SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

FUJITSU LIMITED
ETERNUS AF650 S3

SPC-1 V3.8.0

SUBMISSION IDENTIFIER: A32010

SUBMITTED FOR REVIEW: NOVEMBER 5, 2019

First Edition – November 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 www.spcresults.org.

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

Table of Contents

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

October 28, 2019

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

ETERNUS AF650 S3

The results were:

SPC-1 IOPS™	**800,140**
SPC-1 Price-Performance™	**$255.09/SPC-1 KIOPS™**
SPC-1 IOPS™ Response Time	0.308 ms
SPC-1 Overall Response Time	0.203 ms
SPC-1 ASU Capacity	33,137 GB
SPC-1 ASU Price	$6.16/GB
SPC-1 Total System Price	$204,099.88

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 A32010.

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:

None.

Respectfully Yours,

Doug Johnson, Certified SPC Auditor

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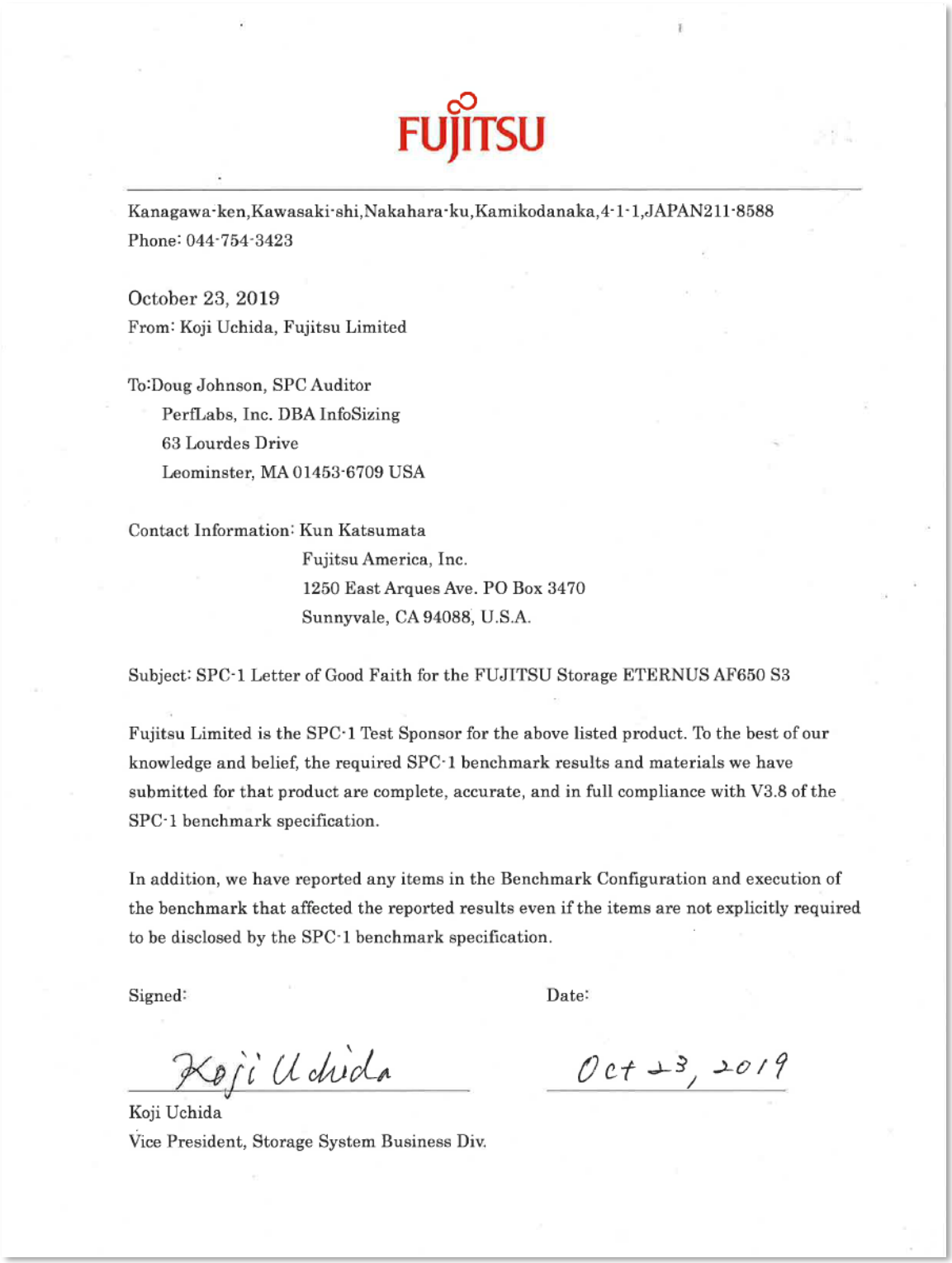
LETTER OF GOOD FAITH



FUJITSU

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

October 23, 2019
From: Koji Uchida, 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 AF650 S3

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:

Koji Uchida Oct 23, 2019

Koji Uchida
Vice President, Storage System Business Div.

SPC BENCHMARK 1™

EXECUTIVE SUMMARY

FUJITSU LIMITED
ETERNUS AF650 S3

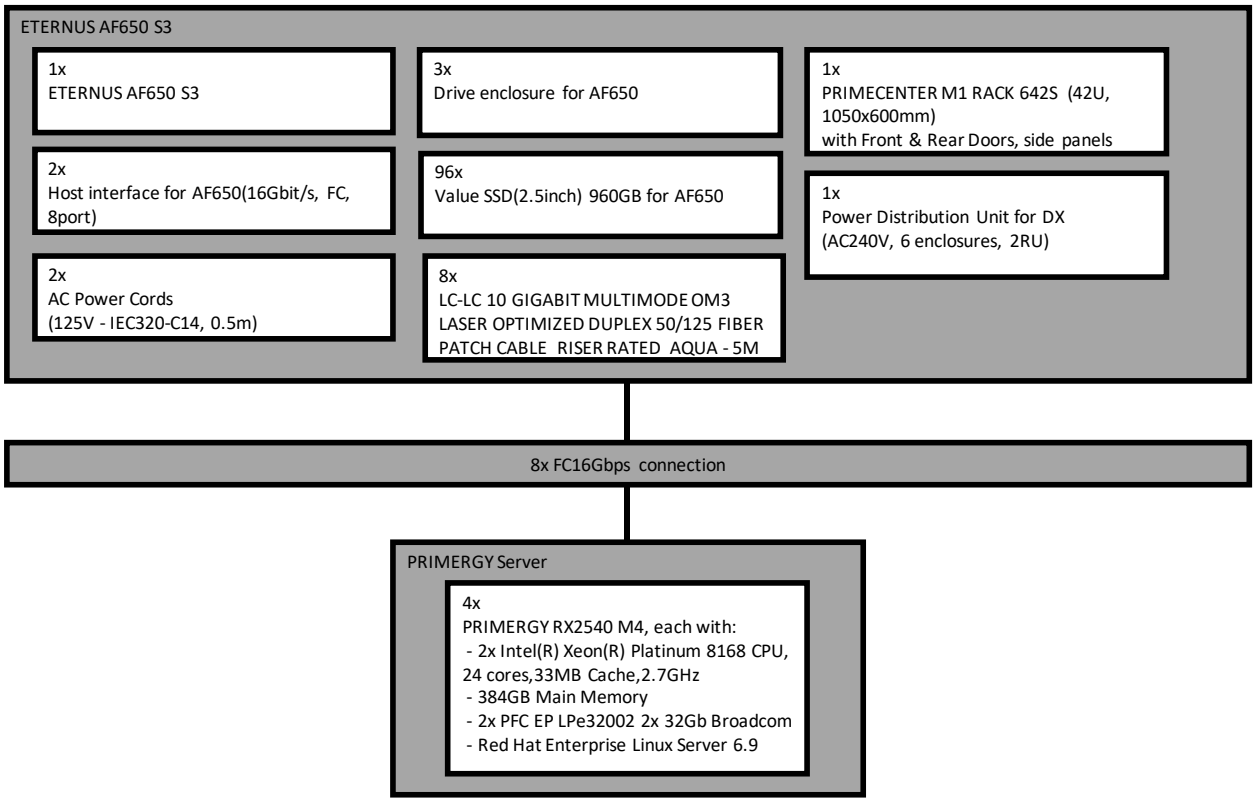
SPC-1 IOPS™	**800,140**
SPC-1 Price-Performance™	**$255.09/SPC-1 KIOPS™**
SPC-1 IOPS™ Response Time	0.308 ms
SPC-1 Overall Response Time	0.203 ms
SPC-1 ASU Capacity	33,137 GB
SPC-1 Space Effectiveness Ratio	NA
SPC-1 ASU Price	$6.16/GB
SPC-1 Total System Price	$204,099.88
Data Protection Level	Protected 2 (RAID1)
Physical Storage Capacity	92,160 GB
Pricing Currency / Target Country	U.S. Dollars / USA

SPC-1 V3.8.0

SUBMISSION IDENTIFIER: A32010

SUBMITTED FOR REVIEW: NOVEMBER 5, 2019

Benchmark Configuration Diagram



Tested Storage Product Description

The Fujitsu Storage ETERNUS AF650 S3 delivers leading storage performance and automated quality of service management, enabling a maximum of system utilization and contributing to a fast ROI. It is the perfect solution when consolidating data of large-scale databases, business-critical applications and business analytics / big data – all into one all-flash system. Extensive high-availability and disaster recovery capabilities make ETERNUS AF650 an ideal storage system for any business data.

For additional details, please visit:

https://www.fujitsu.com/global/products/computing/storage/all-flash-arrays/eternus-af650-s3/

Priced Storage Configuration Components

8x Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
1x ETERNUS AF650 S3 with: 1x Controller Enclosure Module with: 2x Control Module, each with: 384 GB cache 1x Channel Adapter with: 4x 16 Gbps Fibre Channel Host Ports 96x 960 GB SSD Storage Devices (without Hot Spare)

Storage Configuration Pricing

Part No.	Description	Source	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
Hardware & Software							
ET653SAU	ETERNUS AF650 S3	1	1	49,030.00	49,030.00	53%	23,044.10
ETREADAU	Drive enclosure for AF650 S3(2.5inch)	1	3	4,700.00	14,100.00	53%	6,627.00
ETRHH8A	Host interface for AF650 S3(16Gbit/s, FC, 8port)	1	1	8,310.00	8,310.00	53%	3,905.70
ETRSA92	Value SSD(2.5inch) 960GB x12 for AF650 S3	1	8	40,200.00	321,600.00	53%	151,152.00
S26361-F4994-L502	PFC EP LPe32002 2x 32Gb Broadcom	1	8	1,368.00	10,944.00	53%	5,143.68
ETRKC15U	AC100/200V Power Cord for AF650 S3, DX500/DX600/DX900 S5(IEC60320 C14, 1.5m)	1	4	150.00	600.00	53%	282.00
ETRP48U	Power distribution unit for AF650 S3, DX500/DX600/DX900 S5(AC24A/200-240V, 2U, 16Outlets)	1	1	1,870.00	1,870.00	53%	878.90
ETRRASU	19-inch rack (Standard door, 2000mm, Base rack with stabilizers)	1	1	4,070.00	4,070.00	53%	1,912.90
13-61-343827-003	Custom Fibre Host interface cable 3m LC-LC Crossed Polarity Duplex MM-50/125um; 3.0mm; Riser rated; OM3; Aqua Jacket	1	8	80.00	640.00	53%	300.80
					Hardware & Software Subtotal		**193,247.08**
Support & Maintenance							
	ETERNUS AF650 Warranty, 36 Months, Basic Level, 12x5 Phone Support, 9x5 NBD Onsite	1	1	0.00	0.00	0%	0.00
	ETERNUS AF650 Warranty Uplift, 36 Months, Enhanced Plus Level, 24x7 4hr Onsite, Prepaid billing	1	1	13,566.00	13,566.00	20%	10,852.80
					Support & Maintenance Subtotal		**10,852.80**
SPC-1 Total System Price							**204,099.88**
SPC-1 IOPS™							800,140
SPC-1 Price-Performance™ ($/SPC-1 KIOPS™)							**255.09**
SPC-1 ASU Capacity (GB)							33,137
SPC-1 ASU Price ($/GB)							**6.16**

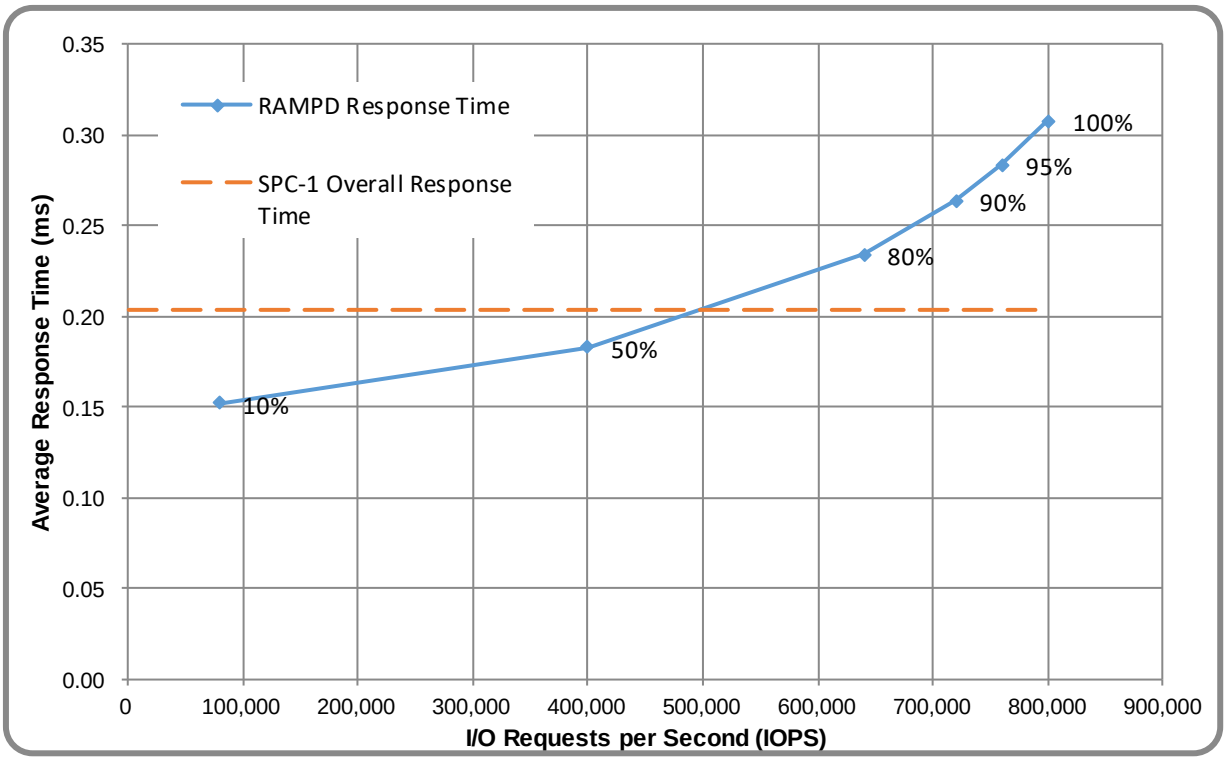
Pricing Sources: 1 = Fujitsu

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: November 5, 2019.

Response Time and Throughput Graph



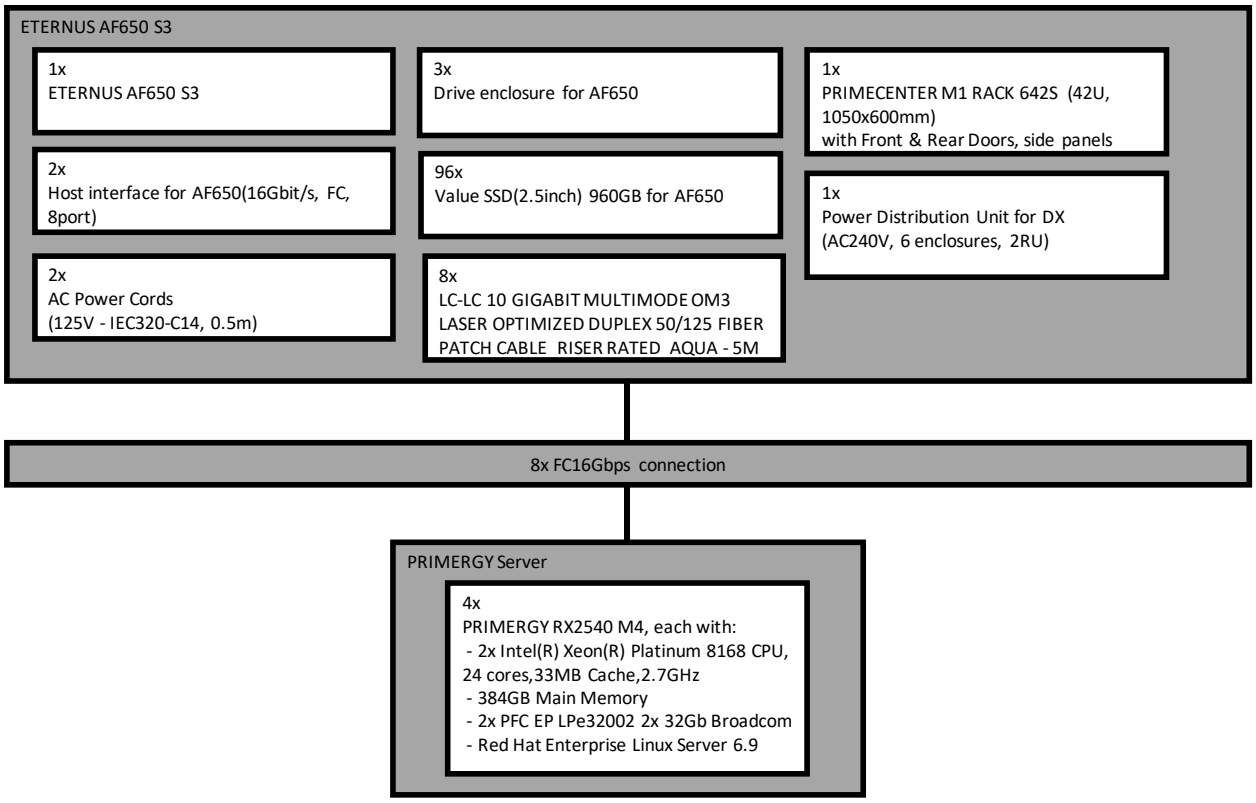
Contact Information	
Test Sponsor Primary Contact	Fujitsu Limited – http://www.fujitsu.com/services/computing/storage/ Kun Katsumata – kkatsumata@us.fujitsu.com
SPC Auditor	InfoSizing – www.sizing.com Doug Johnson – doug@sizing.com

Revision Information	
SPC Benchmark 1™ Revision	V3.8.0
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 direct-attached storage.

Host System and Tested Storage Configuration Components

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

Host Systems
4x Fujitsu PRIMERGY RX2540 M4 Servers, each with: 2x Intel® Xeon® Platinum 8168 (2.7 GHz, 24-Core, 33 MB L3) 384 GB Main Memory Red Hat Enterprise Linux Server 6.9
Tested Storage Configuration
8x Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
1x ETERNUS AF650 S3 with: **1x Controller Enclosure Module with:** **2x Control Module, each with:** **384 GB cache** **1x Channel Adapter with:** **4x 16 Gbps Fibre Channel Host Ports** **96x 960 GB SSD Storage Devices (without Hot Spare)**

Differences Between Tested and Priced Storage Configurations

There were no differences between the TSC 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 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	9	1,656.8	1,656.8	14,911.6	45.0%	No
ASU-2	9	1,656.8	1,656.8	14,911.6	45.0%	No
ASU-3	2	1,656.8	1,656.8	3,313.7	10.0%	No
	SPC-1 ASU Capacity			33,137		

*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
SSD	96	960.0	92,160.0
	Total Physical Capacity		**92,160**
	Physical Capacity Utilization		**35.96%**

Data Protection

The data protection level used for all LVs was **Protected 2 (RAID1)**, which was accomplished by configuring 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).

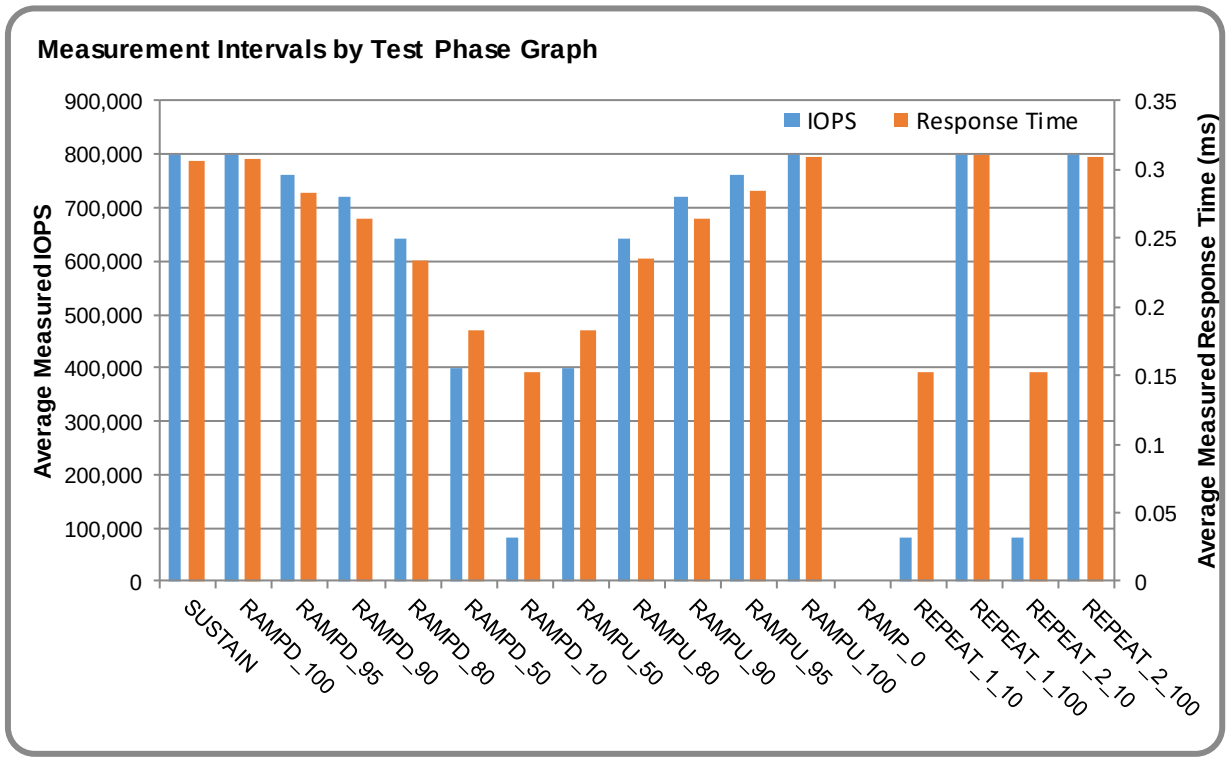
Primary Metrics Test Phases

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

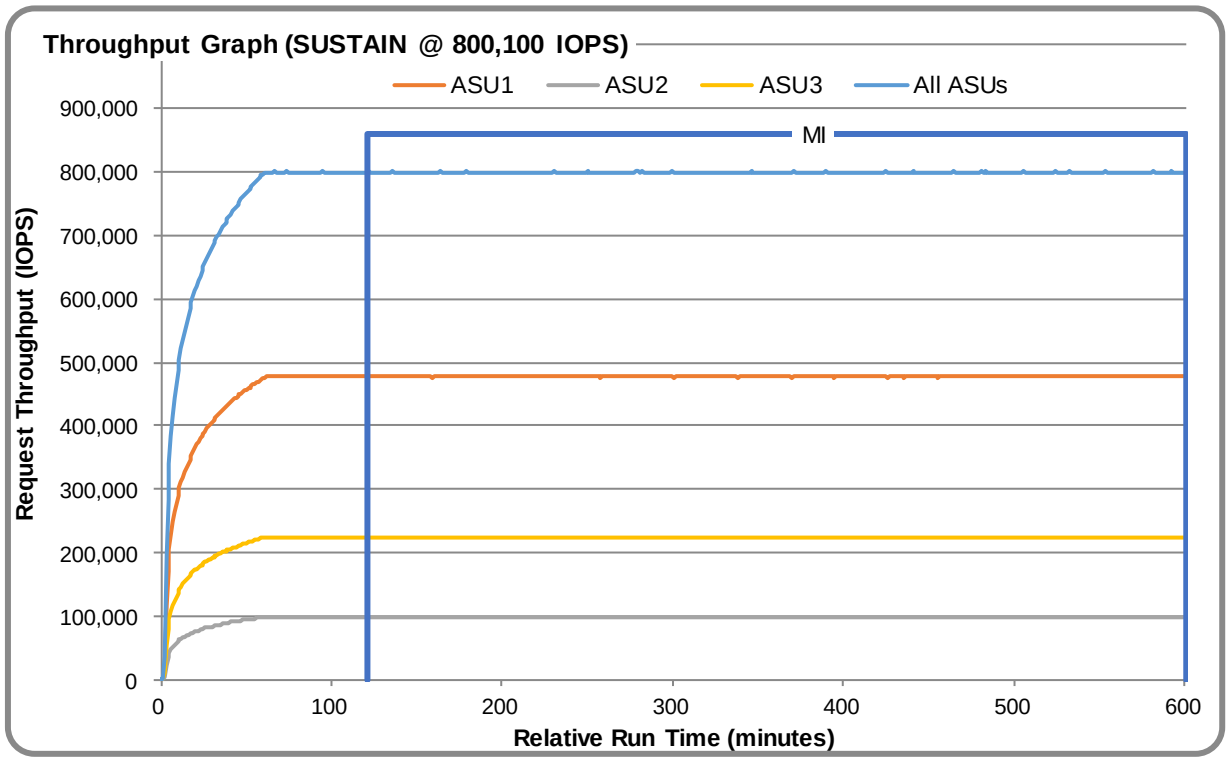
The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

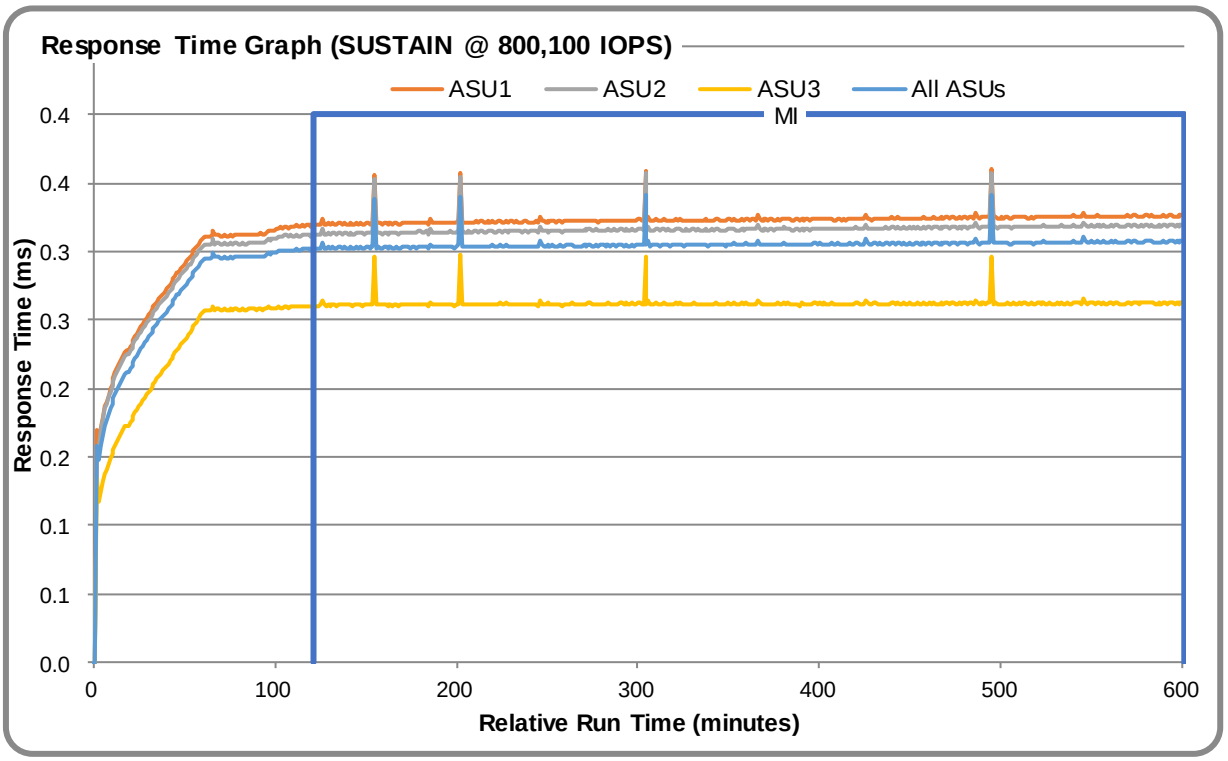
SUSTAIN – Execution Times

Interval	Start Date & Time	End Date & Time	Duration
Transition Period	09-Oct-19 19:00:16	09-Oct-19 21:00:16	2:00:00
Measurement Interval	09-Oct-19 21:00:16	10-Oct-19 05:00:17	8:00:01

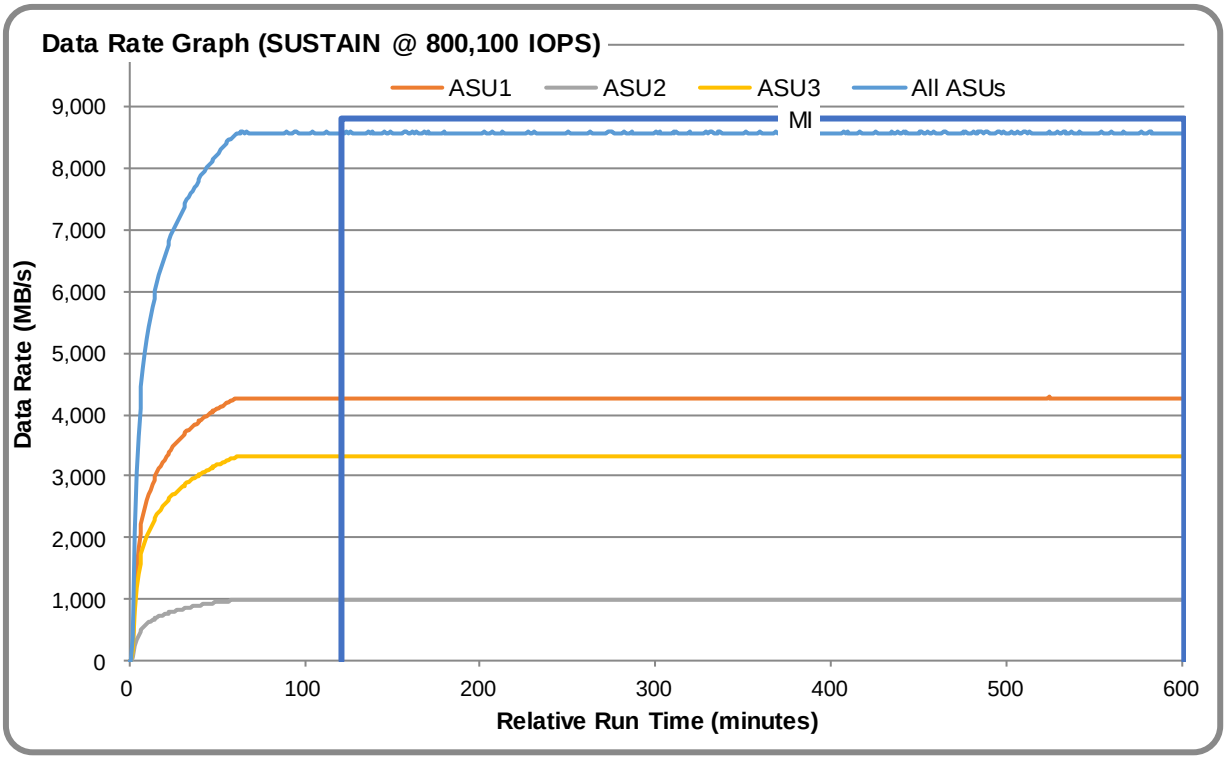
SUSTAIN – Throughput Graph



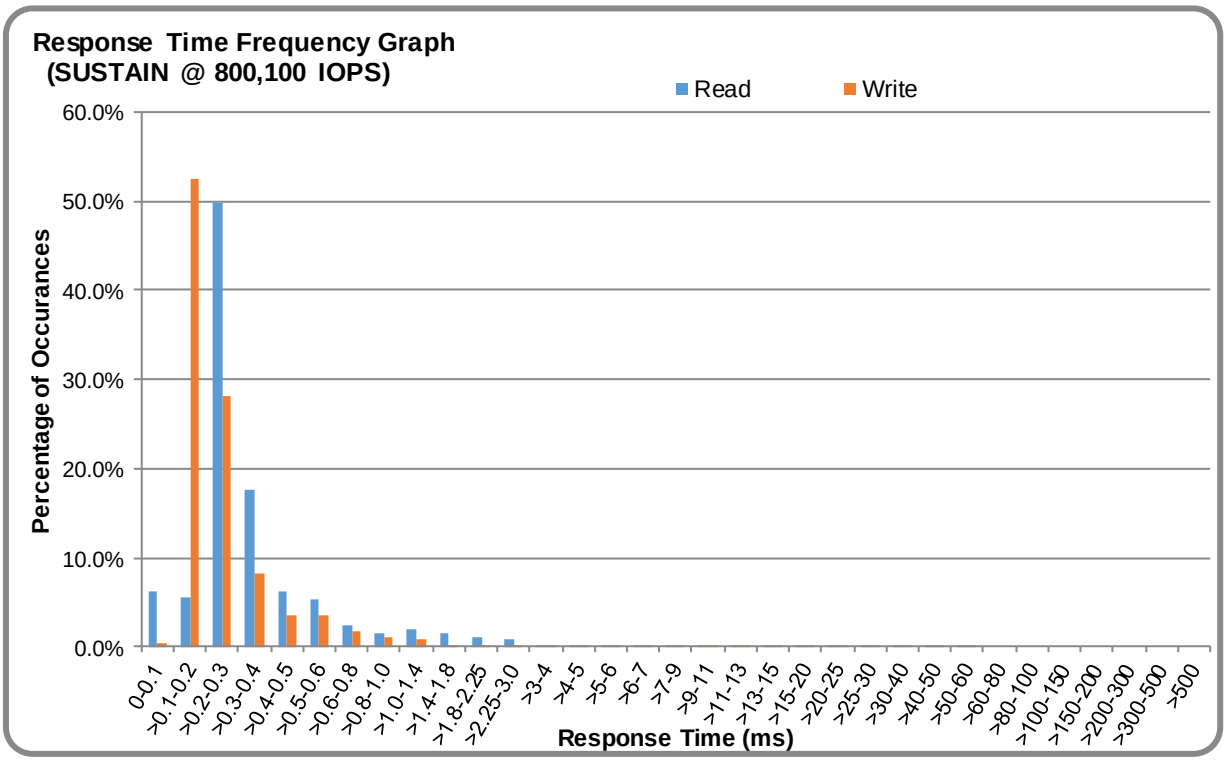
SUSTAIN – Response Time Graph



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	0.0008	0.0002	0.0005	0.0003	0.0010	0.0005	0.0007	0.0002
Difference	0.002%	0.001%	0.001%	0.000%	0.011%	0.005%	0.008%	0.002%

RAMPD_100 Test Phase

RAMPD_100 – Results File

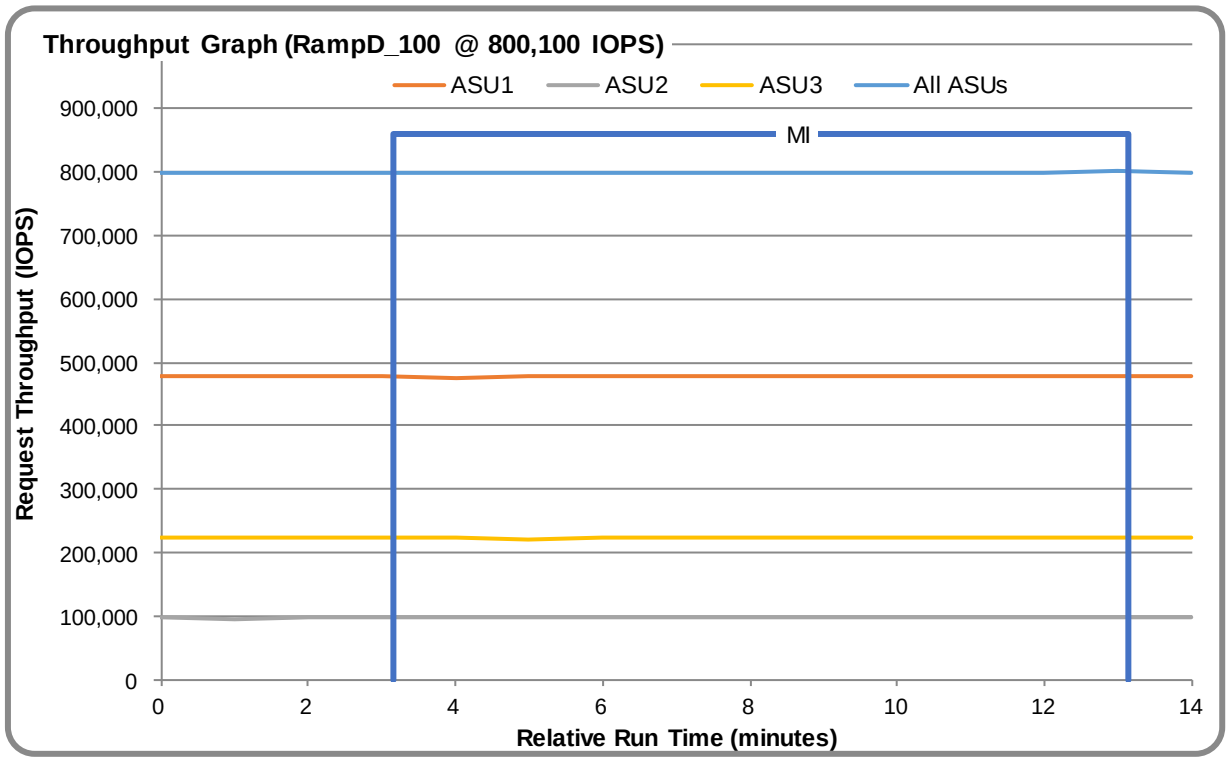
The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

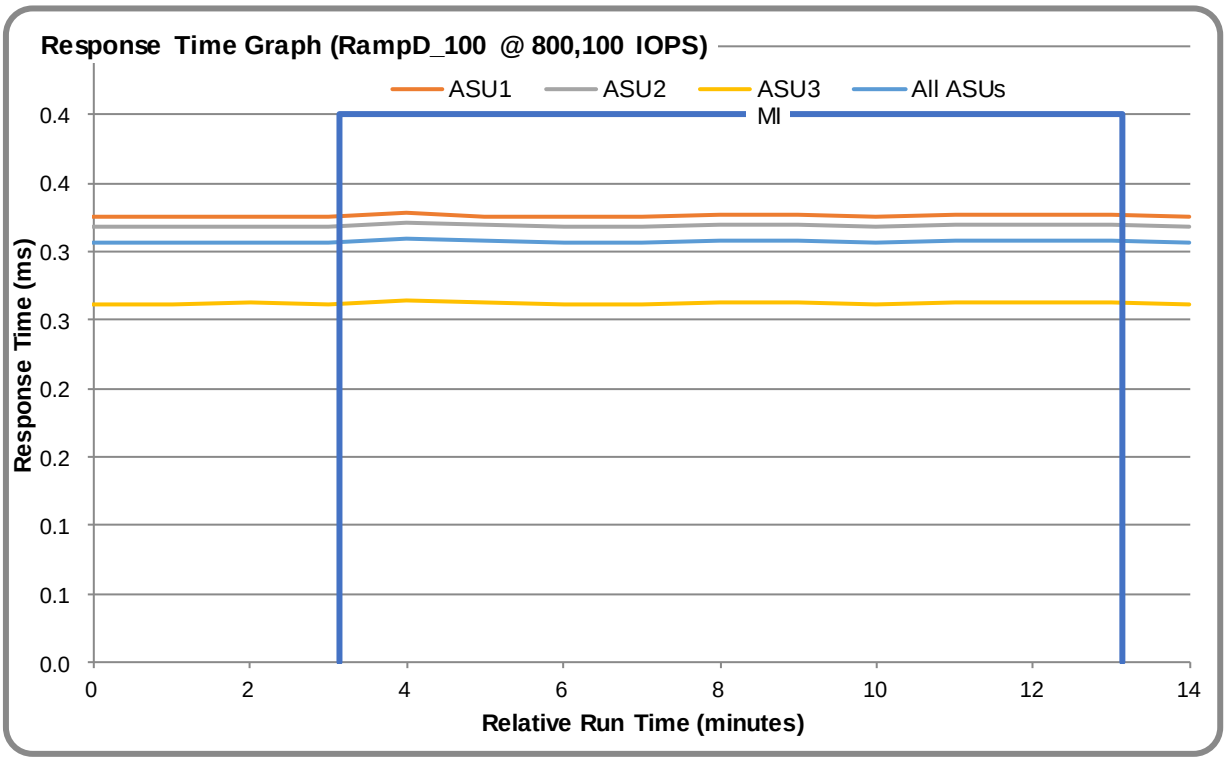
RAMPD_100 – Execution Times

Interval	Start Date & Time	End Date & Time	Duration
Transition Period	10-Oct-19 05:01:16	10-Oct-19 05:04:16	0:03:00
Measurement Interval	10-Oct-19 05:04:16	10-Oct-19 05:14:17	0:10:01

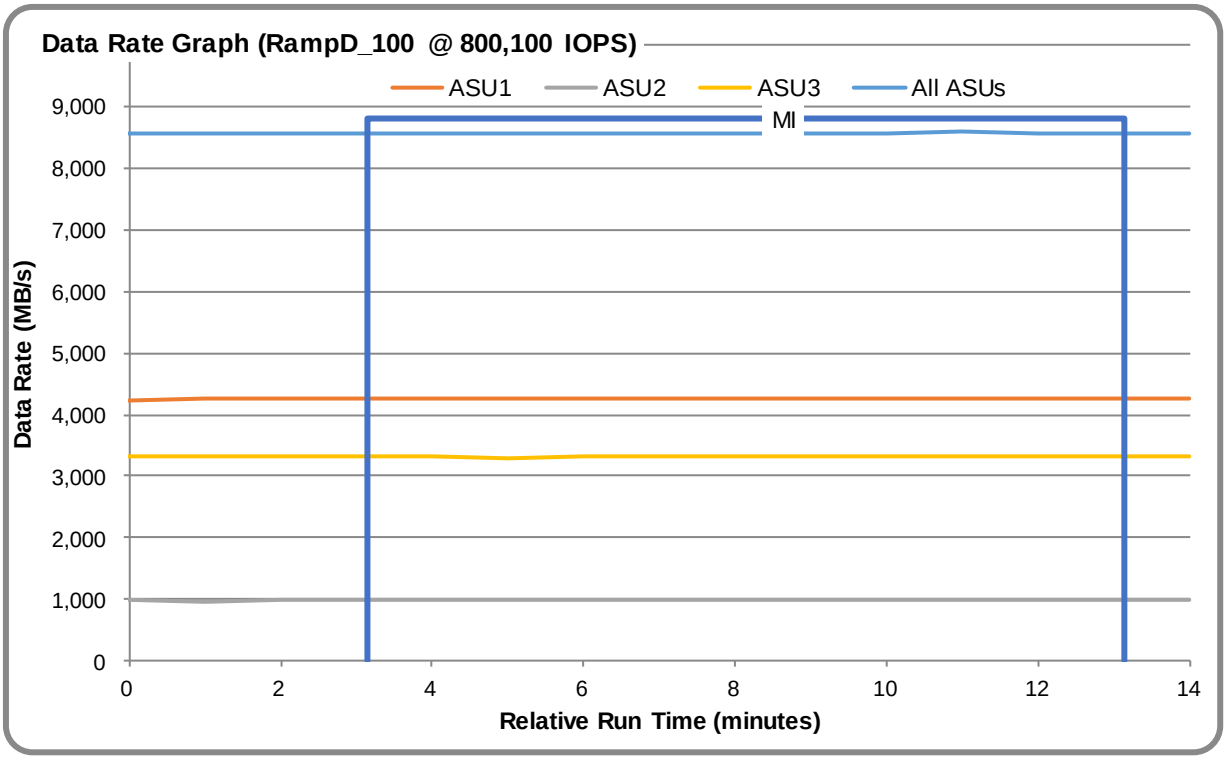
RAMPD_100 – Throughput Graph



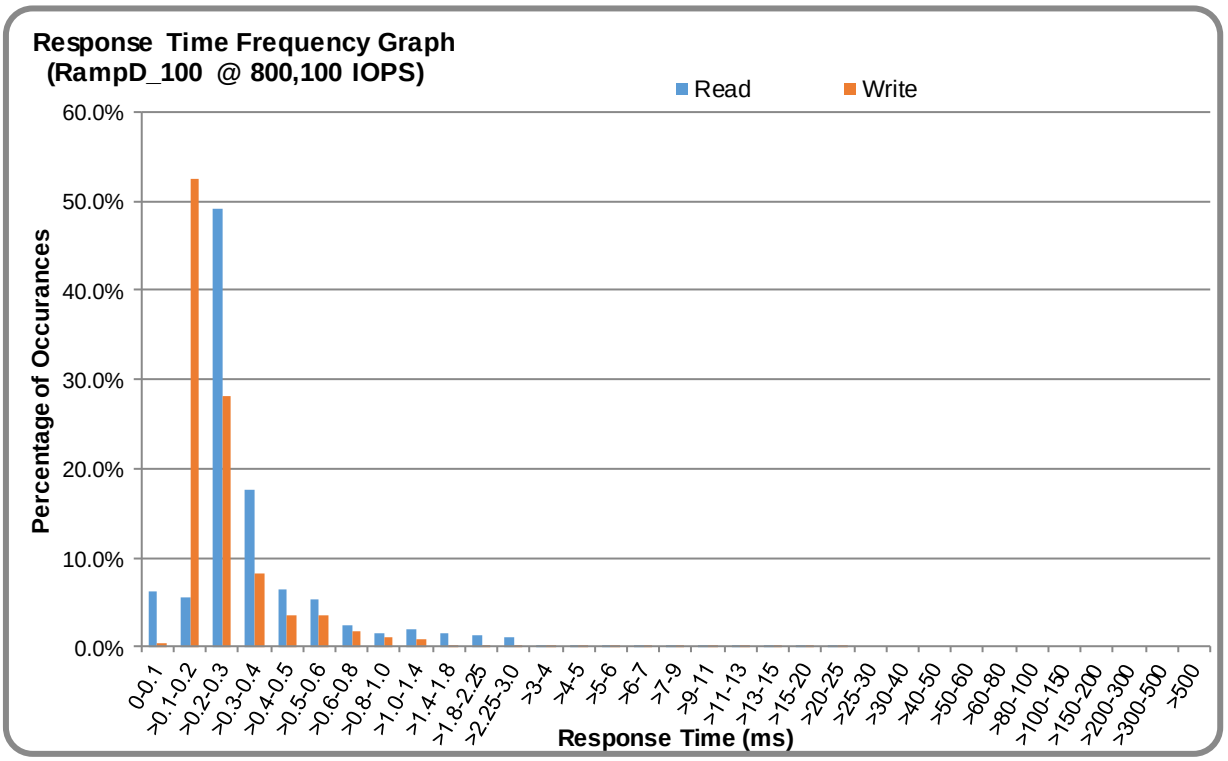
RAMPD_100 – Response Time Graph



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	0.0009	0.0002	0.0005	0.0003	0.0014	0.0004	0.0008	0.0002
Difference	0.011%	0.006%	0.036%	0.006%	0.022%	0.016%	0.024%	0.006%

RAMPD_100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	480,086,178
I/O Requests Completed with Response Time <= 30 ms	480,086,178
I/O Requests Completed with Response Time > 30 ms	0

Response Time Ramp Test

Response Time Ramp Test – Results File

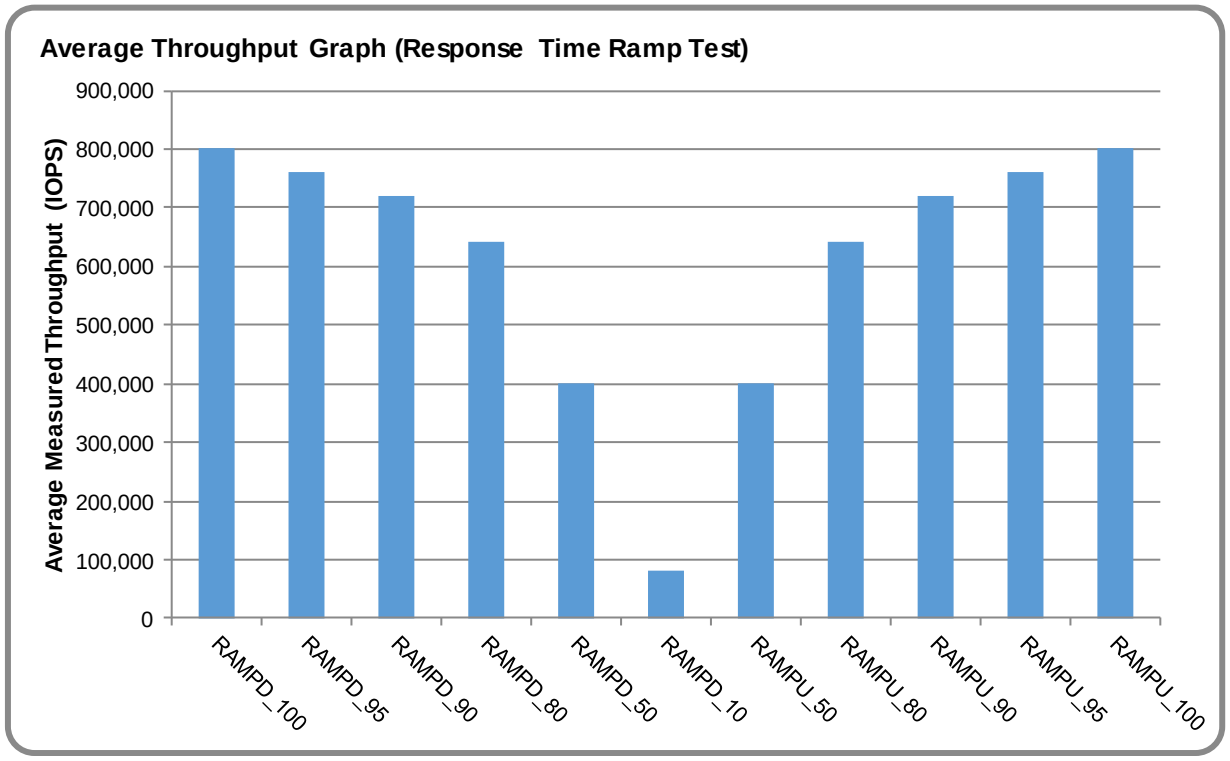
The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

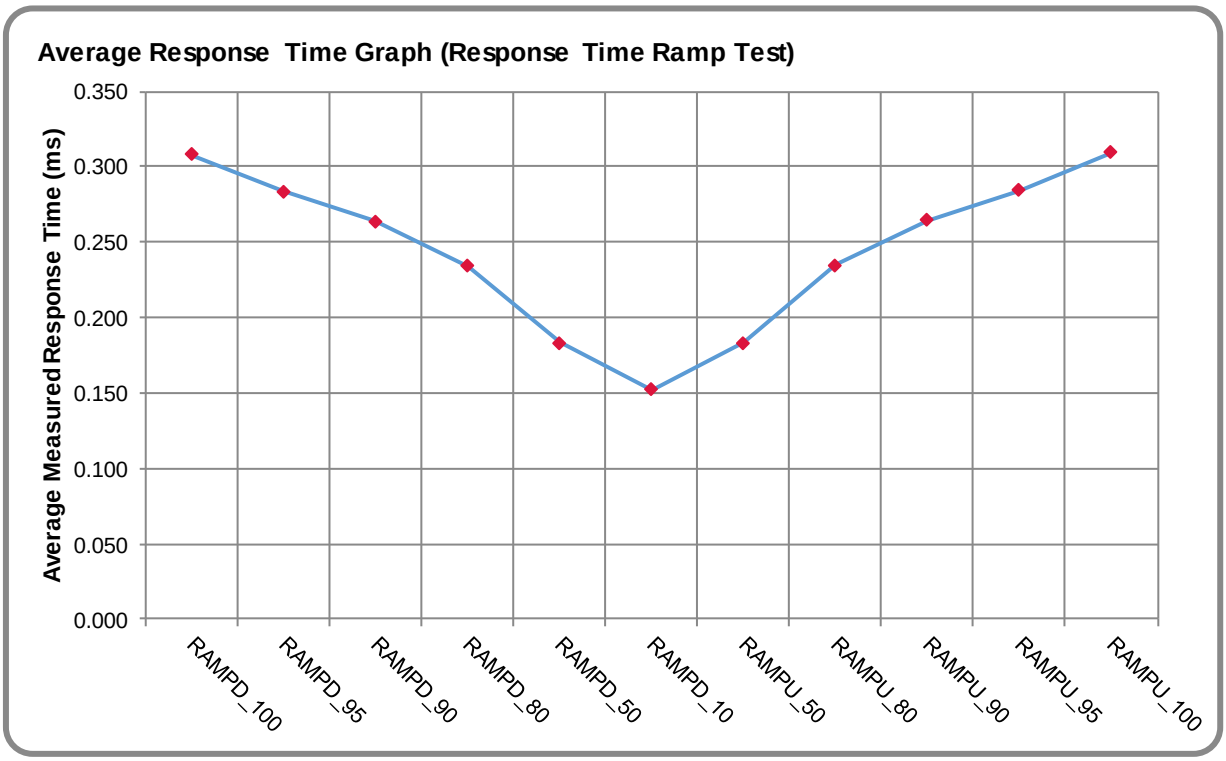
Response Time Ramp Test – Phases

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).

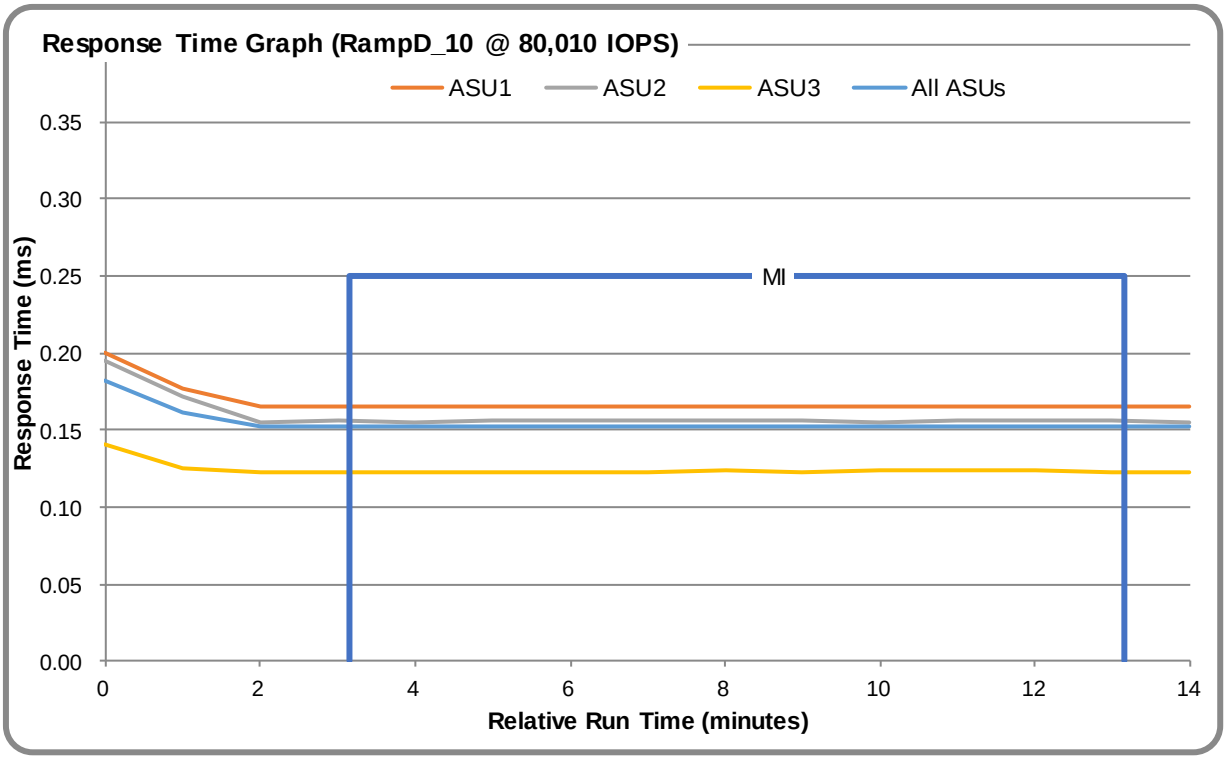
Response Time Ramp Test – Average Throughput Graph



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:

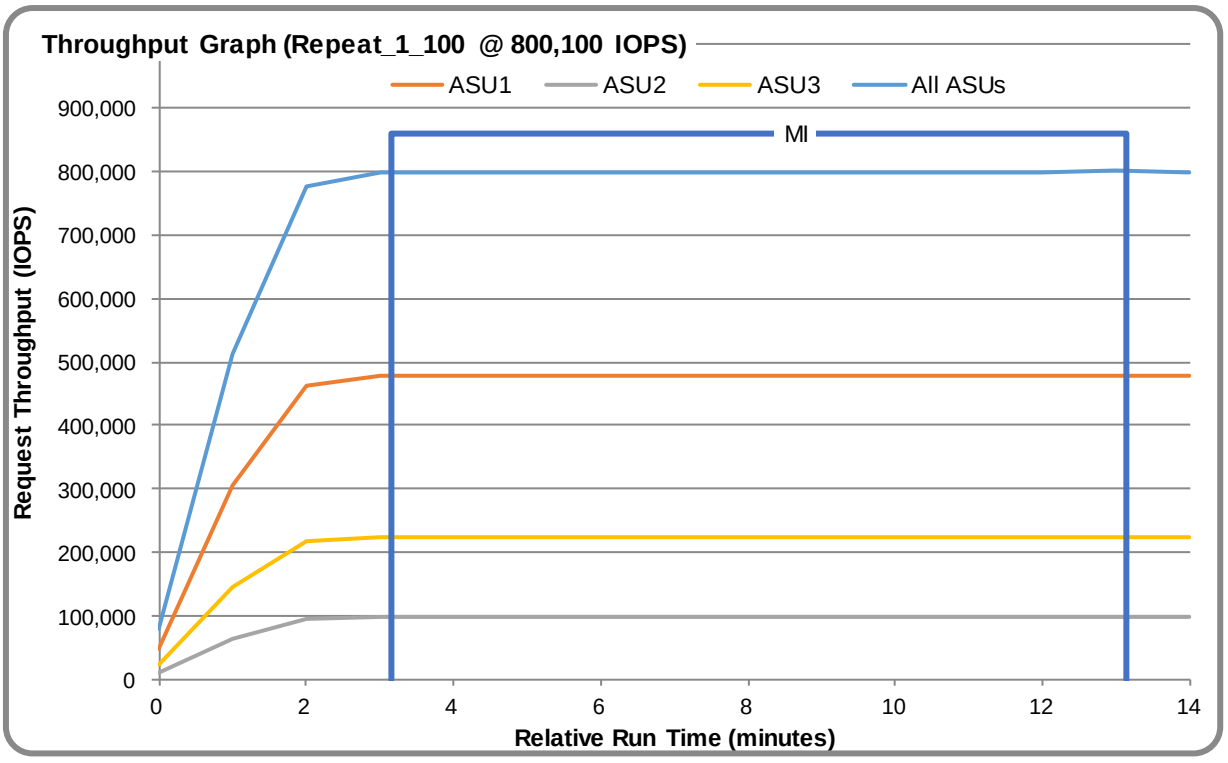
- **SPC1_METRICS_0_Raw_Results.xlsx**

Repeatability Test Results

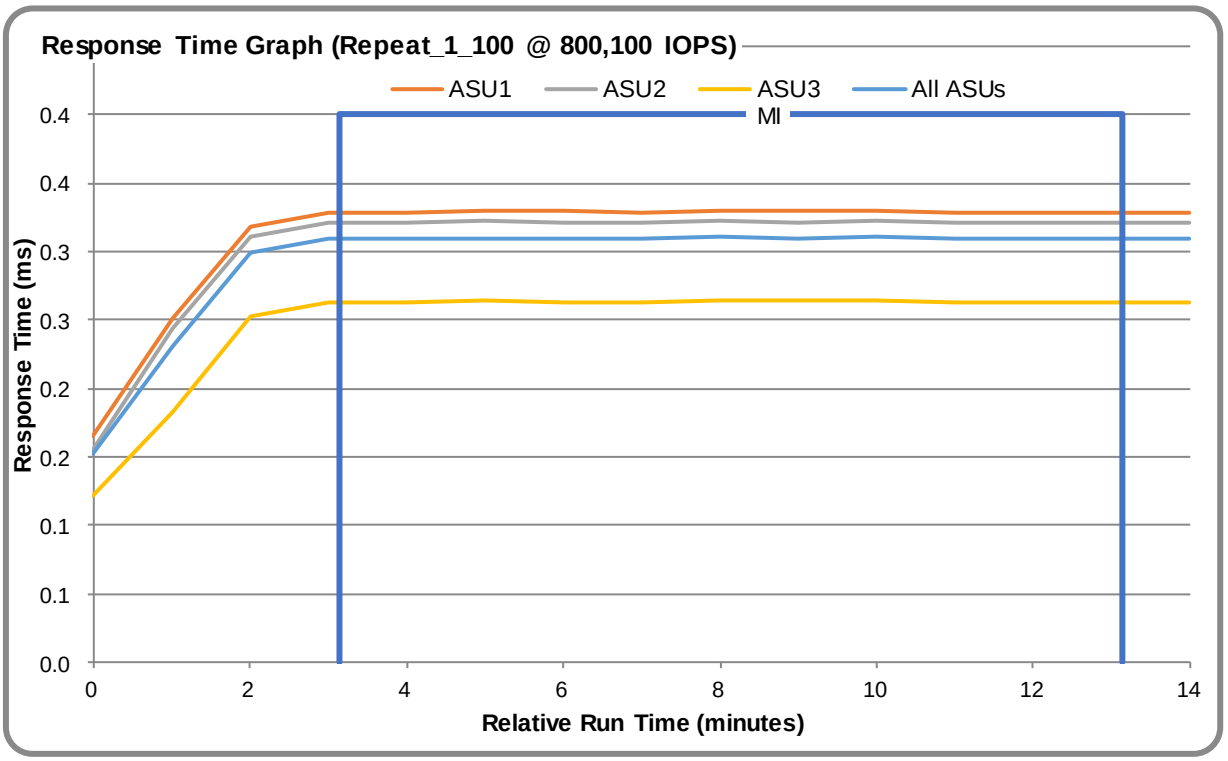
The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the table below.

Test Phase	100% IOPS	10% IOPS
RAMPD	800,140.9	80,002.5
REPEAT_1	800,208.7	80,007.3
REPEAT_2	800,152.8	80,023.2

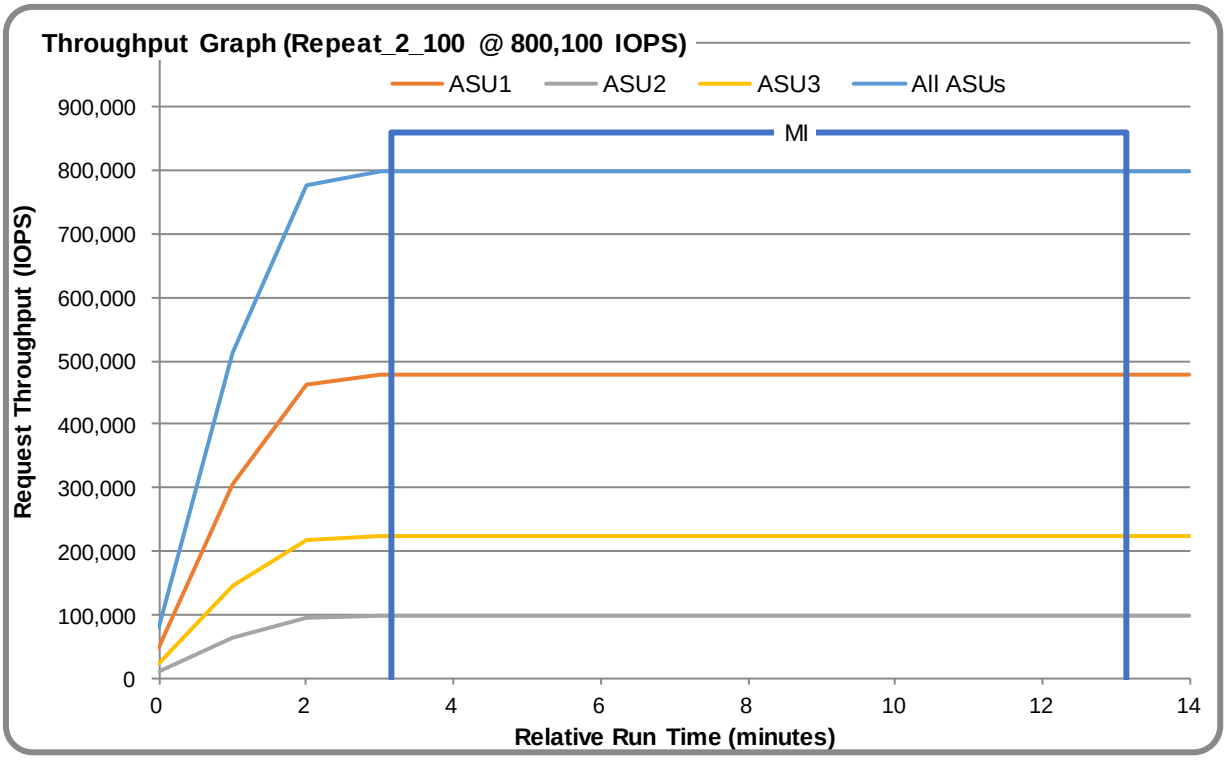
REPEAT_1_100 – Throughput Graph



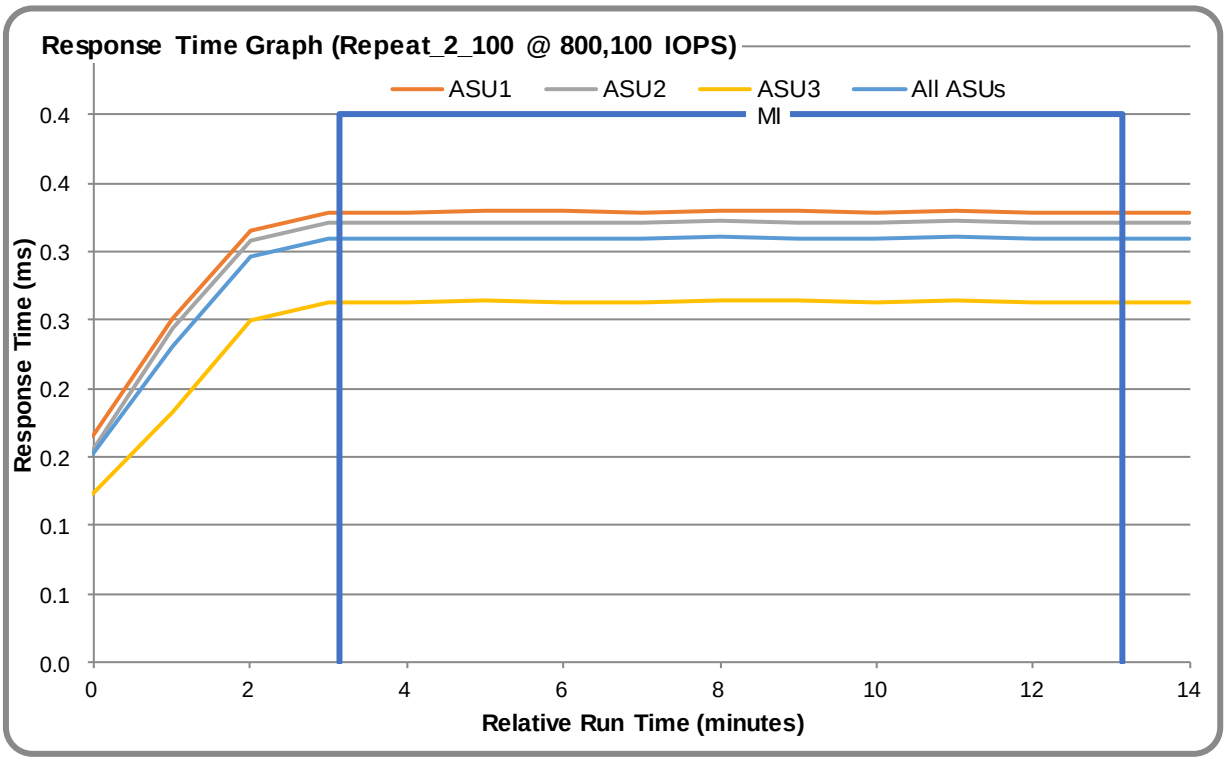
REPEAT_1_100 – Response Time Graph



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	0.0007	0.0002	0.0005	0.0003	0.0011	0.0005	0.0006	0.0001
Difference	0.005%	0.004%	0.010%	0.007%	0.011%	0.002%	0.014%	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	0.0009	0.0003	0.0007	0.0003	0.0011	0.0004	0.0006	0.0003
Difference	0.017%	0.007%	0.029%	0.006%	0.016%	0.020%	0.006%	0.003%

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	164,388,396
Total Number of Logical Blocks Verified	84,500,163
Total Number of Logical Blocks Overwritten	79,888,233
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

Redundantly configured batteries inside the ETERNUS AF650 S3 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**
AF650S3_20190911.exp	Configure CLI expect script	/D_Creation
AF650S3_20190911makeLV.sh	Linux LVM configuration script	/D_Creation
definitions.exp	Procedure definitions	/D_Creation
doFDRcfg.sh	Shell script to configure the array	/D_Creation
showFormatStatus.exp	Check for physical format progress	/D_Creation
/E_Inventory	**Configuration inventory**	**root**
log_BeforeF_AM191009170554.zlg_001.txt	Configuration details before the run	/E_Inventory
log_AfterJ_AM191009170554.zlg_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
SPC1_AF650S3_20190911.asu	ASU configuration file	/F_generator
SPC1_AF650S3_20190911.hst	Host configuration file	/F_generator

APPENDIX B: THIRD PARTY QUOTATION

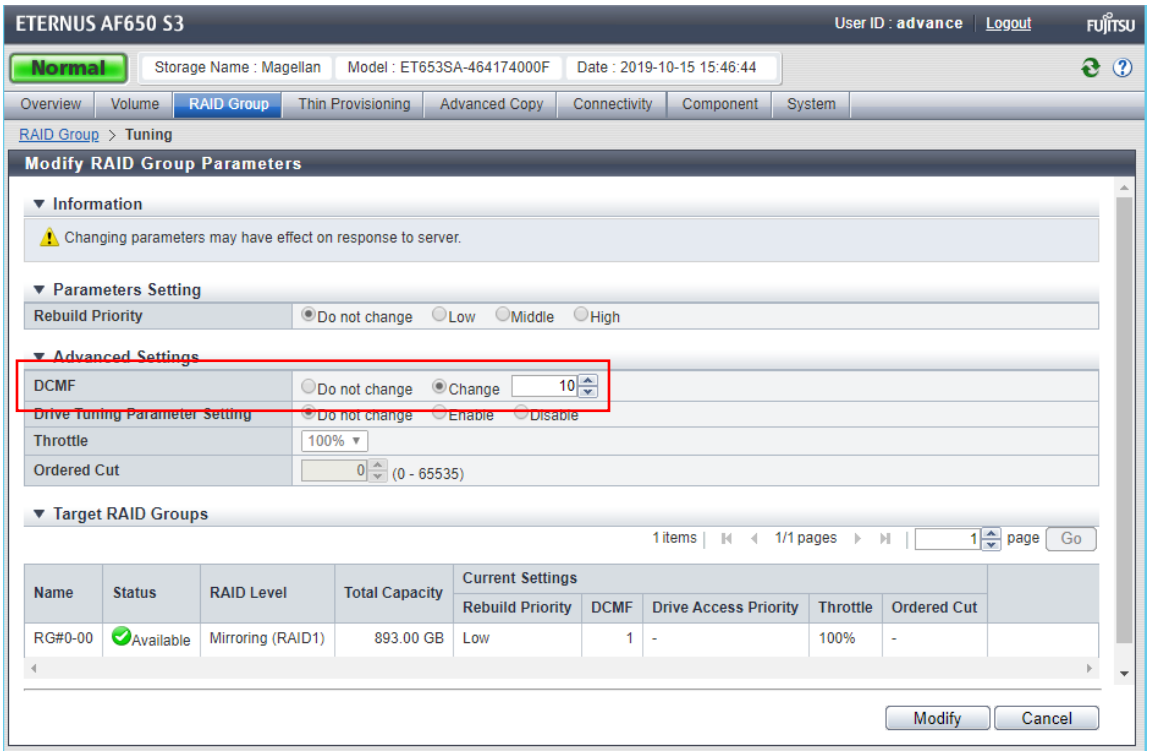
All components are available directly through the Test Sponsor (Fujitsu Limited).

APPENDIX C: TUNING PARAMETERS AND OPTIONS

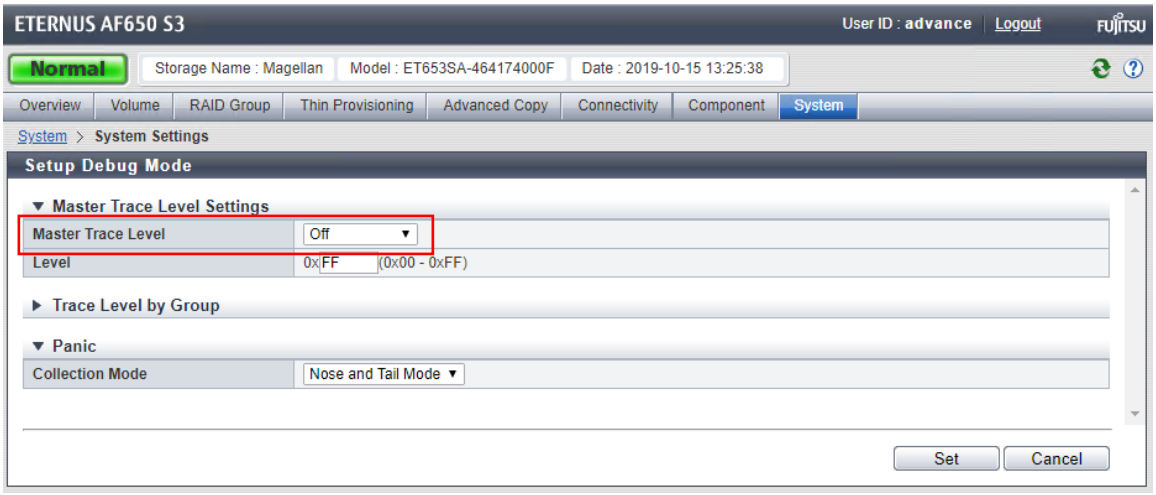
The standard Fujitsu GUI was used to apply the Tuning options for this test.

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:



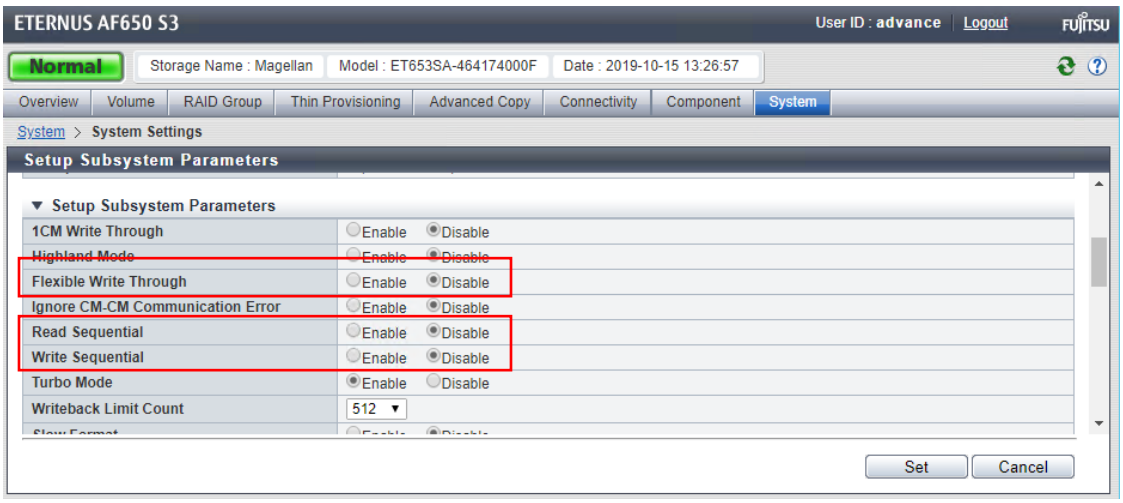
3. Disable Debug Trace
   The following GUI setting was applied:
   System-> System Settings -> Setup Debug Mode: The Master Trace Level was set to Off (Default: Standard)



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 AF650 S3 SPC-1 configuration.

The 'master' script, **doFDRcfg.sh**, was executed, which in turn, invoked the script, **AF650S3_20190911.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 **AF650S3_20190911.exp** script completed steps 1-4, described below for the 8-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 48 RAID Groups were created, according to the configuration plan, **ConfigurationDesign_AF650S3_20190911.xslx**, 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#0-00 through RG#1-23.

Step 2 – Creation of the Logical Volumes

4 wide striped logical volumes were created across 24 RAID Groups assigned to the same CM. Total of 8 wide striped logical volumes were created.

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 **AF650S3_20190911.exp** script provided mapping to 8 host ports.

The port LUN mapping was assigned for each of the Logical Volumes using 4 ports on Channel Adapters (CA) in each of the 2 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 same CM.

Step 5 – Creation of striped logical volumes.

Built in logical volume manager in Linux is used to stripe each LUN presented by ETERNUS AF650 S3 array.

This is done in 3 steps included in the **AF650S3_20190911makeLV.sh** script.

1. Create Physical Volumes (PV) for each LUN presented from AF650 S3.

   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000000000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000010000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000020000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000030000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000040000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000050000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000060000
   pvcreate /dev/disk/by-id/scsi-3600000e00d3000000300000000070000

2. Create one Volume Group with physical extent size of 512KiB

```
vgcreate asu_vg1 /dev/sda

vgextend asu_vg1 /dev/sdf

vgextend asu_vg1 /dev/sdb

vgextend asu_vg1 /dev/sdg

vgextend asu_vg1 /dev/sdc

vgextend asu_vg1 /dev/sdh

vgextend asu_vg1 /dev/sdd

vgextend asu_vg1 /dev/sdi
```

3. Create 20 Logical Volumes for each ASU with 512KiB Stripe size

   lvcreate -n asu101 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu102 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu103 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu104 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu105 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu106 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu107 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu108 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu109 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu201 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu202 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu203 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu204 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu205 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu206 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu207 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu208 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu209 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu301 -i 8 -I 512 -C y -L 1580096MiB asu_vg1
   lvcreate -n asu302 -i 8 -I 512 -C y -L 1580096MiB asu_vg1

Referenced Scripts

- doFDRcfg.sh
- AF650S3_20190911.exp
- showFormatStatus.exp
- AF650S3_20190911makeLV.sh

APPENDIX E: CONFIGURATION INVENTORY

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

- log_BeforeF_AM191009170554.zlg_001.txt
- log_AfterJ_AM191009170554.zlg_001.txt

APPENDIX F: WORKLOAD GENERATOR

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

- SPC1_AF650S3_20190911.asu

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

- SPC1_AF650S3_20190911.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_01.sh and doFDRall_02.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