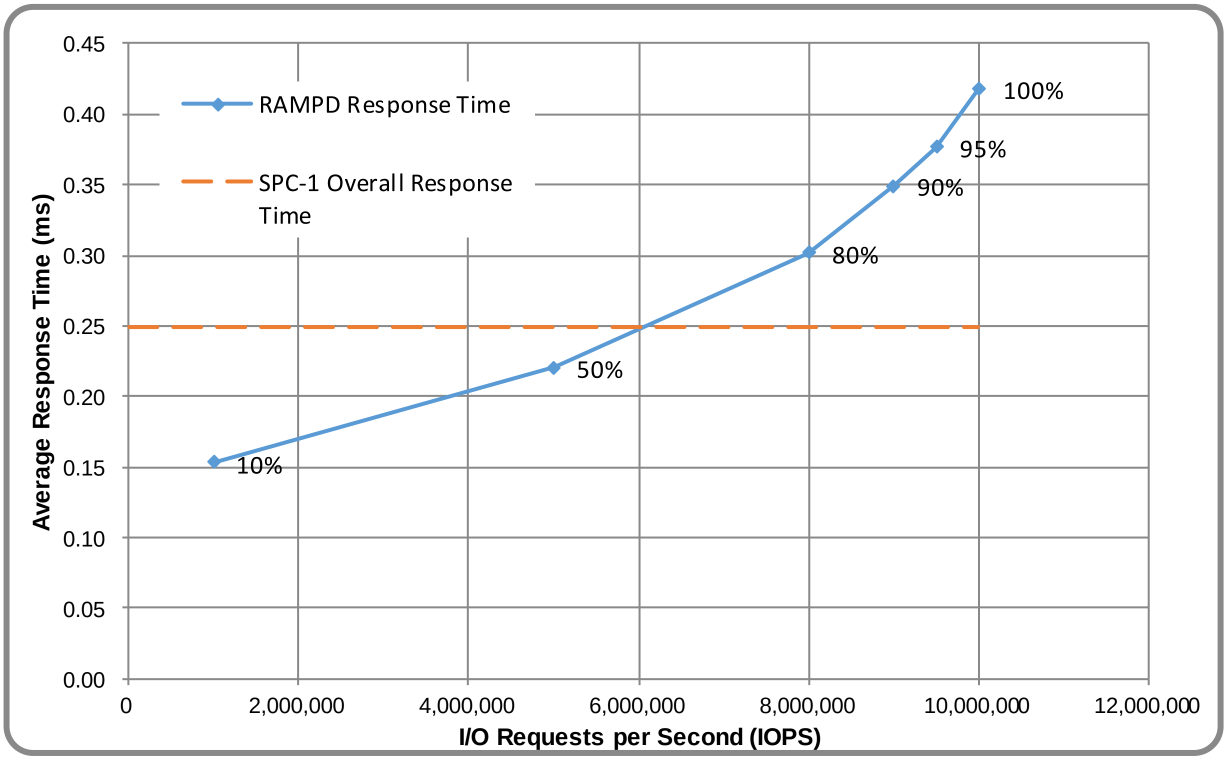
Part No.	Description	Source	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
Hardware & Software							
ET894SBU	ET DX8900S4 FrontendEncl. T2	1	1	169,850.00	169,850.00	75%	42,462.50
ETTCAU	ET DX8900S4 ControllerEncl. Contr. x2	1	12	196,800.00	2,361,600.00	75%	590,400.00
ETTEADU	ET DX8x00S4 DriveEncl. 2.5 x1	1	12	9,320.00	111,840.00	75%	27,960.00
ETSKC30U	DX8x00S3S4 PwrCable IEC60320 C14 2x3m	1	26	300.00	7,800.00	75%	1,950.00
ETTHFCA	DX8x00 S4 InterfCard FC 2Port 16G x1	1	17	5,430.00	92,310.00	75%	23,077.50
ETTHFDA	DX8x00 S4 InterfCard FC 2Port 32G x1	1	7	14,150.00	99,050.00	75%	24,762.50
ETTHFCB	DX8x00 S4 InterfCard FC 4Port 16G x1	1	6	10,790.00	64,740.00	75%	16,185.00
ETTHFDB	DX8x00 S4 InterfCard FC 4Port 32G x1	1	30	28,190.00	845,700.00	75%	211,425.00
ETTMB15	DX8900S4 1536G Mem.set 2Contr. 6x128DIM	1	12	538,320.00	6,459,840.00	75%	1,614,960.00
ETTSA4N	DX8x00S4 Value SSD SAS 400GB 2.5 x1	1	576	15,860.00	9,135,360.00	75%	2,283,840.00
ETSRASU	DX8x00S3S4 Std. Base Rack with stabi.	1	1	25,840.00	25,840.00	75%	6,460.00
ETSRBSU	DX8x00S3S4 Std. Exp. Rack with stabi.	1	1	15,040.00	15,040.00	75%	3,760.00
ETSPDJU	DX8x00S3S4 PwrDistr. hor. 2U 16Outlets	1	7	5,080.00	35,560.00	75%	8,890.00
ETTKA11	DX8900S4 Ext. Cables f.FE 8x1.1m 4x3m	1	1	5,780.00	5,780.00	75%	1,445.00
ETSKA30	DX8x00S3S4 Ext. Cables f.FE 8x3m 4x3m	1	3	6,020.00	18,060.00	75%	4,515.00
ETSKA1X	DX8x00S3S4Ext. Cables f.FE 8x10m 4x10m	1	8	27,600.00	220,800.00	75%	55,200.00
BR-G630-48-R-M	Brocade G630, 48x PoD, w/o SFP+ modules	1	2	125,157.54	250,315.08	72%	70,088.23
XBR-MENT24PTPOD-	S/W, POD license, 24-port, 24 x 32G SWL SFP+	1	4	56,190.38	224,761.54	72%	62,933.24
BR-6520-48-16G-R-M	Brocade 6520, 48x PoD, with 48x SFP+ modules	1	2	106,154.00	212,308.00	72%	59,446.24
XBR-ENTPOD-16G	24 Port on Demand for 6520, with 24x SFP+ modules	1	4	43,142.31	172,569.23	72%	48,319.39
XBR-000193	16Gb/s SFP+ modules, 8-pack for G630	1	24	7,885.00	189,240.00	72%	52,987.20
CBL-MLLC10	FC cable MMF 10 m, Connector LC-LC, OM2	1	368	120.00	44,160.00	76%	10,598.40
S26361-F4044-L502	PFC EP LPe32002 2x 32Gb Broadcom	1	33	4,895.00	161,535.00	76%	38,768.40
S26361-F4994-L502	PFC EP LPe16002	1	55	2,815.00	154,825.00	76%	37,158.00
						Hardware & Software Subtotal	5,297,591.60
Support & Maintenance							
ET8900-W004360-AAN	ETERNUS DX8900 S4 Warranty Uplift, 36 Months, Enhanced Plus Level, 24x7 4hr Onsite, Prepaid billing	1	1	3,535,477.59	3,535,477.59	70%	1,060,643.28
G630-SVS-P4OS-3	PREMIER 4HR ONSITE SUPPORT, G630 Switch	1	2	25,286.00	50,572.00	0%	50,572.00
6520-SVS-P4OS-3	PREMIER 4HR ONSITE SUPPORT, BR-6520-48-16G, BR-6520-96-16, BR-6520-48-8G	1	2	16,858.00	33,716.00	0%	33,716.00
						Support & Maintenance Subtotal	1,144,931.28
SPC-1 Total System Price							6,442,522.88
SPC-1 IOPS™							10,001,522
SPC-1 Price-Performance™ ($/SPC-1 KIOPS™)							644.16
SPC-1 ASU Capacity (GB)							90,452
SPC-1 ASU Price ($/GB)							71.23

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

Warranty: The 3-year maintenance and support included in the above pricing meets or exceeds a 24x7 coverage with a 4-hour response time.

Availability Date: Currently available.

Response Time and Throughput Graph



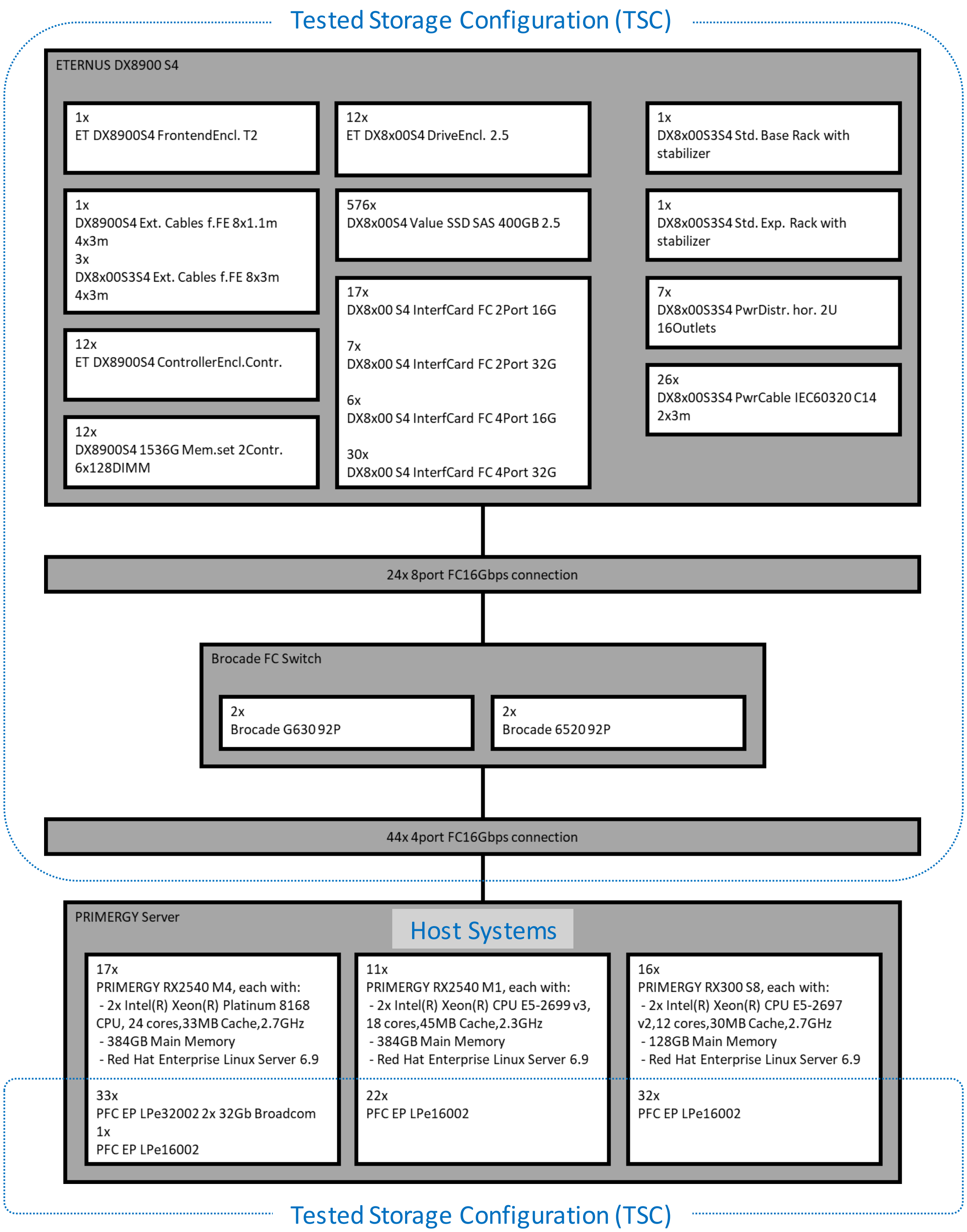
Contact Information	
Test Sponsor Primary Contact	Fujitsu Limited – http://www.fujitsu.com/services/computing/storage/ Kun Katsumata – kkatsumata@us.fujitsu.com
SPC Auditor	InfoSizing – www.sizing.com Doug Johnson – doug@sizing.com

Revision Information	
SPC Benchmark 1™ Revision	V3.8
SPC-1 Workload Generator Revision	v3.0.2-1-g823a
Publication Revision History	Initial Publication

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 Benchmark Configuration utilized 44 PRIMERGY servers as hosts systems to drive the Tested Storage Configuration. Each host system had four 16Gbps Fiber Channel connections; one connection to each of the four Brocade Fiber Channel switches. Each Brocade switch had two 16Gbps connections to each of the 24 Control Modules in the DX8900 S4. Additionally, each Control Module was connected to the other Control Modules via the Frontend enclosure in the DX 8900 S4.

Host System and Tested Storage Configuration Components

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

Host Systems

16x Fujitsu PRIMERGY RX2540 M4, each with :
    2x Intel® Xeon® Platinum 8168 CPU (2.7GHz, 24 Cores, 33MB Cache)
    384GB Main Memory
    Red Hat Enterprise Linux Server 6.9
    2x PFC EP LPe32002 2x 32Gb Broadcom
1x Fujitsu PRIMERGY RX2540 M4, with :
    2x Intel® Xeon® Platinum 8168 CPU (2.7GHz, 24 Cores, 33MB Cache)
    384GB Main Memory
    Red Hat Enterprise Linux Server 6.9
    1x PFC EP LPe32002 2x 32Gb Broadcom
    1x PFC EP LPe16002
11x Fujitsu PRIMERGY RX2540 M1, each with :
    2x Intel® Xeon® E5-2699 v3 CPU (2.3GHz, 18 Cores, 45MB Cache)
    384GB Main Memory
    Red Hat Enterprise Linux Server 6.9
    2x PFC EP LPe16002
16x Fujitsu PRIMERGY RX300 S8, each with :
    2x Intel® Xeon® E5-2697 v2 CPU (2.7GHz, 12 Cores, 30MB Cache)
    128GB Main Memory
    Red Hat Enterprise Linux Server 6.9
    2x PFC EP LPe16002

Tested Storage Configuration

2x Emulex LPe16002 dual port 16Gb Fiber Channel HBAs per Host System
    (used in PRIMERGY RX2540 M1, PRIMERGY RX300 S8)
2x Emulex LPe32002 dual port 32Gb Fiber Channel HBAs per Host System
    (used in 16 of the PRIMERGY RX2540 M4)
1x Emulex LPe16002 dual port 16Gb Fiber Channel HBA
1x Emulex LPe32002 dual port 32Gb Fiber Channel HBA
    (used in 1 of the PRIMERGY RX2540 M4)
All LPe16002s and LPe32002s were connected at a link speed of 16Gbps (176 ports total)

1x DS8900 S4, with:
    12x Controller Module Enclosures– 2.5'' – 2RU, each with:
        24x 400GB SSD Storage Devices
        2x Control Modules (CM), each with:
            768 GB cache (1,536 GB total)
            2x Channel Adapters (CA) with 4x 16Gbps or 32Gbps host ports
                Or
            4x Channel Adapters (CA) with 2x 16Gbps or 32Gbps host ports
        All CMs have 8 ports linked at 16 Gbps (192 ports total)
    12x Drive Enclosures, each with:
        24x 400GB SSD Storage Devices
(576 SSDs total)

2x Brocade G630 Fiber Channel Switches, each with:
    96 FC ports of which 92 ports are populated with 16Gbps SFP
2x Brocade 6520 Fiber Channel Switches, each with:
    96 FC ports of which 92 ports are populated with 16Gbps SFP
(368 16Gbps ports total)

Differences Between Tested and Priced Storage Configurations

The TSC used eight sparsely populated racks to hold the DX8900 S4 components. The PSC consolidates the DX8900 S4 components into two racks. If the TSC had been configured with just two racks, there would not have been a difference in the reported SPC-1 performance.

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 Application Storage Unit Mapping

The following table details the capacity of the Application Storage Units (ASUs) and how they are mapped to logical volumes (LVs). All capacities are reported in GB.

	LV per ASU	LV Capacity	Used per LV	Total per ASU	% ASU Capacity	Optimized*
ASU-1	36	1,130.6	1,130.6	40,703.4	45.0%	No
ASU-2	36	1,130.6	1,130.6	40,703.4	45.0%	No
ASU-3	8	1,130.6	1,130.6	9,045.2	10.0%	No
	SPC-1 ASU Capacity			90,452		

*See Space Optimization Techniques

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. All capacities are reported in GB.

Devices	Count	Physical Capacity	Total Capacity
400 GB SSD	576	400.0	230,400.0
	Total Physical Capacity		**230,400**
	Physical Capacity Utilization		**39.26%**

Data Protection

The data protection level used for all LVs was **Protected 2 (RAID1)**, which was accomplished by configuring multiple FC paths, dual controllers, dual power, dual fans, and RAID1 device protection.

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).

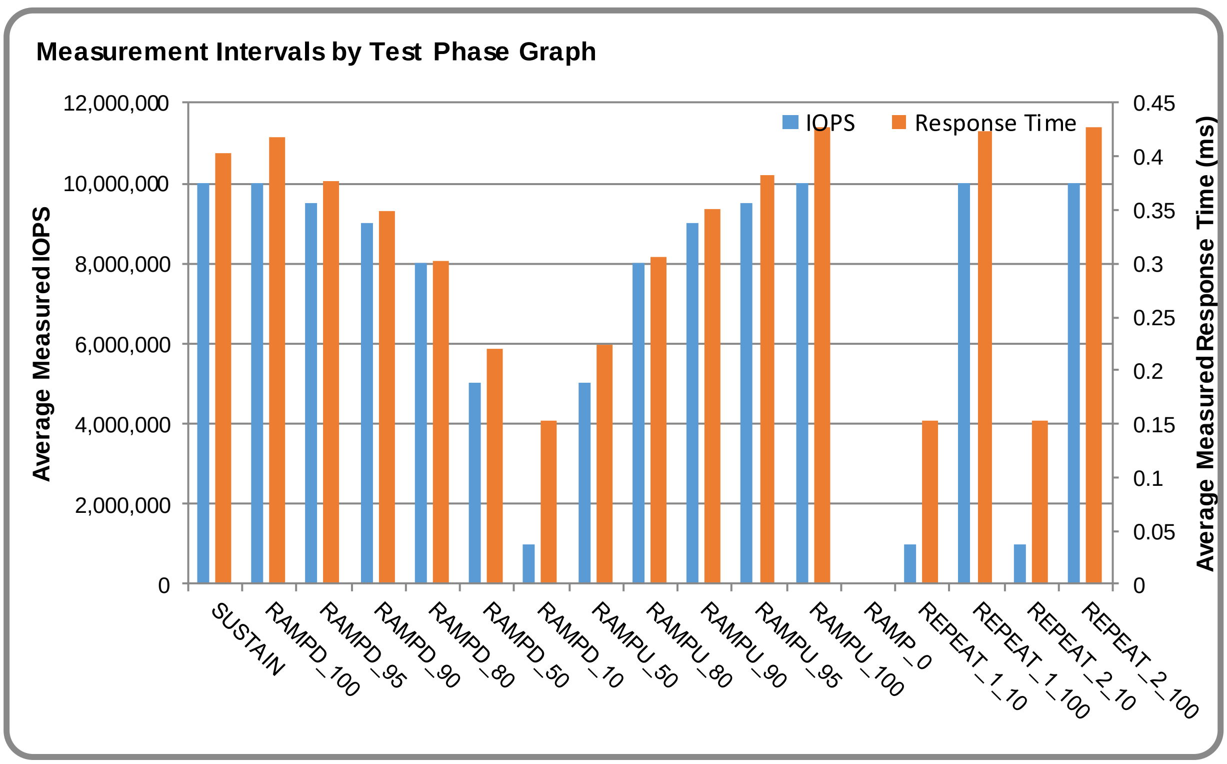
Primary Metrics Test Phases

The benchmark execution consists of the Primary Metrics Test Phases, including the Test Phases SUSTAIN, RAMPD_100 to RAMPD_10, RAMPU_50 to RAMPU_100, RAMP_0, REPEAT_1 and REPEAT_2.

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

Measurement Intervals by Test Phase Graph

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



Exception and Waiver

None.

SUSTAIN Test Phase

SUSTAIN – Results File

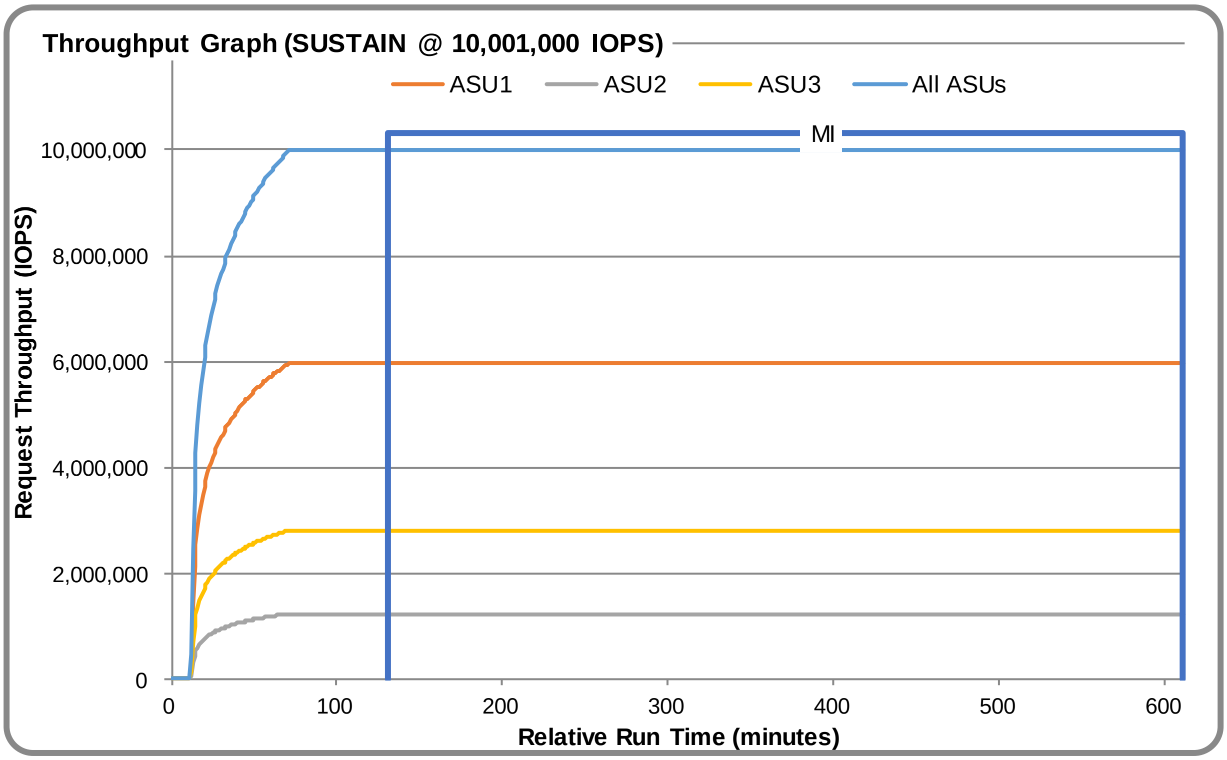
The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

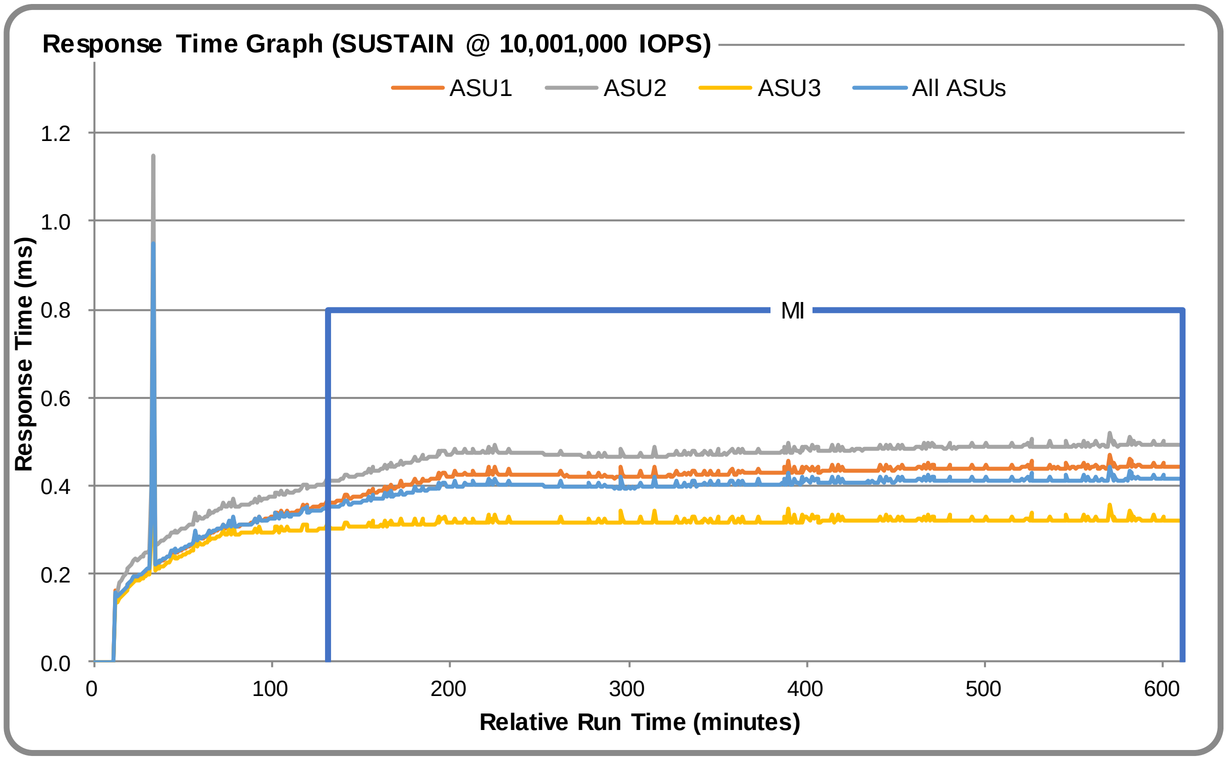
SUSTAIN – Execution Times

Interval	Start Date & Time	End Date & Time	Duration
Transition Period	05-Mar-19 14:50:49	05-Mar-19 16:50:49	2:00:00
Measurement Interval	05-Mar-19 16:50:49	06-Mar-19 00:50:50	8:00:01

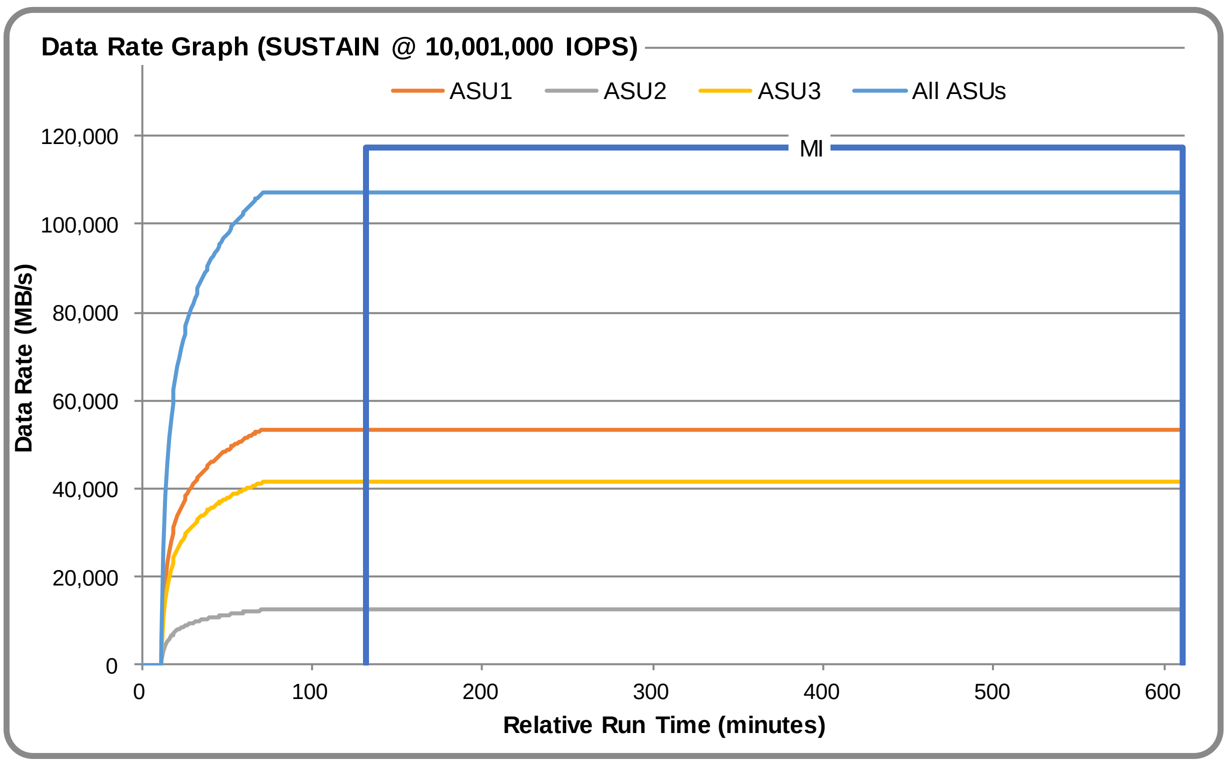
SUSTAIN – Throughput Graph



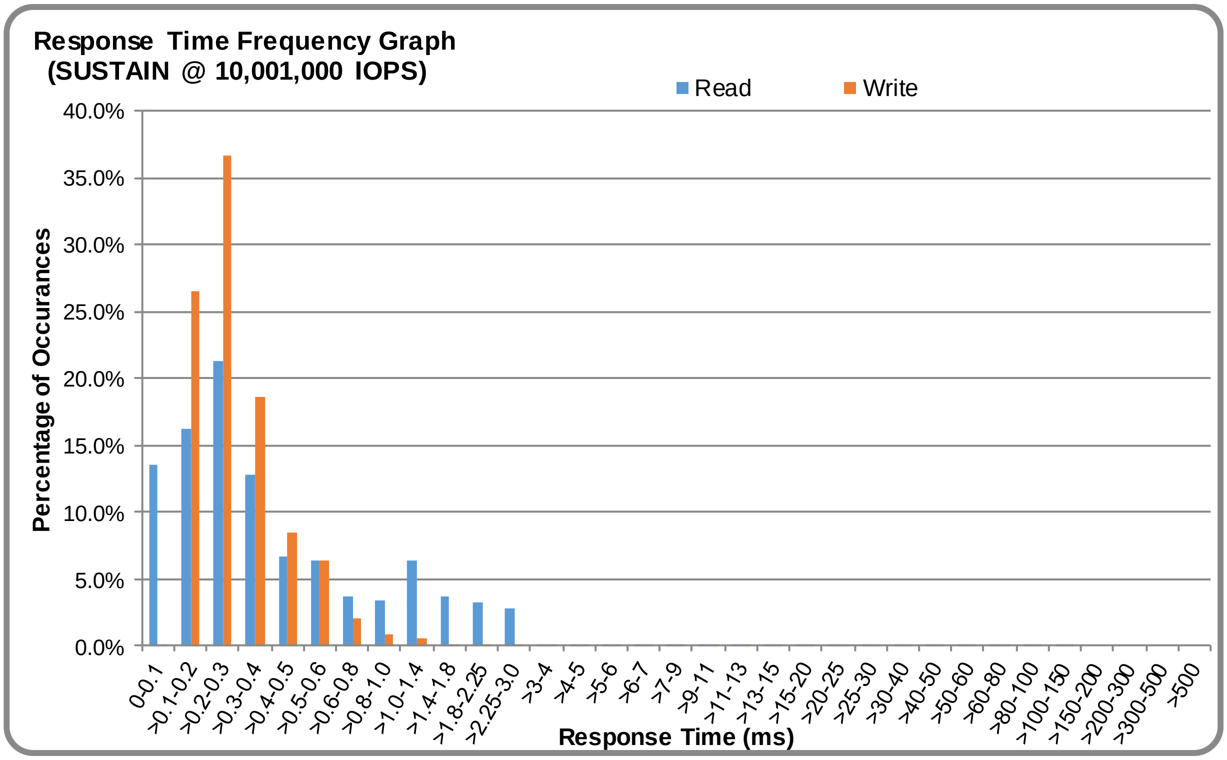
SUSTAIN – Response Time Graph



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 Defined 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	0.0002	0.0001	0.0002	0.0001	0.0003	0.0001	0.0002	0.0001
Difference	0.005%	0.002%	0.004%	0.000%	0.008%	0.004%	0.005%	0.002%

RAMPD_100 Test Phase

RAMPD_100 – Results File

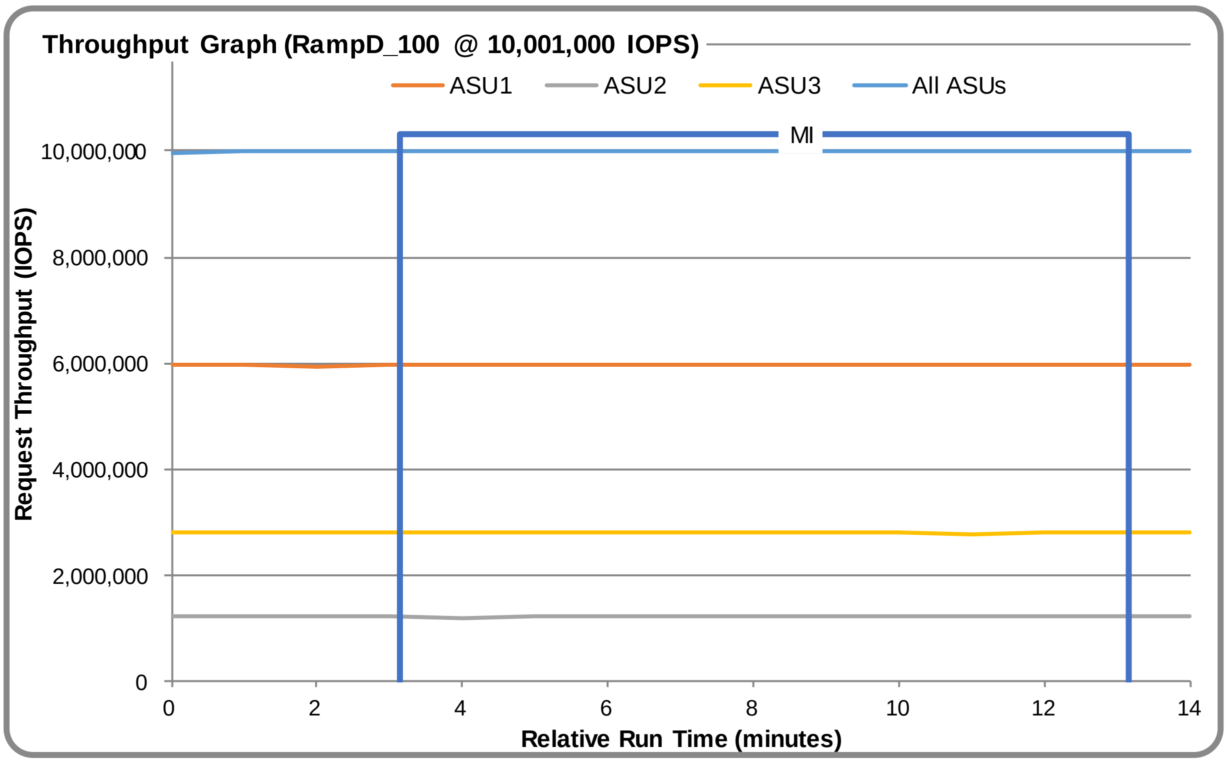
The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

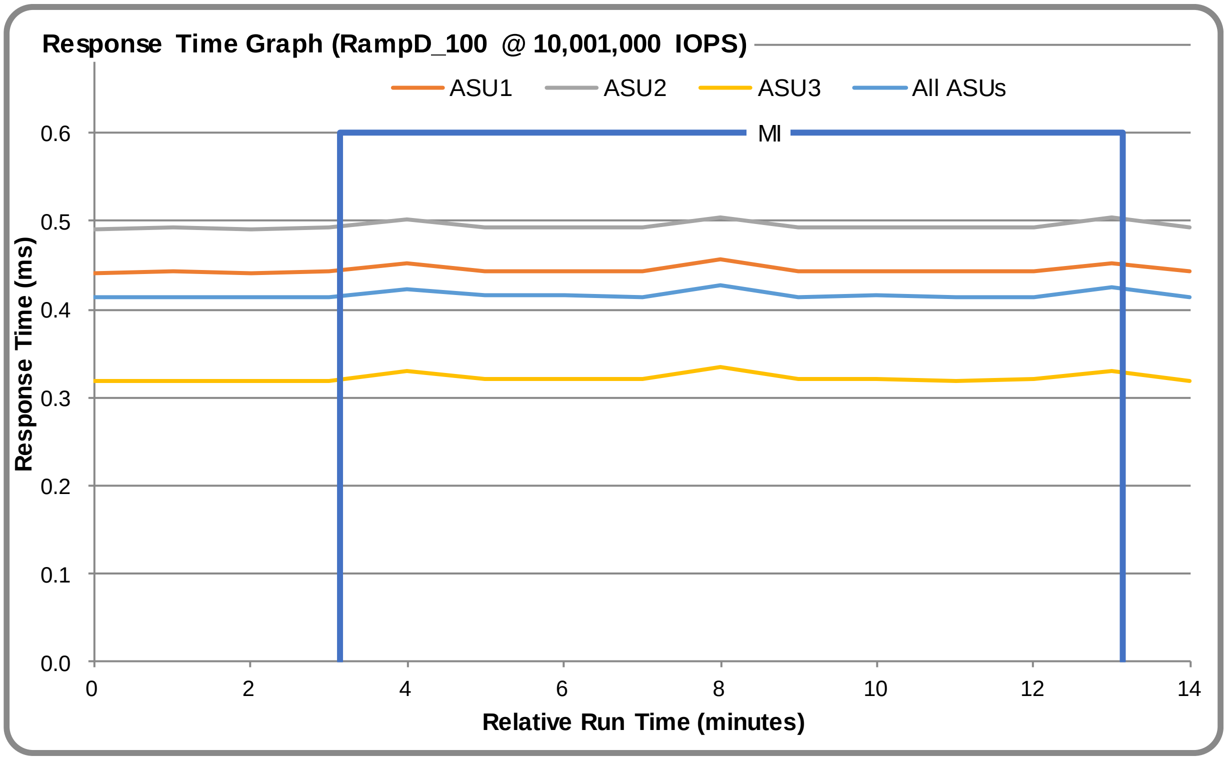
RAMPD_100 – Execution Times

Interval	Start Date & Time	End Date & Time	Duration
Transition Period	06-Mar-19 00:51:49	06-Mar-19 00:54:49	0:03:00
Measurement Interval	06-Mar-19 00:54:49	06-Mar-19 01:04:50	0:10:01

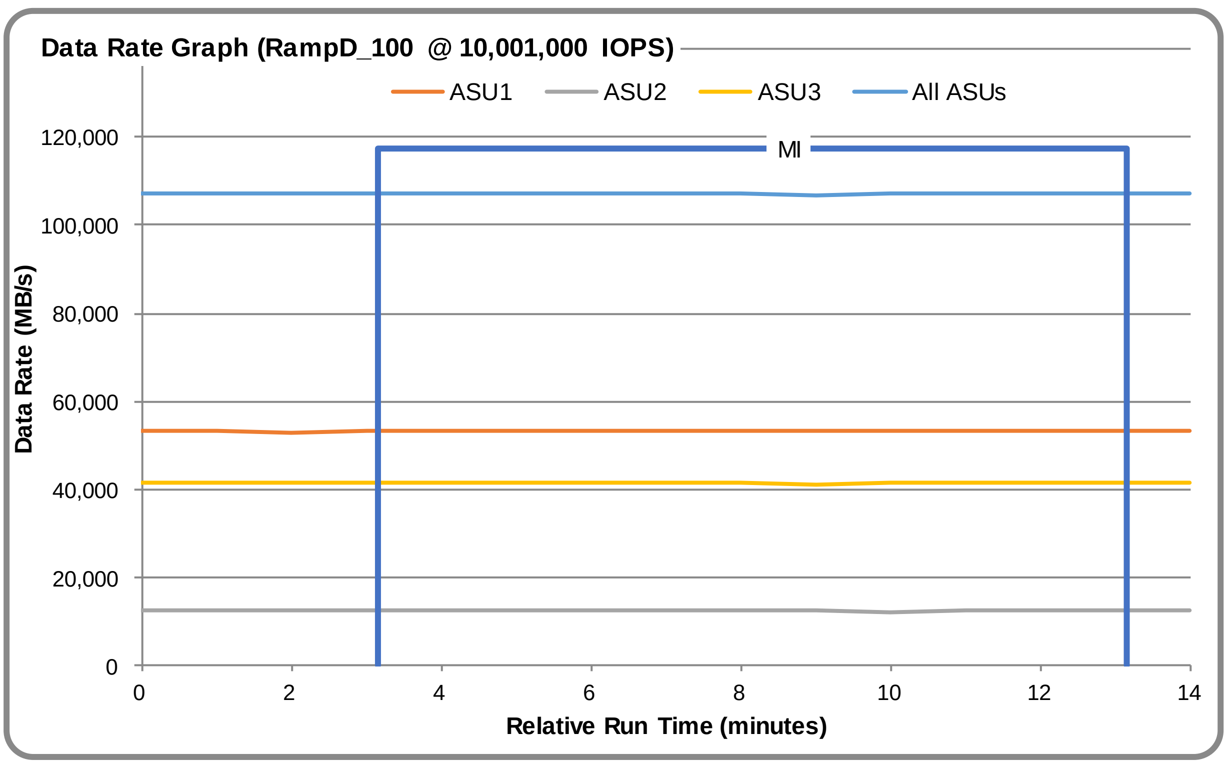
RAMPD_100 – Throughput Graph



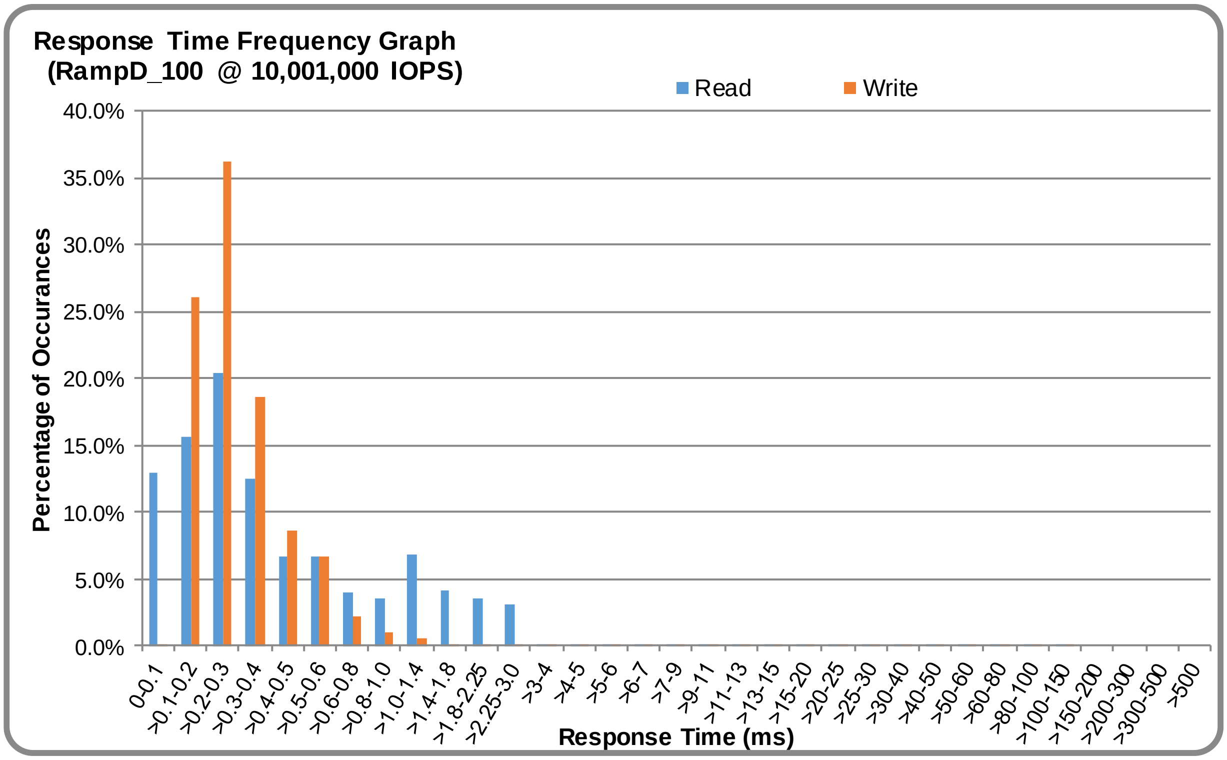
RAMPD_100 – Response Time Graph



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 Defined 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	0.0002	0.0001	0.0001	0.0001	0.0003	0.0002	0.0002	0.0001
Difference	0.012%	0.000%	0.002%	0.001%	0.006%	0.004%	0.005%	0.003%

RAMPD_100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	6,000,925,272
I/O Requests Completed with Response Time <= 30 ms	6,000,669,251
I/O Requests Completed with Response Time > 30 ms	256,021

Response Time Ramp Test

Response Time Ramp Test – Results File

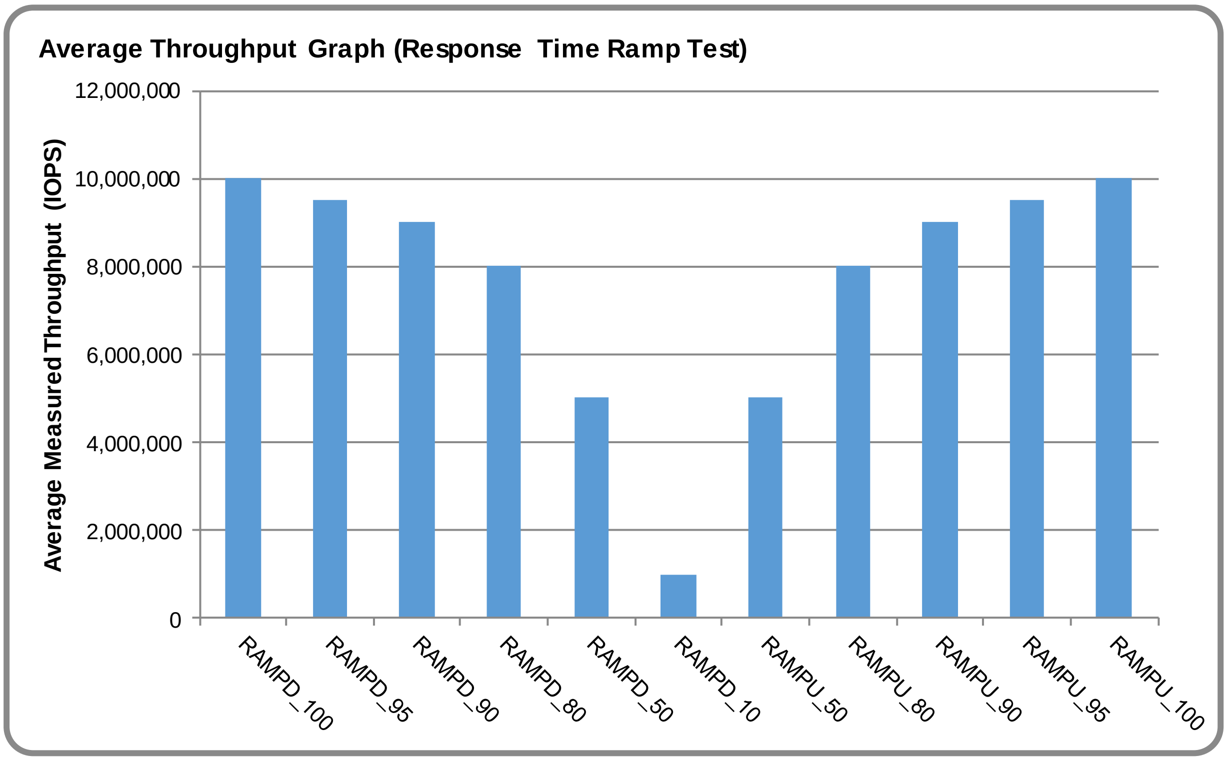
The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

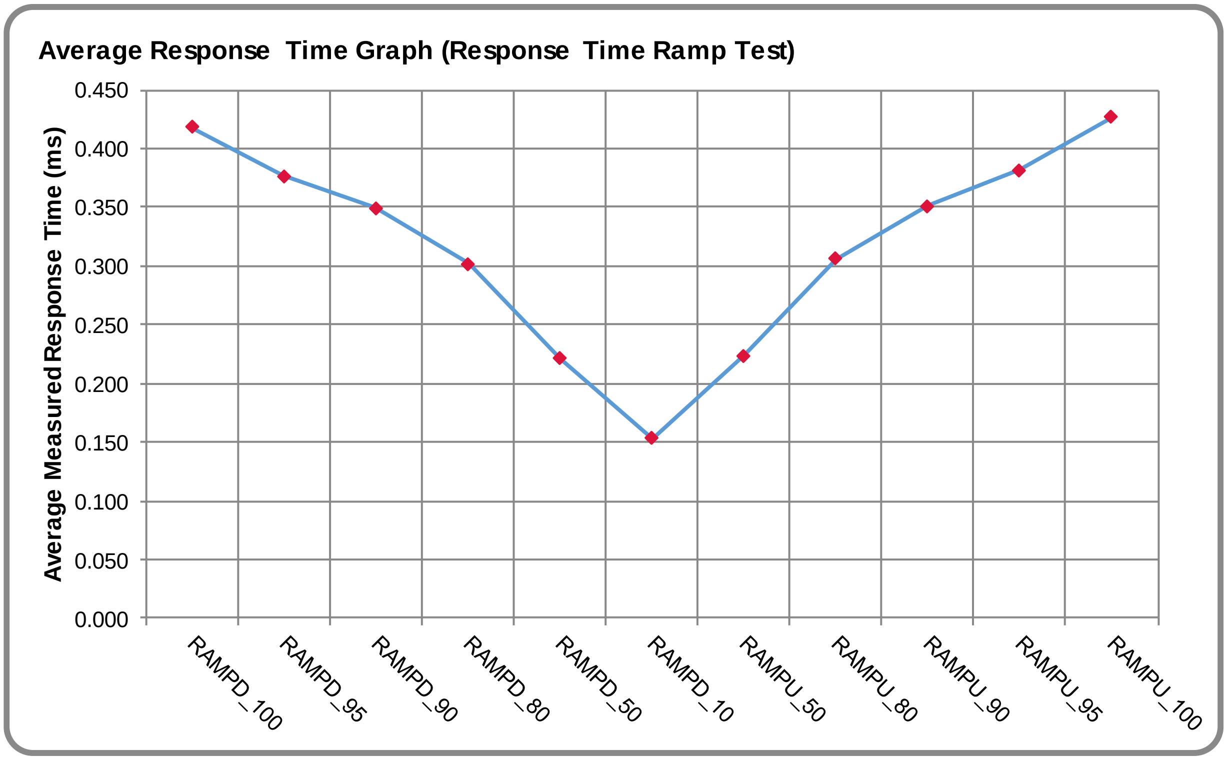
Response Time Ramp Test – Phases

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).

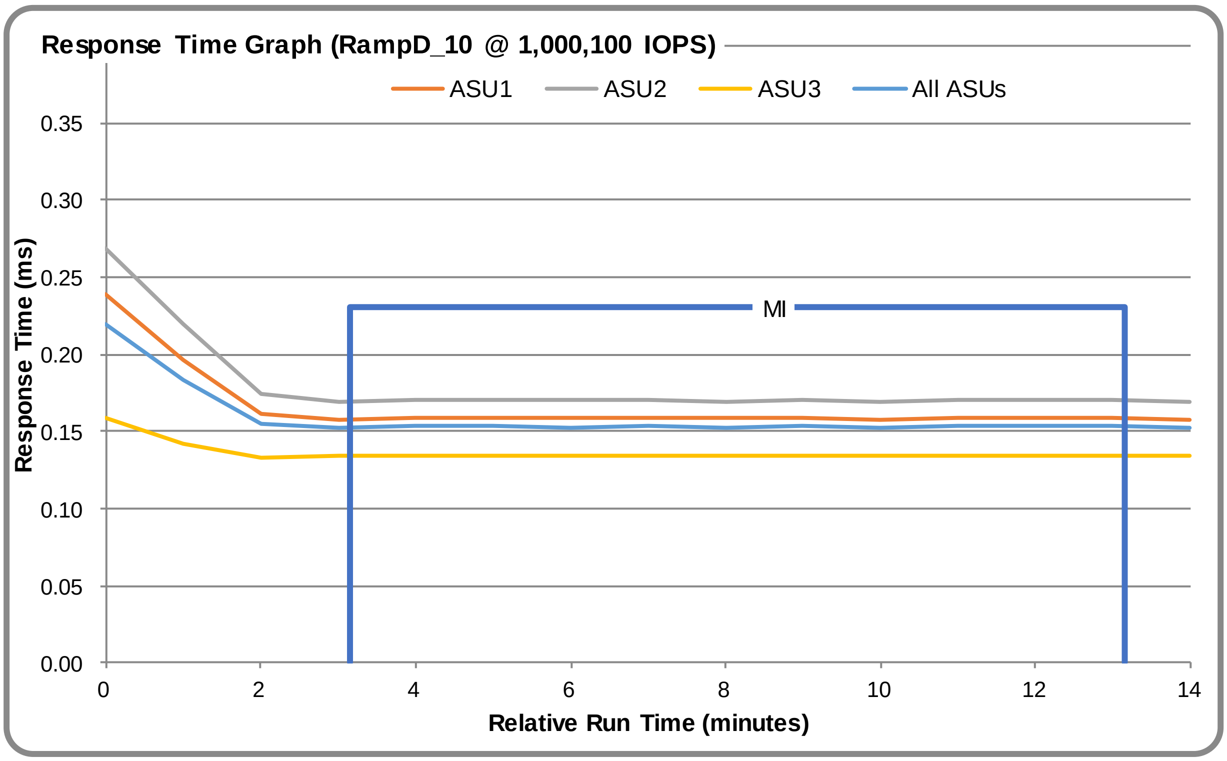
Response Time Ramp Test – Average Throughput Graph



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:

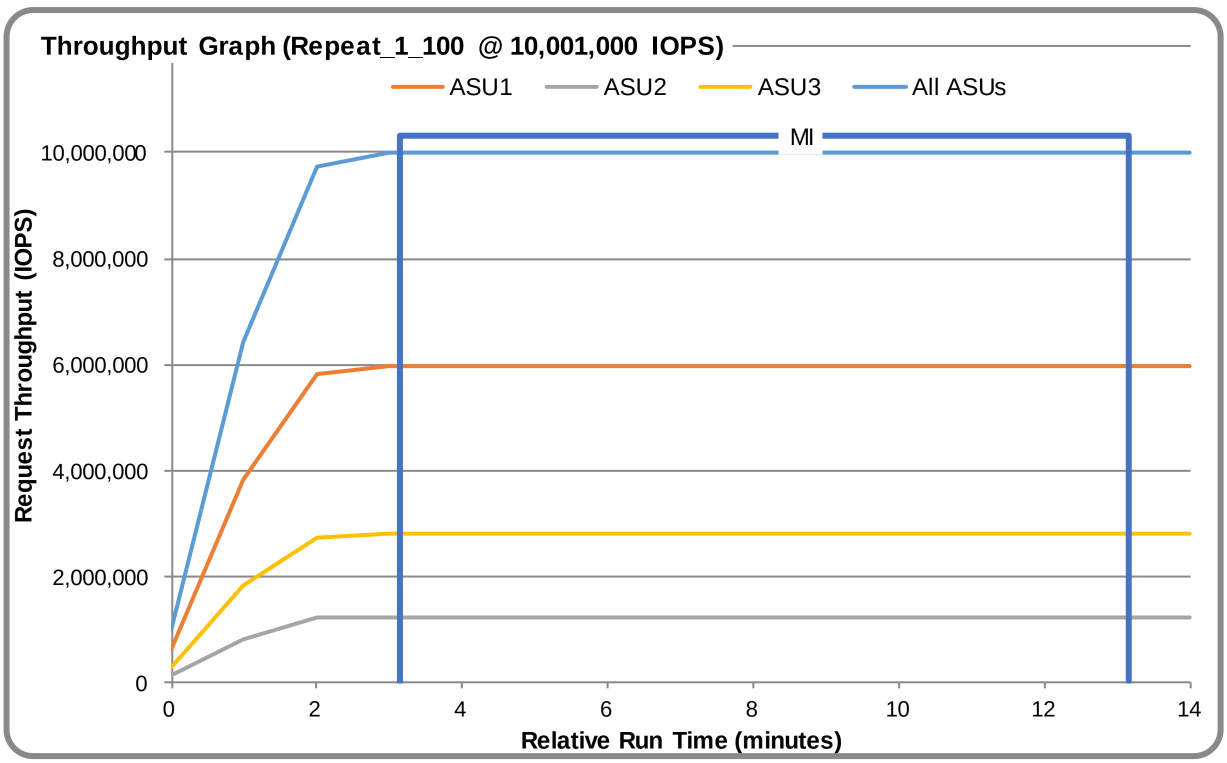
- **SPC1_METRICS_0_Raw_Results.xlsx**

Repeatability Test Results

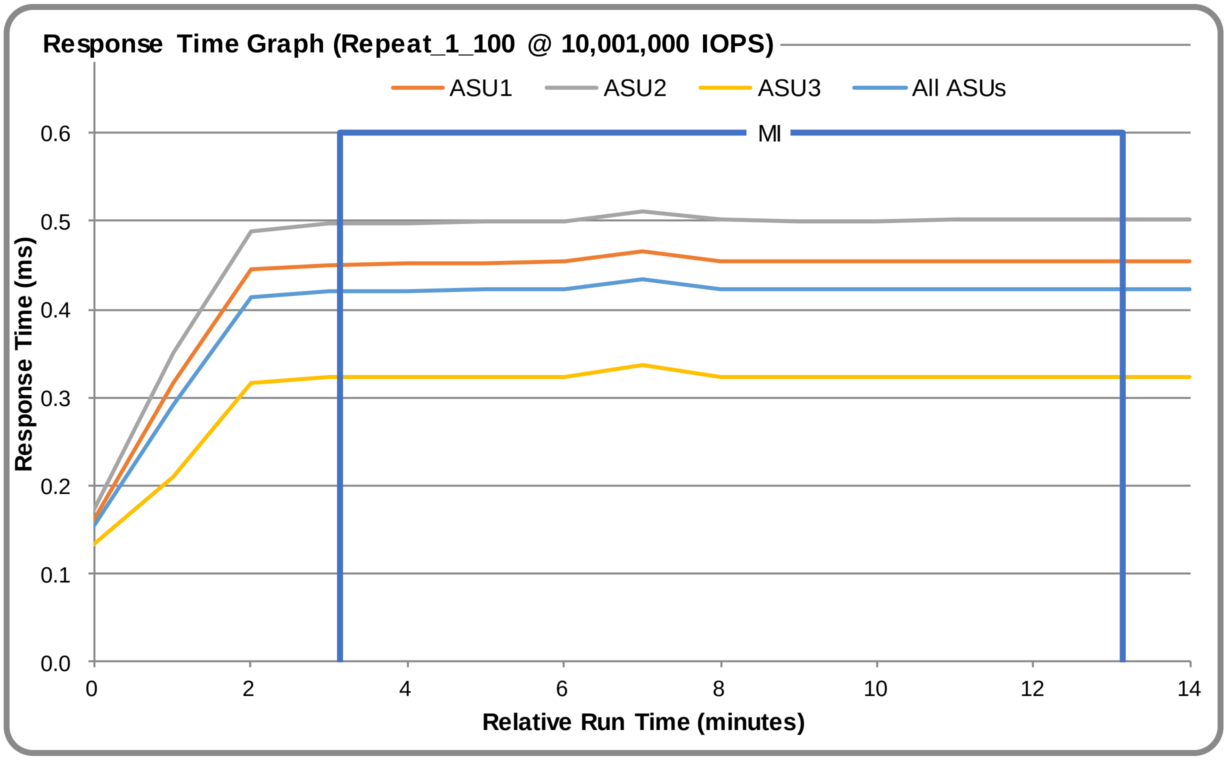
The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the table below.

Test Phase	100% IOPS	10% IOPS
RAMPD	10,001,522.1	1,000,086.6
REPEAT_1	10,001,587.2	1,000,202.0
REPEAT_2	10,001,716.1	1,000,116.5

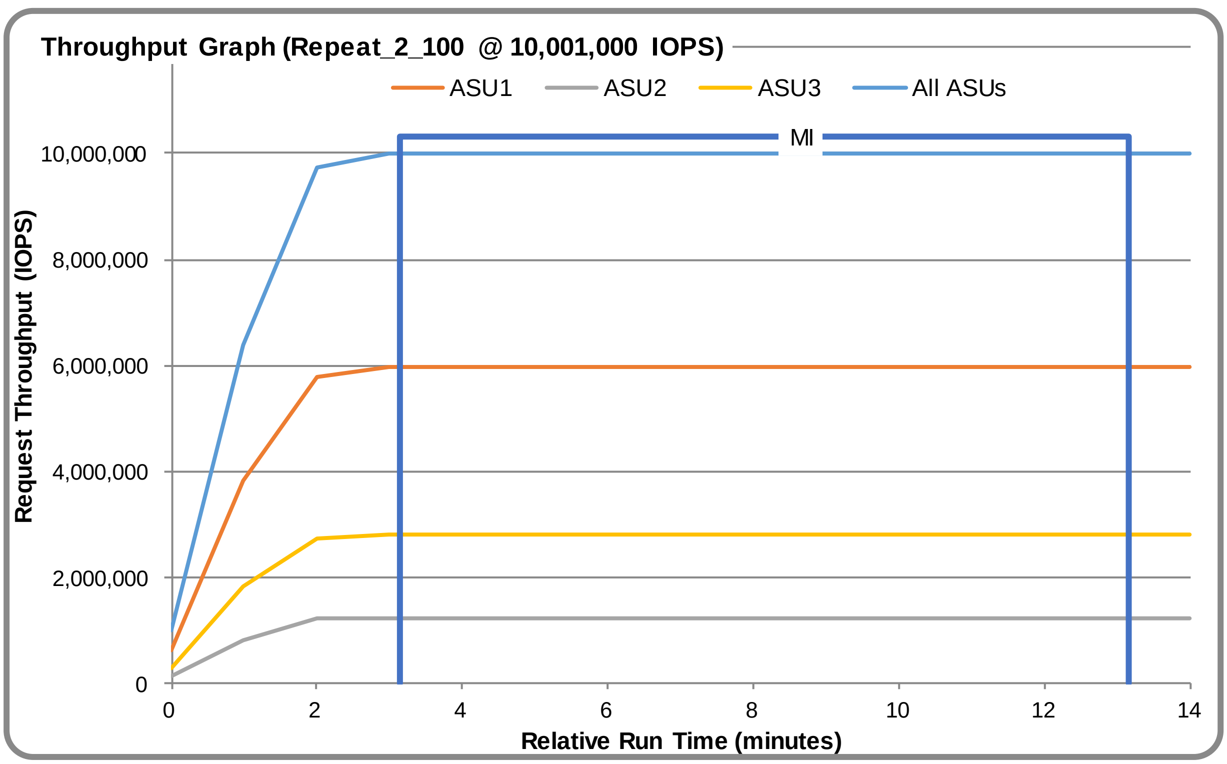
REPEAT_1_100 – Throughput Graph



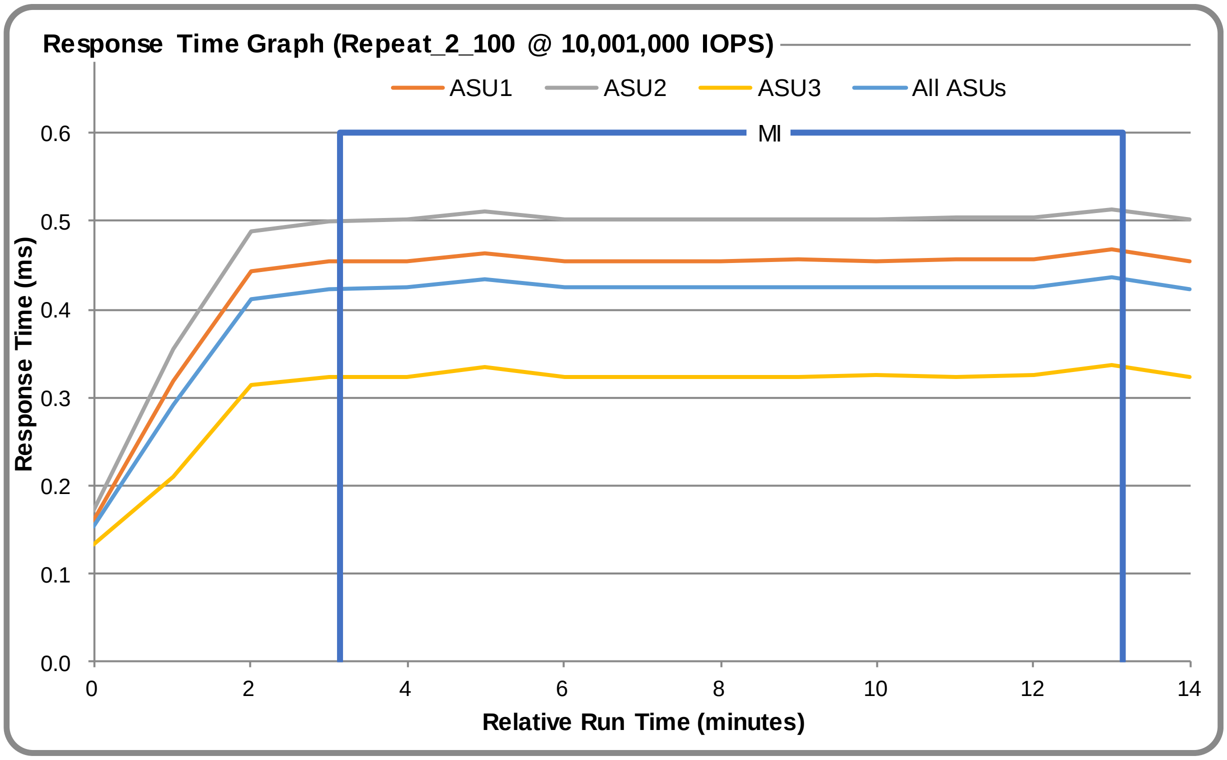
REPEAT_1_100 – Response Time Graph



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 Defined 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	0.0002	0.0001	0.0001	0.0000	0.0002	0.0002	0.0001	0.0001
Difference	0.013%	0.004%	0.006%	0.002%	0.009%	0.004%	0.003%	0.000%

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	0.0002	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0001
Difference	0.010%	0.002%	0.000%	0.000%	0.020%	0.002%	0.004%	0.002%

Space Optimization Techniques

Description of Utilized Techniques

The TSC did not use any space optimization techniques.

Physical Free Space Metrics

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.

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	1,236,219,154
Total Number of Logical Blocks Verified	587,348,595
Total Number of Logical Blocks Overwritten	648,870,559
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks (sec.)	301
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

Redundantly configured batteries inside the ETERNUS DX8900S4 storage system allow data in cache memory to be moved to non-volatile memory or to physical disk drives in the event of a power outage. This secured data can then be maintained in that state indefinitely until the power is restored.

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**
All tuning done via GUI (see Appendix C)		
/D_Creation	**Storage configuration creation**	**root**
definitions.exp	Procedure definitions	/D_Creation
doFDRcfg.sh	Shell script to configure the array	/D_Creation
DX8900S4_20190208.exp	Configure CLI expect script	/D_Creation
DX8900S4_20190208makeLV.sh	Linux LVM configuration script	/D_Creation
DX8900S4_20190208switch.exp	Configure switches expect script	/D_Creation
showFormatStatus.exp	Check for physical format progress	/D_Creation
/E_Inventory	**Configuration inventory**	**root**
log_BeforeF_JX190305084945.zlg_001.txt	Configuration details before the run	/E_Inventory
log_AfterJ_JX190305084945.zlg2_001.txt	Configuration details after the run	/E_Inventory
/F_Generator	**Workload generator**	**root**
doFDRall_01.sh	Master run file 1	/F_generator
doFDRall_02.sh	Master run file 2	/F_generator
exportLog.exp	Storage array log export	/F_generator
exportSupportSave.exp	Switch configuration export	/F_generator
SPC1_DX8900S4_20190208.asu	ASU configuration file	/F_generator
SPC1_DX8900S4_20190208.hst	Host configuration file	/F_generator

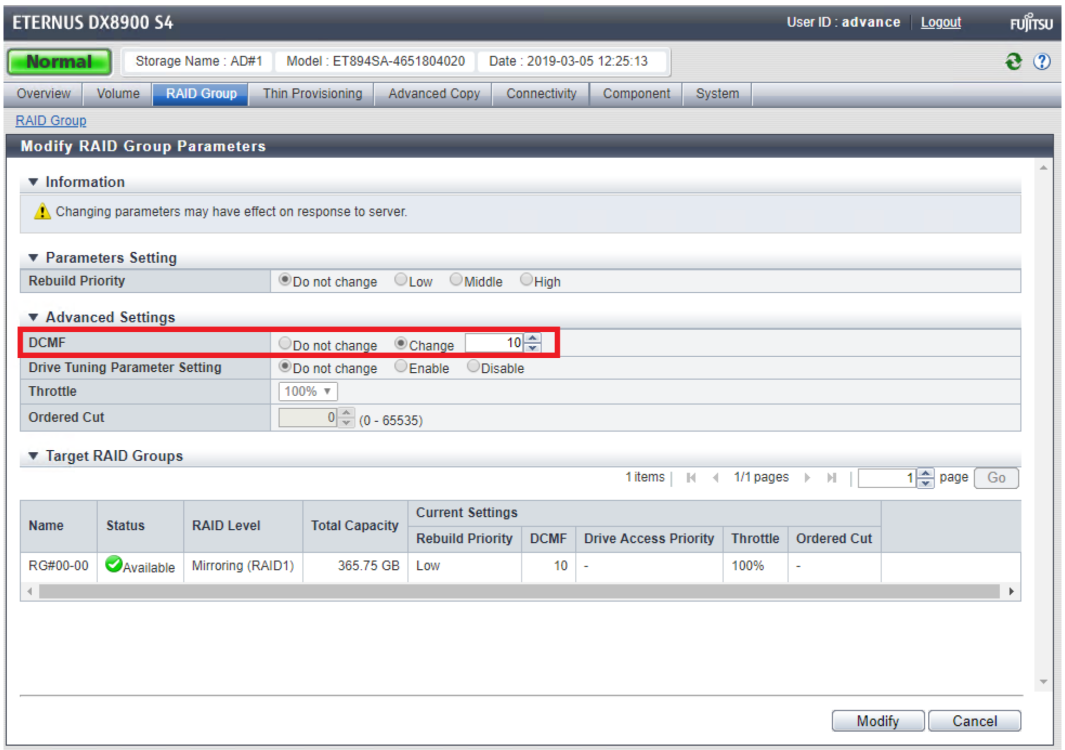
APPENDIX B: THIRD PARTY QUOTATION

All components are available directly through the Test Sponsor (Fujitsu Limited).

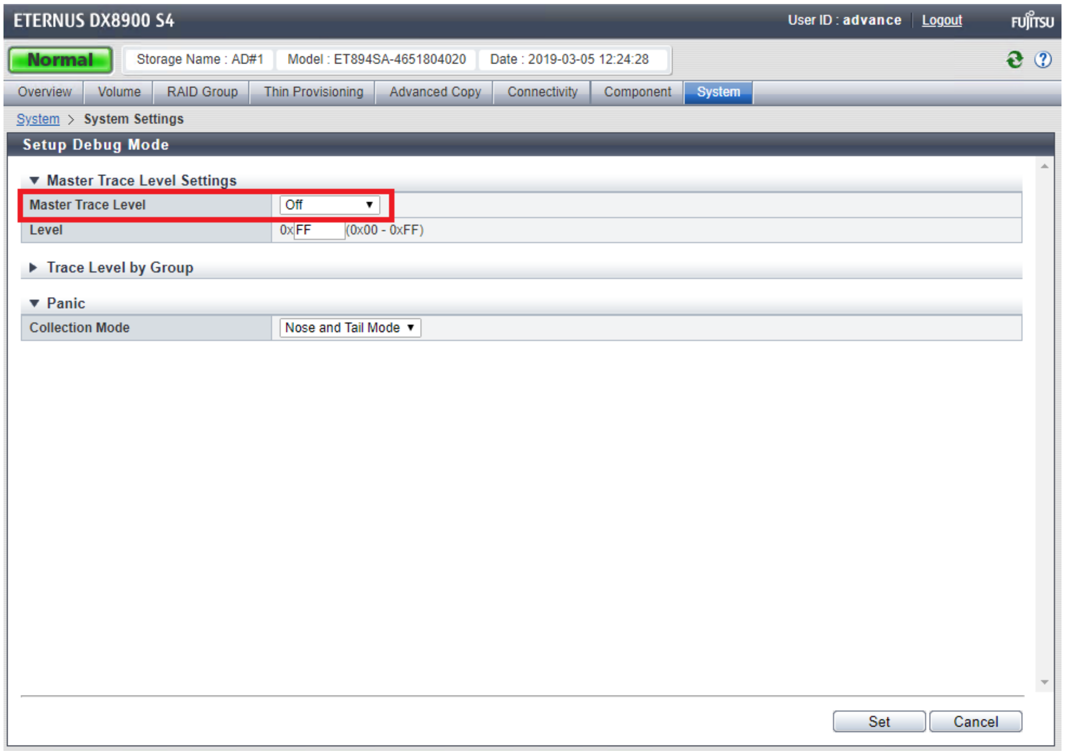
APPENDIX C: TUNING PARAMETERS AND OPTIONS

The standard Fujitsu GUI was used to apply the Tuning options for this test.

1. In order to execute some of the commands listed below it is necessary to create an user account with maintainer role. Please create such user account and login with the new account.
2. Change DCMF (Disk Command Multiplication Factor) value from the default (1) to (10) for all RAID Groups.
   The following GUI screen (RAID Group -> Tuning -> Modify RAID Group Parameter is used for each RAID Group and the DCMF parameter is changed to 10 as highlighted in red frame below:



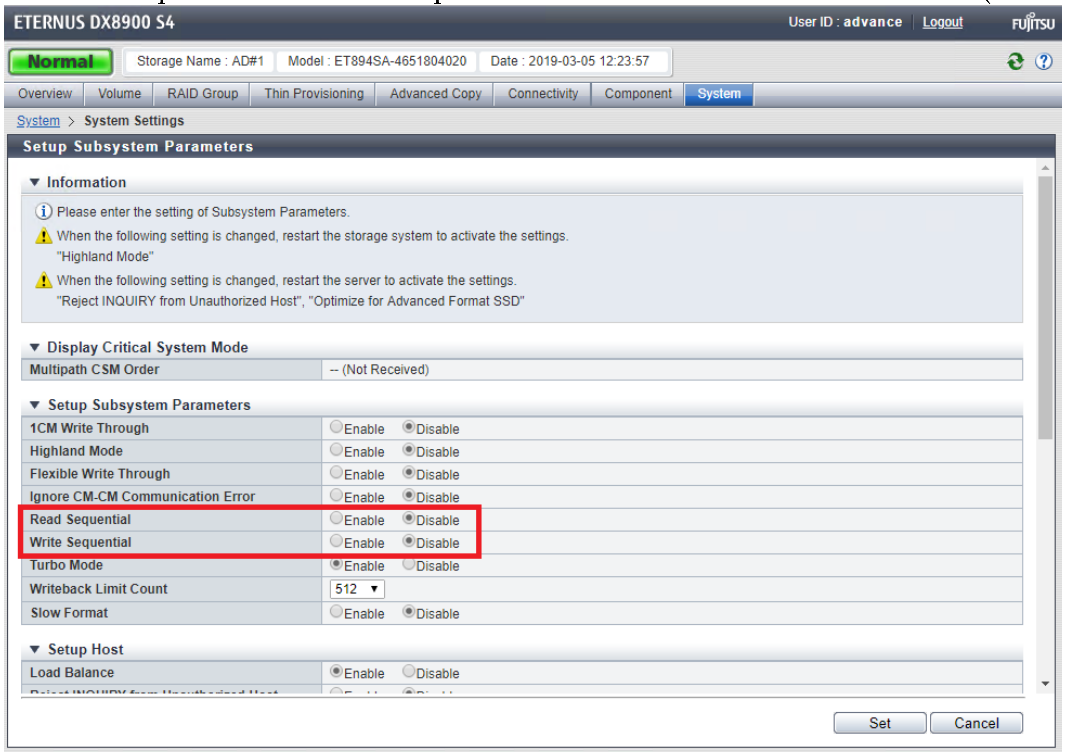
3. Disable Debug Trace
   The following GUI setting was applied.
   System-> System Settings -> Setup Debug Mode: The Master Trace Level was set to Off (Default: Standard)



4. Disable Read Sequential/Write Sequential
   The following GUI setting was applied.
   System-> System Settings -> Setup Subsystem Parameters:

   Flexible Write Through was set to Disable (Default: Enable)

Read Sequential/Write Sequential was set to Disable (Default: Enable)



APPENDIX D: STORAGE CONFIGURATION CREATION

The standard Fujitsu Command Line tool (CLI) was used to create the ETERNUS DX8900 S4 SPC-1 configuration.

The 'master' script, **doFDRcfg.sh**, was executed, which in turn, invoked the script, **DX8900S4_20190208.exp**. The 'master' script included shell commands to monitor the progress as the physical formatting proceeded, which used the **expect** script **showFormatStatus.exp** to pick up the status information from the array.

The **DX8900S4_20190208.exp** script completed steps 1-4, described below for the 176 host port configuration.

Each **expect** script included the **docli** procedure, which was used to issue the CLI commands to the array. That procedure used **ssh** for communication with the array. A second procedure in the script, **doexit**, was used to conclude the execution sequence at the end of the script.

Step 1 – Creation of RAID Groups

A total of 288 RAID Groups were created, according to the configuration plan, **ConfigurationDesign_DX8900S4_20190208.xlsx**, which is typically prepared in concert with a Fujitsu SE. Each RAID Group was made up of 2 disk drives in a RAID1(1+1) configuration and assigned to a specific CM for operational control. The RAID Groups were named RG#00-00 through RG#b1-11.

Step 2 – Creation of the Logical Volumes

Wide striped logical volumes were created across 12 sets of RAID Groups (each with 12 RAID Groups). Eight volumes were created on each of the RAID Groups, one for each of the eight Fiber Channel ports of each controller, for a total of 192 logical volumes.

Step 3 – Creation of the Global Hot Spares

No drives were designated as the Global Hot Spare.

Step 4 – Assignment of LUN Mapping to the Linux Host Systems

The **DX8900S4_20190208.exp** script provided mapping to 176 host ports.

The port LUN mapping was assigned for each of the Logical Volumes using 8 ports on Channel Adapters (CA) in each of the 24 Controller Modules (CM). Each of the volumes, which were defined on RAID Groups owned by a CM, were assigned LUN numbers on the active ports on the CAs installed on the same CM.

Step 5 – Creation of the twenty four way striped logical volumes.

Built in logical volume manager in Linux is used to stripe each pair of LUNs presented by ETERNUS DX8900 S4 array.

This is done in 3 steps included in the DX8900S4_20190208makeLV.sh script.

1. Create Physical Volumes (PV) for each LUN presented from DX8900 S4.

pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000000000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000010000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000020000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000030000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000040000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000050000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000060000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000070000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000080000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000090000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300000a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300000b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300000c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300000d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300000e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300000f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000100000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000110000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000120000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000130000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000140000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000150000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000160000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000170000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000180000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000190000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300001a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300001b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300001c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300001d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300001e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300001f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000200000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000210000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000220000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000230000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000240000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000250000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000260000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000270000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000280000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000290000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300002a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300002b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300002c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300002d0000

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pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013002e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013002f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000300000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000310000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000320000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000330000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000340000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000350000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000360000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000370000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000380000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000390000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013003a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013003b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013003c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013003d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013003e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013003f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000400000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000410000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000420000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000430000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000440000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000450000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000460000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000470000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000480000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000490000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013004a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013004b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013004c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013004d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013004e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013004f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000500000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000510000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000520000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000530000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000540000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000550000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000560000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000570000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000580000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000590000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013005a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013005b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013005c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013005d0000
```

```
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130005e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130005f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000600000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000610000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000620000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000630000
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pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130006b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130006c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130006d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130006e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130006f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000700000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000710000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000720000
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pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000740000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000750000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000760000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000770000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000780000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000790000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130007a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130007b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130007c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130007d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130007e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130007f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000800000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000810000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000820000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000830000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000840000
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pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130008a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130008b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130008c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130008d0000
```

```
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300008e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300008f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000900000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000910000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000920000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000930000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000940000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000950000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000960000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000970000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000980000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000990000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300009a0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300009b0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300009c0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300009d0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300009e0000
pvcreate /dev/disk/by-id/scsi-3600000e00d310000003101300009f0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a00000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a10000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a20000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a30000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a40000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a50000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a60000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a70000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a80000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000a90000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000aa0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000ab0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000ac0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000ad0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000ae0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000af0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b00000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b10000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b20000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b30000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b40000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b50000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b60000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b70000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b80000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000b90000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000ba0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000bb0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000bc0000
pvcreate /dev/disk/by-id/scsi-3600000e00d31000000310130000bd0000
```

pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000be0000
pvcreate /dev/disk/by-id/scsi-3600000e00d3100000031013000bf0000

2. Create two Volume Groups with physical extent size of 512KiB

```
vgcreate asu_vg1 /dev/sda

vgextend asu_vg1 /dev/sddx

vgextend asu_vg1 /dev/sdr

vgextend asu_vg1 /dev/sdev

vgextend asu_vg1 /dev/sdi

vgextend asu_vg1 /dev/sddr

vgextend asu_vg1 /dev/sdq

vgextend asu_vg1 /dev/sdex

vgextend asu_vg1 /dev/sdm

vgextend asu_vg1 /dev/sdej

vgextend asu_vg1 /dev/sds

vgextend asu_vg1 /dev/sdfb

vgextend asu_vg1 /dev/sdae

vgextend asu_vg1 /dev/sdft

vgextend asu_vg1 /dev/sdt

vgextend asu_vg1 /dev/sdfd

vgextend asu_vg1 /dev/sdai

vgextend asu_vg1 /dev/sdfw

vgextend asu_vg1 /dev/sdu

vgextend asu_vg1 /dev/sdff

vgextend asu_vg1 /dev/sdar

vgextend asu_vg1 /dev/sdgf

vgextend asu_vg1 /dev/sdw

vgextend asu_vg1 /dev/sdfl

vgextend asu_vg1 /dev/sdas

vgextend asu_vg1 /dev/sdgg

vgextend asu_vg1 /dev/sdz
```

```
vgextend asu_vg1 /dev/sdfp
vgextend asu_vg1 /dev/sdat
vgextend asu_vg1 /dev/sdgh
vgextend asu_vg1 /dev/sdy
vgextend asu_vg1 /dev/sdfh
vgextend asu_vg1 /dev/sdau
vgextend asu_vg1 /dev/sdgi
vgextend asu_vg1 /dev/sdx
vgextend asu_vg1 /dev/sdfj
vgextend asu_vg1 /dev/sdav
vgextend asu_vg1 /dev/sdgj
vgextend asu_vg1 /dev/sdac
vgextend asu_vg1 /dev/sdfm
vgextend asu_vg1 /dev/sdb
vgextend asu_vg1 /dev/sddt
vgextend asu_vg1 /dev/sdaa
vgextend asu_vg1 /dev/sdfr
vgextend asu_vg1 /dev/sdk
vgextend asu_vg1 /dev/sddv
vgextend asu_vg1 /dev/sdad
vgextend asu_vg1 /dev/sdfn
vgextend asu_vg1 /dev/sdc
vgextend asu_vg1 /dev/sdez
vgextend asu_vg1 /dev/sdaf
vgextend asu_vg1 /dev/sdfq
vgextend asu_vg1 /dev/sdf
vgextend asu_vg1 /dev/sdep
vgextend asu_vg1 /dev/sdab
vgextend asu_vg1 /dev/sdfs
vgextend asu_vg1 /dev/sdd
```

```
vgextend asu_vg1 /dev/sdel
vgextend asu_vg1 /dev/sdag
vgextend asu_vg1 /dev/sdfu
vgextend asu_vg1 /dev/sde
vgextend asu_vg1 /dev/sddz
vgextend asu_vg1 /dev/sdah
vgextend asu_vg1 /dev/sdfv
vgextend asu_vg1 /dev/sdh
vgextend asu_vg1 /dev/sden
vgextend asu_vg1 /dev/sdaj
vgextend asu_vg1 /dev/sdfx
vgextend asu_vg1 /dev/sdg
vgextend asu_vg1 /dev/sdeb
vgextend asu_vg1 /dev/sdak
vgextend asu_vg1 /dev/sdfy
vgextend asu_vg1 /dev/sdp
vgextend asu_vg1 /dev/sded
vgextend asu_vg1 /dev/sdal
vgextend asu_vg1 /dev/sdfz
vgextend asu_vg1 /dev/sdj
vgextend asu_vg1 /dev/sder
vgextend asu_vg1 /dev/sdan
vgextend asu_vg1 /dev/sdga
vgextend asu_vg1 /dev/sdl
vgextend asu_vg1 /dev/sdef
vgextend asu_vg1 /dev/sdam
vgextend asu_vg1 /dev/sdgc
vgextend asu_vg1 /dev/sdn
vgextend asu_vg1 /dev/sdeh
vgextend asu_vg1 /dev/sdao
```

```
vgextend asu_vg1 /dev/sdgb
vgextend asu_vg1 /dev/sdo
vgextend asu_vg1 /dev/sdfo
vgextend asu_vg1 /dev/sdap
vgextend asu_vg1 /dev/sdgd
vgextend asu_vg1 /dev/sdv
vgextend asu_vg1 /dev/sdet
vgextend asu_vg1 /dev/sdaq
vgextend asu_vg1 /dev/sdge

vgcreate asu_vg2 /dev/sdaw
vgextend asu_vg2 /dev/sdcs
vgextend asu_vg2 /dev/sdbn
vgextend asu_vg2 /dev/sddi
vgextend asu_vg2 /dev/sdbc
vgextend asu_vg2 /dev/sdct
vgextend asu_vg2 /dev/sdbo
vgextend asu_vg2 /dev/sdfe
vgextend asu_vg2 /dev/sdbg
vgextend asu_vg2 /dev/sddf
vgextend asu_vg2 /dev/sdbp
vgextend asu_vg2 /dev/sddj
vgextend asu_vg2 /dev/sdbt
vgextend asu_vg2 /dev/sddp
vgextend asu_vg2 /dev/sdbq
vgextend asu_vg2 /dev/sddk
vgextend asu_vg2 /dev/sdce
vgextend asu_vg2 /dev/sdek
vgextend asu_vg2 /dev/sdbr
vgextend asu_vg2 /dev/sddo
```

```
vgextend asu_vg2 /dev/sdcm
vgextend asu_vg2 /dev/sdfa
vgextend asu_vg2 /dev/sdbs
vgextend asu_vg2 /dev/sddm
vgextend asu_vg2 /dev/sdco
vgextend asu_vg2 /dev/sdfc
vgextend asu_vg2 /dev/sdbu
vgextend asu_vg2 /dev/sddn
vgextend asu_vg2 /dev/sdcp
vgextend asu_vg2 /dev/sdfg
vgextend asu_vg2 /dev/sdbv
vgextend asu_vg2 /dev/sddq
vgextend asu_vg2 /dev/sdcq
vgextend asu_vg2 /dev/sdfi
vgextend asu_vg2 /dev/sdbw
vgextend asu_vg2 /dev/sdds
vgextend asu_vg2 /dev/sdcr
vgextend asu_vg2 /dev/sdfk
vgextend asu_vg2 /dev/sdbx
vgextend asu_vg2 /dev/sddy
vgextend asu_vg2 /dev/sdax
vgextend asu_vg2 /dev/sdcu
vgextend asu_vg2 /dev/sdby
vgextend asu_vg2 /dev/sddu
vgextend asu_vg2 /dev/sdba
vgextend asu_vg2 /dev/sdcv
vgextend asu_vg2 /dev/sdbz
vgextend asu_vg2 /dev/sddw
vgextend asu_vg2 /dev/sday
vgextend asu_vg2 /dev/sdcw
```

```
vgextend asu_vg2 /dev/sdca
vgextend asu_vg2 /dev/sdea
vgextend asu_vg2 /dev/sdbb
vgextend asu_vg2 /dev/sddb
vgextend asu_vg2 /dev/sdcb
vgextend asu_vg2 /dev/sdec
vgextend asu_vg2 /dev/sdaz
vgextend asu_vg2 /dev/sdcx
vgextend asu_vg2 /dev/sdcc
vgextend asu_vg2 /dev/sdee
vgextend asu_vg2 /dev/sdbd
vgextend asu_vg2 /dev/sdcz
vgextend asu_vg2 /dev/sdcd
vgextend asu_vg2 /dev/sdeg
vgextend asu_vg2 /dev/sdbe
vgextend asu_vg2 /dev/sddd
vgextend asu_vg2 /dev/sdcf
vgextend asu_vg2 /dev/sdei
vgextend asu_vg2 /dev/sdbj
vgextend asu_vg2 /dev/sdcy
vgextend asu_vg2 /dev/sdcg
vgextend asu_vg2 /dev/sdem
vgextend asu_vg2 /dev/sdbf
vgextend asu_vg2 /dev/sdda
vgextend asu_vg2 /dev/sdch
vgextend asu_vg2 /dev/sdeo
vgextend asu_vg2 /dev/sdbh
vgextend asu_vg2 /dev/sddc
vgextend asu_vg2 /dev/sdci
vgextend asu_vg2 /dev/sdeq
```

```
vgextend asu_vg2 /dev/sdbi
vgextend asu_vg2 /dev/sdde
vgextend asu_vg2 /dev/sdcj
vgextend asu_vg2 /dev/sdes
vgextend asu_vg2 /dev/sdbl
vgextend asu_vg2 /dev/sddl
vgextend asu_vg2 /dev/sdck
vgextend asu_vg2 /dev/sdeu
vgextend asu_vg2 /dev/sdbm
vgextend asu_vg2 /dev/sddg
vgextend asu_vg2 /dev/sdcl
vgextend asu_vg2 /dev/sdew
vgextend asu_vg2 /dev/sdbk
vgextend asu_vg2 /dev/sddh
vgextend asu_vg2 /dev/sdcn
vgextend asu_vg2 /dev/sdey
```

3. Create 80 Logical Volumes for each ASU with 512KiB Stripe size

```
lvcreate -n asu101 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu102 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu103 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu104 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu105 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu106 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu107 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu108 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu109 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu110 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu111 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu112 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu113 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu114 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu115 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu116 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu117 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu118 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
```

```
lvcreate -n asu119 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu120 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu121 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu122 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu123 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu124 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu125 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu126 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu127 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu128 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu129 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu130 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu131 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu132 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu133 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu134 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu135 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu136 -i 96 -I 512 -C y -L 1078272MiB asu_vg2

lvcreate -n asu201 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu202 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu203 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu204 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu205 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu206 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu207 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu208 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu209 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu210 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu211 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu212 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu213 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu214 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu215 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu216 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu217 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu218 -i 96 -I 512 -C y -L 1078272MiB asu_vg1

lvcreate -n asu219 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu220 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu221 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu222 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu223 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu224 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu225 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu226 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu227 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu228 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
```

```
lvcreate -n asu229 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu230 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu231 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu232 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu233 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu234 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu235 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu236 -i 96 -I 512 -C y -L 1078272MiB asu_vg2

lvcreate -n asu301 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu302 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu303 -i 96 -I 512 -C y -L 1078272MiB asu_vg1
lvcreate -n asu304 -i 96 -I 512 -C y -L 1078272MiB asu_vg1

lvcreate -n asu305 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu306 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu307 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
lvcreate -n asu308 -i 96 -I 512 -C y -L 1078272MiB asu_vg2
```

Step 6 – Configuration of FC Switch zoning.

Four FC switches were used in the configuration: sb10,sb20 (Brocade G630),sb30,sb40 (Brocade 6520). Each switch belong to it’s own fabric and the following script is used to setup zones so that each HBA port belongs to 48 1-1 zones representing the CA ports.
DX8900S4_20190208switch.exp script is executed against each switch to configure the zones.

Referenced Scripts

- **doFDRcfg.sh**
- **definitions.exp**
- **DX8900S4_20190208.exp**
- **showFormatStatus.exp**
- **DX8900S4_20190208makeLV.sh**
- **DX8900S4_20190208switch.exp**

APPENDIX E: CONFIGURATION INVENTORY

The following files (included in the Supporting Files) capture the configuration before and after the test run

- **log_BeforeF_JX190305084945.zlg_001.txt**
- **log_AfterJ_JX190305084945.zlg2_001.txt**

APPENDIX F: WORKLOAD GENERATOR

The ASU configuration file can be found in the Supporting Files.

- **SPC1_DX8900S4_20190208.asu**

The Host configuration file can be found in the Supporting Files.

- **SPC1_DX8900S4_20190208.hst**

The following 'master' script was used to execute the required ASU pre-fill, Primary Metrics Test (Sustainability Test Phase, IOPS Test Phase, and Response Time Ramp Test Phase), Repeatability Test (Repeatability Test Phase 1 and Repeatability Test Phase 2), the SPC-1 Persistence Test Run 1 and the SPC-2 Persistence Test in an uninterrupted sequence with doFDRall_1XV.sh and doFDRall_2H.sh.

The 'master' script invokes various other scripts which appear below in the Referenced Scripts section with a brief description of each referenced script.

- **doFDRall_01.sh**
- **doFDRall_02.sh**

Referenced Scripts

The 'master' script invokes the following script in order to export the log file from the storage array.

- **exportLog.exp**

The following script is executed in order to export the Switch configuration from the FC switches.

- **exportSupporSave.exp**