SPC Benchmark 1™

Full Disclosure Report

Fujitsu Limited
Eternus AF650 S2

SPC-1 V3.5.0

Submission Identifier: A32004

Submitted For Review: January 19, 2018

Second Edition – February 2018

Trademarks

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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.storageperformance.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
Certified Auditor

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

January 16, 2018

I verified the SPC Benchmark 1™ (SPC-1™ V3.5.0) test execution and performance results of the following Tested Storage Product:

ETERNUS AF650 S2

The results were:

SPC-1 IOPS™	**620,153**
SPC-1 Price-Performance™	**$0.27/SPC-1 IOPS™**
SPC-1 IOPS™ Response Time	0.372 ms
SPC-1 Overall Response Time	0.248 ms
SPC-1 ASU Capacity	9,073 GB
SPC-1 ASU Price	$18.45/GB
SPC-1 Total System Price	$167,308.70

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 v03.00.2551. 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.storageperformance.org under the Submission Identifier A32004.

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

LETTER OF GOOD FAITH

FUJITSU

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

December 13, 2017
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 AF650 S2

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 V3.5 of the SPC-1 benchmark specification.

In addition, we have reported any items in the benchmark configuration and execution of the benchmark necessary to reproduce the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed: Date:

Yoshinori Terao
Vice President, System Development Div. II

December, 13, 2017

SPC Benchmark 1™ V3.5.0   Full Disclosure Report   Submission Identifier: A32004
Fujitsu Limited   Submitted for Review: January 19, 2018
Eternus AF650 S2

SPC BENCHMARK 1™

EXECUTIVE SUMMARY

FUJITSU LIMITED
ETERNUS AF650 S2

SPC-1 IOPS™	**620,153**
SPC-1 Price-Performance™	**$269.79/SPC-1 KIOPS™**
SPC-1 IOPS™ Response Time	0.372 ms
SPC-1 Overall Response Time	0.248 ms
SPC-1 ASU Capacity	9,073 GB
SPC-1 ASU Price	$18.45/GB
SPC-1 Total System Price	$167,308.70
Data Protection Level	Protected 2 (RAID1)
Physical Storage Capacity	25,600 GB
Pricing Currency / Target Country	U.S. Dollars / USA

SPC-1 V3.5.0

SUBMISSION IDENTIFIER: A32004

SUBMITTED FOR REVIEW: JANUARY 19, 2018

Benchmark Configuration Diagram

ETERNUS AF650S2 Drive Enclosures
4 x w/ 16 drives each (total 64 drives)

DE10

DE00

DE30

DE20

8 x 12Gbps SAS-3 x4 Links

AF650S2 Control Enclosure
(2 Controllers, 256 GB memory,
4 x 4 port 16Gbps FC Channel Adapters)

Standard Fujitsu
42 U Rack
with dual 20A 240VAC
PDU

4 x 16Gbps
Fibre Channel
Links

4 x 16Gbps
Fibre Channel
Links

4 x 16Gbps
Fibre Channel
Links

4 x 16Gbps
Fibre Channel
Links

4 x Fujitsu PRIMERGY
RX2540M4 Servers each with:
2 x 2.7GHZ Intel Xeon Platinum 8168 CPUs,
384GB memory,
2 x LPE16002 HBAs

Tested Storage Product Description

The ETERNUS AF650 S2 is the ideal choice for application scenarios with demanding data and performance requirements. The system delivers impressive IOPS performance with lowest latency even at full load. Thus, it offers a solution that resolves all performance issues in critical applications – such as real-time business analytics or VDI environments - without requiring any complicated tuning. It also fits best as general-purpose storage for all Tier-1 applications in small and mid-sized companies.

Priced Storage Configuration Components

| |
|---|
| **8 x Emulex LPE16002 dual port 16 Gb Fibre Channel HBAs** |
| **1 x AF650 S2, with:**
       2 x Controller Modules (CM) each with:
              256 GB cache (512 GB total)
              2 x Channel Adapter (CA) each with
                    4 x 16 Gps Fibre Channel Host Ports
       64 x 400 GB SSD devices (without Hot Spare) |

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Storage Configuration Pricing

Product ID	Description	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
	Hardware & Software					
ET652SAU	ETERNUS AF650 S2	1	$84,770.00	84,770	50%	42,385.00
ETQEADAU	Drive enclosure for AF650	4	$4,700.00	18,800	50%	9,400.00
ETQHH8A	Host interface for AF650(16Gbit/s, FC, 8port)	2	$8,310.00	16,620	50%	8,310.00
ETQSAF2	Value SSD(2.5inch) 400GB x12 for AF650	5	$20,900.00	104,500	50%	52,250.00
ETQSAF1	Value SSD(2.5inch) 400GB x1 for AF650	4	$2,100.00	8,400	50%	4,200.00
S26361-F4994-L502	PFC EP LPe16002	8	$1,373.00	10,984	50%	5,492.00
ETPKC10U	AC Power Cords (125V - IEC320-C14, 0.5m)	5	$130.00	650	50%	325.00
ETPP12U-L	Power Distribution Unit for DX (AC240V, 6 enclosures, 2RU)	1	$2,170.00	2,170	50%	1,085.00
PYRACK_S26361-K827-V340_206528-02	PRIMECENTER M1 RACK 642S (42U, 1050x600mm) with Front & Rear Doors, side panels	1	$3,157.00	3,157	50%	1,578.50
61-343827-003	LC-LC 10 GIGABIT MULTIMODE OM3 LASER OPTIMIZED DUPLEX 50/125 FIBER PATCH CABLE RISER RATED AQUA - 5M	16	$140.00	2,240	50%	1,120.00
				Hardware & Software Subtotal		**126,145.50**
	Support & Maintenance					
	Provide 24 hour per day / 7days per week 4 hour response maintenance for 36 months					
ETAF65-W059360-AED	ETERNUS AF650 Warranty, 36 Months, Basic Level, 12x5 Phone Support, 9x5 NBD Onsite	1	0	0	20%	0.00
ETAF65-U004361-AED	ETERNUS AF650 Warranty Uplift, 36 Months, Enhanced Plus Level, 24x7 4hr Onsite, Prepaid billing	1	51,454	51,454	20%	41,163.20
				Support & Maintenance Subtotal		**41,163.20**
	SPC-1 Total System Price					**167,308.70**
	SPC-1 IOPS™					620,153
	SPC-1 Price-Performance™ ($/SPC-1 KIOPS™)					**269.79**
	SPC-1 ASU Capacity (GB)					9,073
	SPC-1 ASU Price ($/GB)					**18.45**

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: January 24, 2018.

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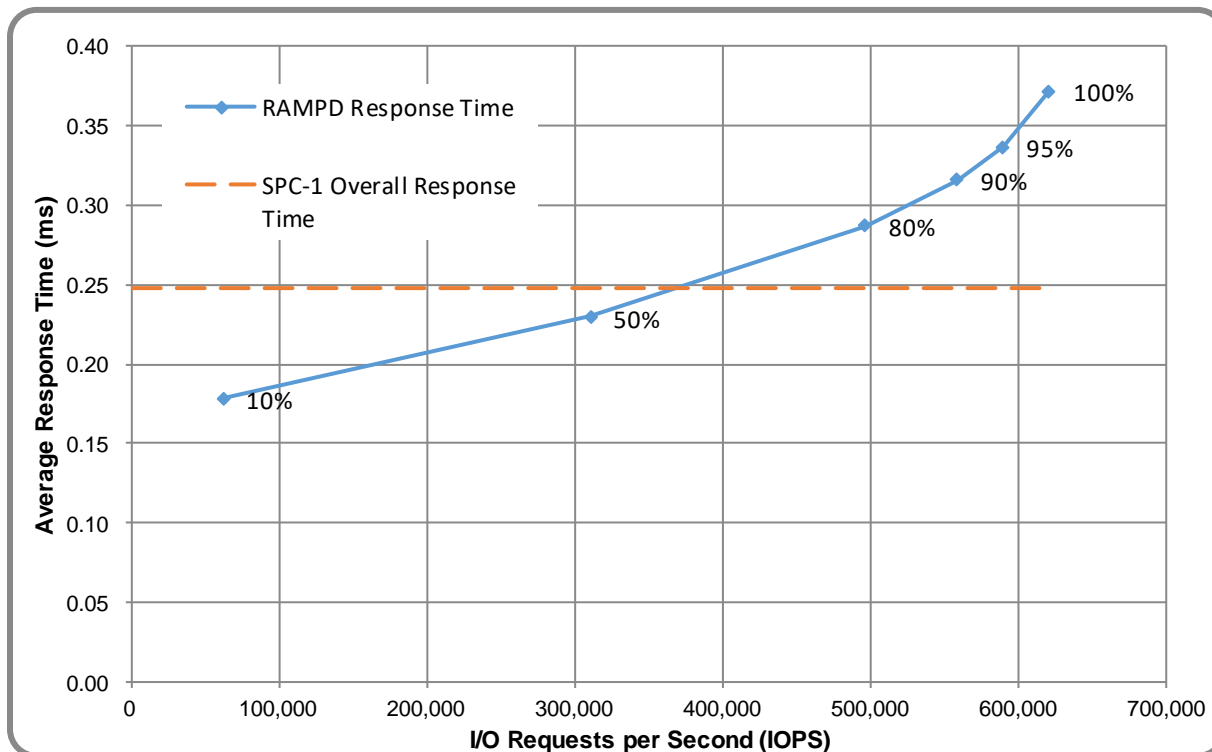
Contact Information	
Test Sponsor Primary Contact	Fujitsu Limited – http://www.fujitsu.com/services/computing/storage/ Kun Katsumata – kkatsumata@us.fujitsu.com
SPC Auditor	InfoSizing – www.sizing.com Doug Johnson – doug@sizing.com

Revision Information	
SPC Benchmark 1™ Revision	V3.5.0
SPC-1 Workload Generator Revision	V 03.00.2551
Publication Revision History	• First Edition: January 19, 2018 • Second Edition: February 15, 2018 o Updated SPC-1 Price-Performance™ metric based on SPC-1 v3.6.0 definition.

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).
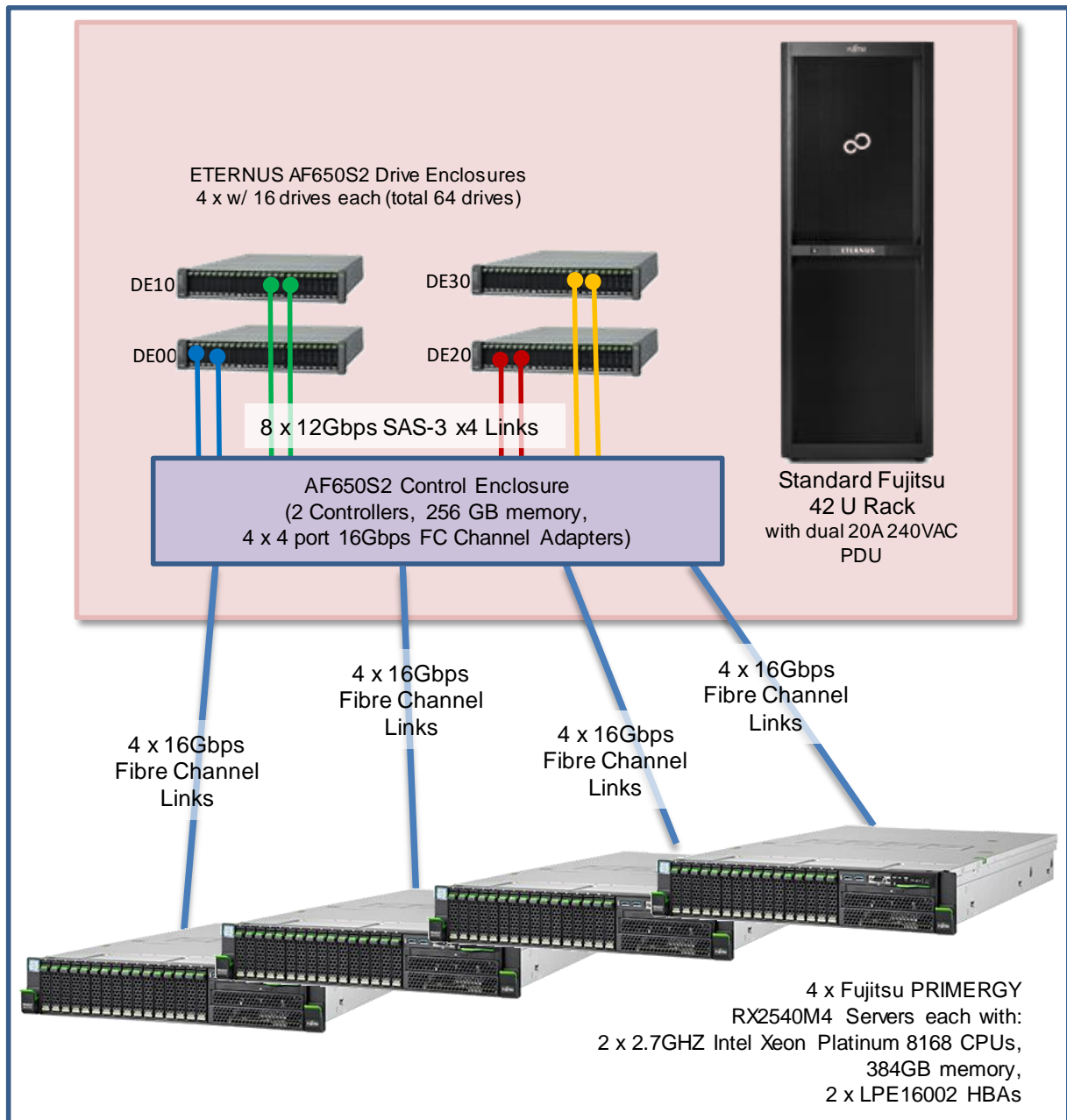
Storage Network Configuration

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 Tested Storage Configuration (TSC).

Host Systems
4 x Fujitsu PRIMERGY RX2540 M4 Servers, each with :
4 x Intel Xeon Platinum 8168 (2.70 GHz, 48 Cores, 33 MB L3)
384 GB Main Memory
Red Hat Enterprise Linux Server release 6.9
Tested Storage Configuration
8 x Emulex LPE16002 dual port 16 Gb Fibre Channel HBAs
1 x AF650 S2, with:
2 x Controller Modules (CM) each with:
256 GB cache (512 GB total)
2 x Channel Adapter (CA) each with
4 x 16 Gps Fibre Channel Host Ports
64 x 400 GB SSD devices (without Hot Spare)

Differences Between Tested and Priced Storage Configurations

The TSC was configured with a Fujitsu Standard 42 U Rack. The PSC has a Standard PRIMECENTER 42 U Rack. If the TSC had been configured with a Standard PRIMECENTER 42 U Rack 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

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Fujitsu Limited   Submitted for Review: January 19, 2018
Eternus AF650 S2

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	1	5,648	4,080	4,080	45.0%
ASU-2	1	5,648	4,080	4,080	45.0%
ASU-3	1	1,245	913	913	10.1%
			SPC-1 ASU Capacity	9,073	

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
400 GB SSD	64	400.0	25,600.0
Total Physical Capacity			25,600
Physical Capacity Utilization			35.44%

Data Protection

The data protection level used for all logical volumes 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.

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.
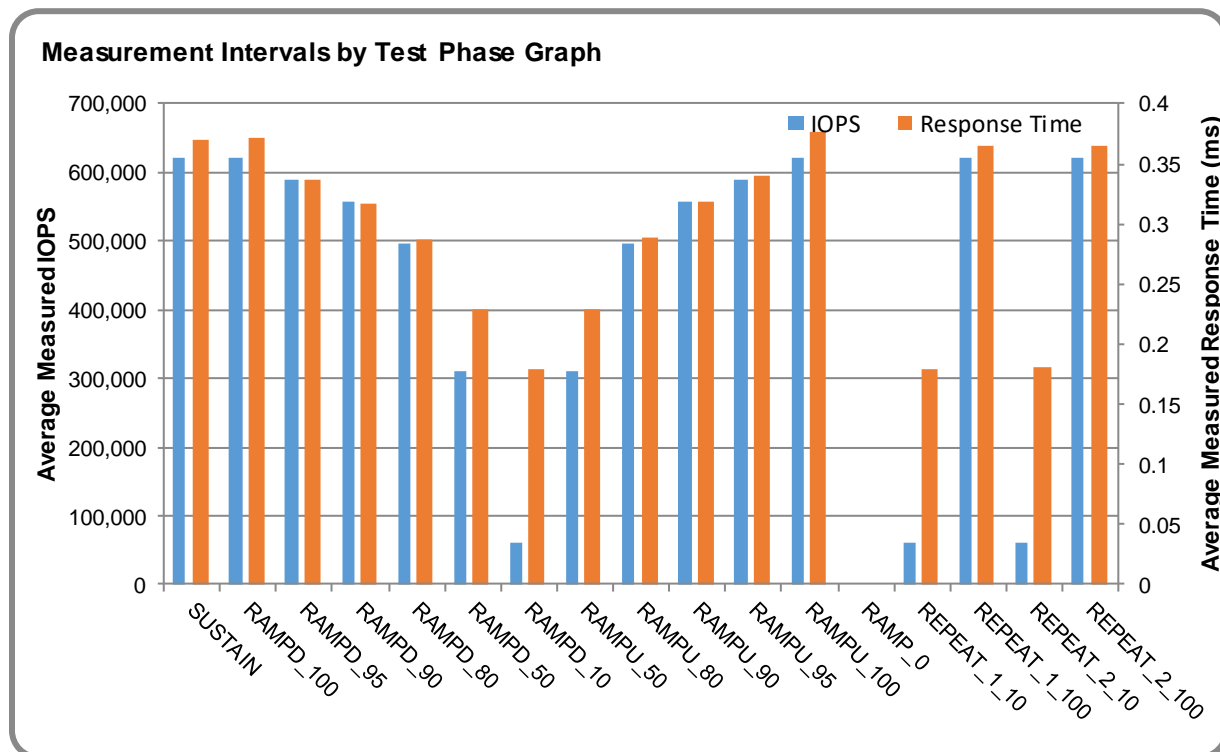
Exception and Waiver

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:
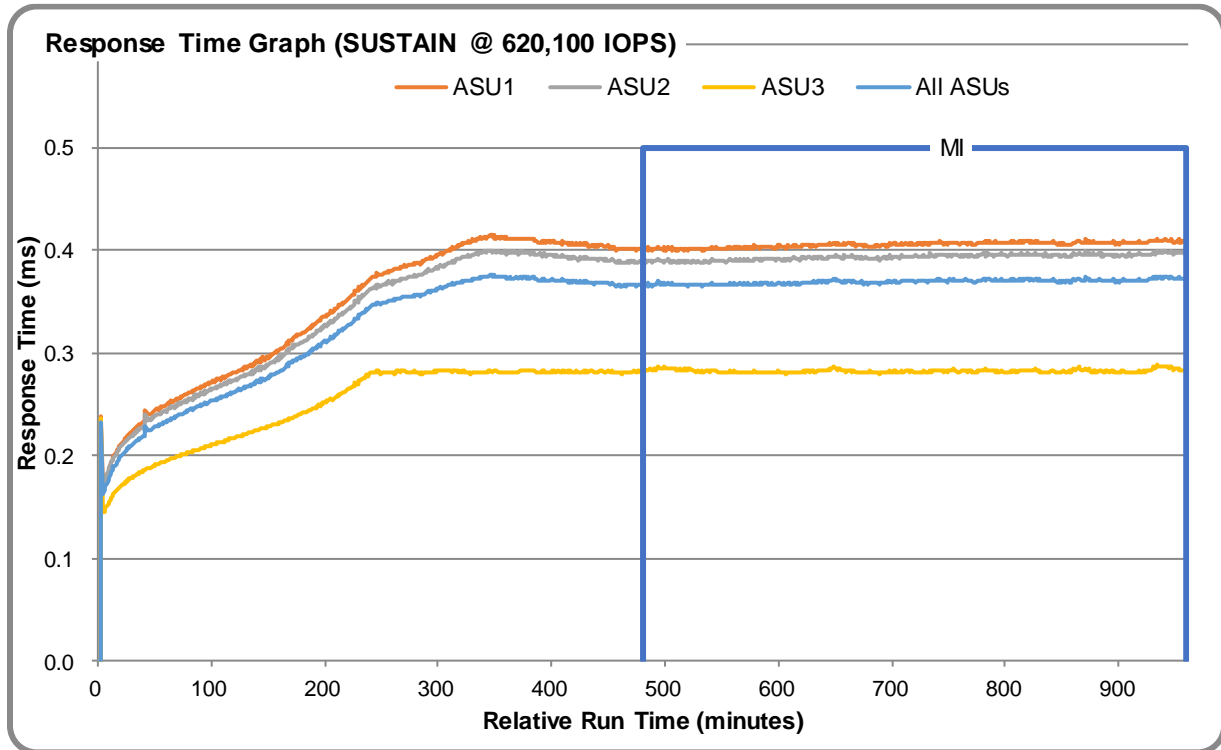
- **SPC1_METRICS_0_Raw_Results.xlsx**

SUSTAIN – Execution Times

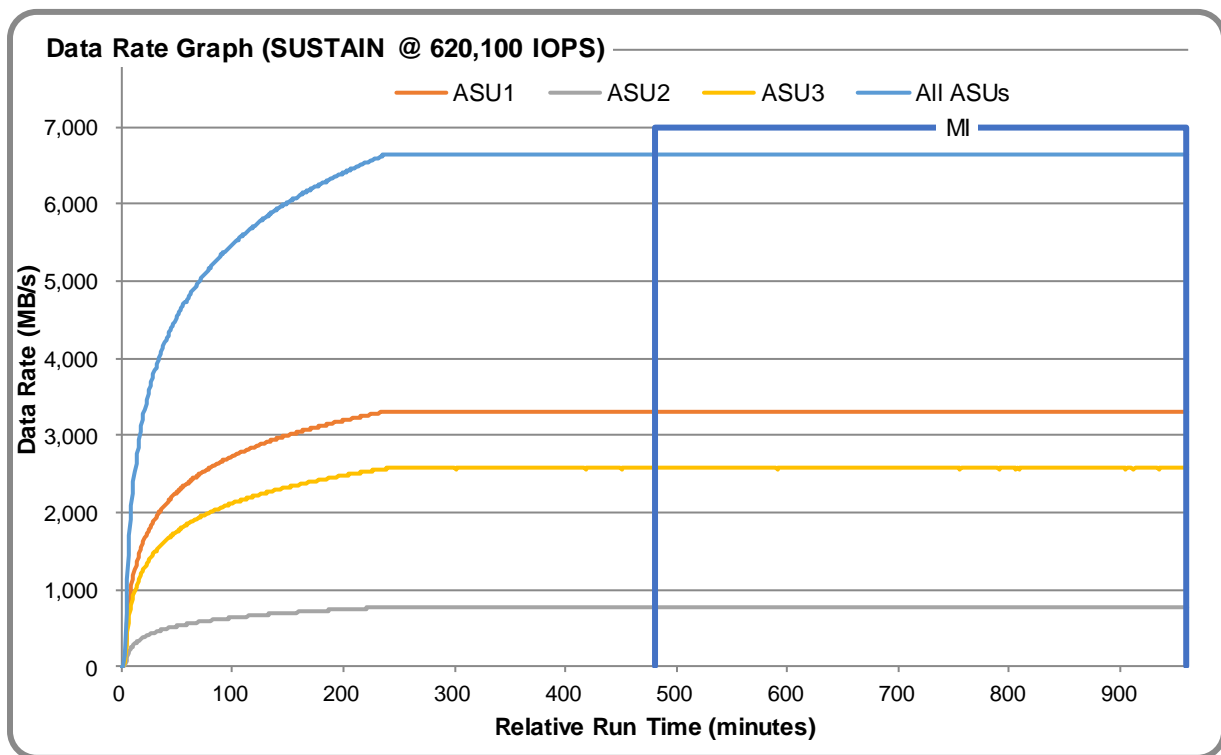| Interval	Start Date & Time	End Date & Time	Duration
Transition Period	12-Dec-17 12:54:33	12-Dec-17 20:54:30	7:59:57.248
Measurement Interval	12-Dec-17 20:54:30	13-Dec-17 04:54:31	8:00:01.000

SUSTAIN – Throughput Graph
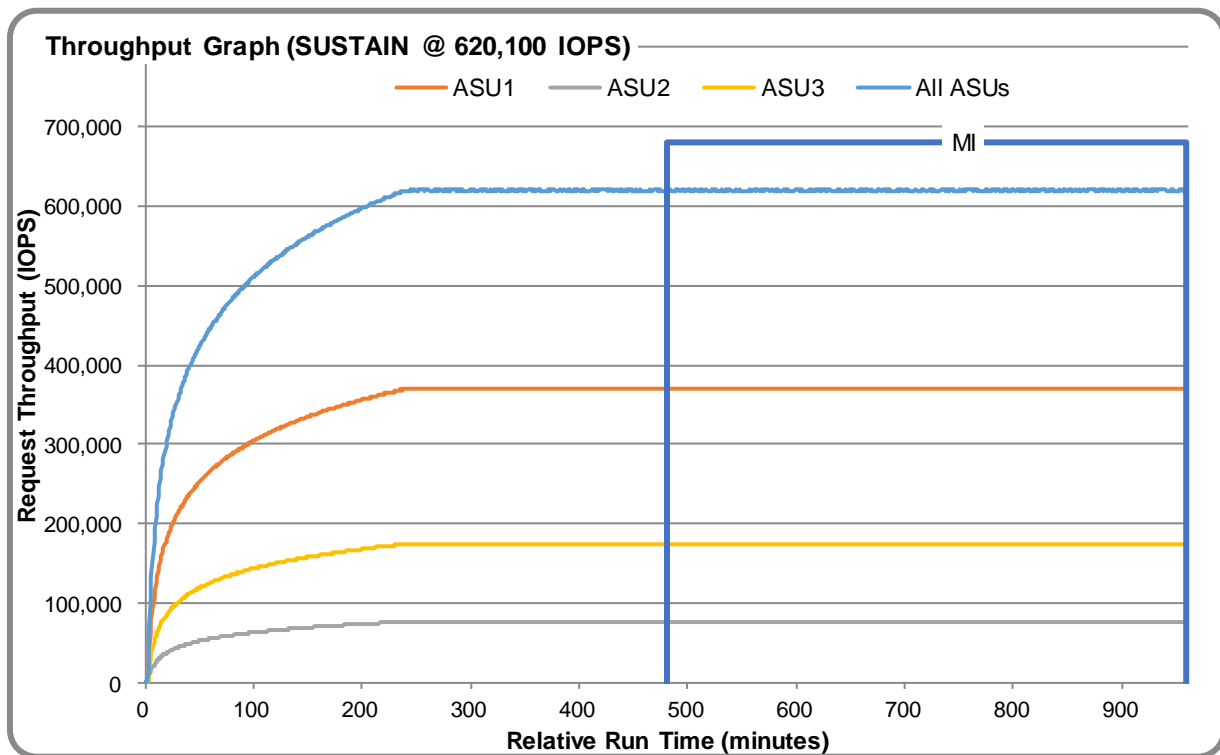
SUSTAIN – Response Time Graph

Response Time Graph (SUSTAIN @ 620,100 IOPS)

SUSTAIN – Data Rate Graph

Data Rate Graph (SUSTAIN @ 620,100 IOPS)

SUSTAIN – Response Time Frequency Graph
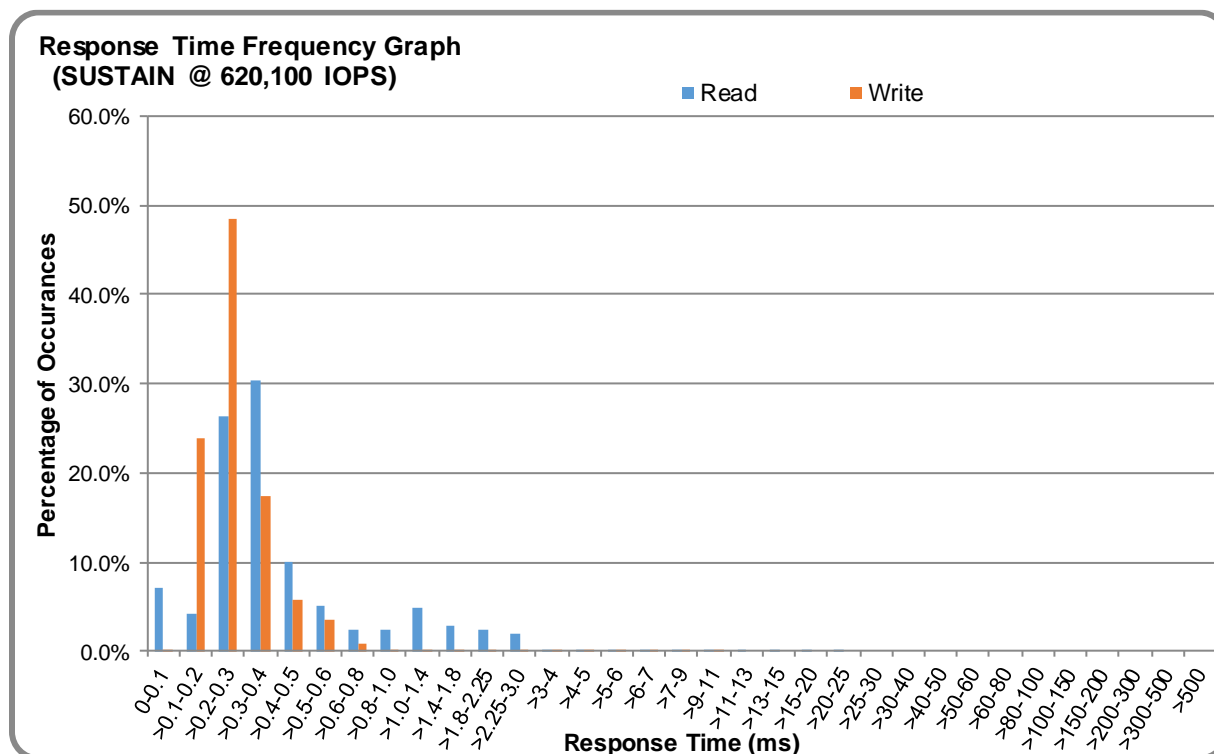
SUSTAIN – Intensity Multiplier

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	0.0009	0.0003	0.0006	0.0003	0.0013	0.0006	0.0009	0.0003
Difference	0.002%	0.002%	0.004%	0.001%	0.015%	0.003%	0.000%	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:
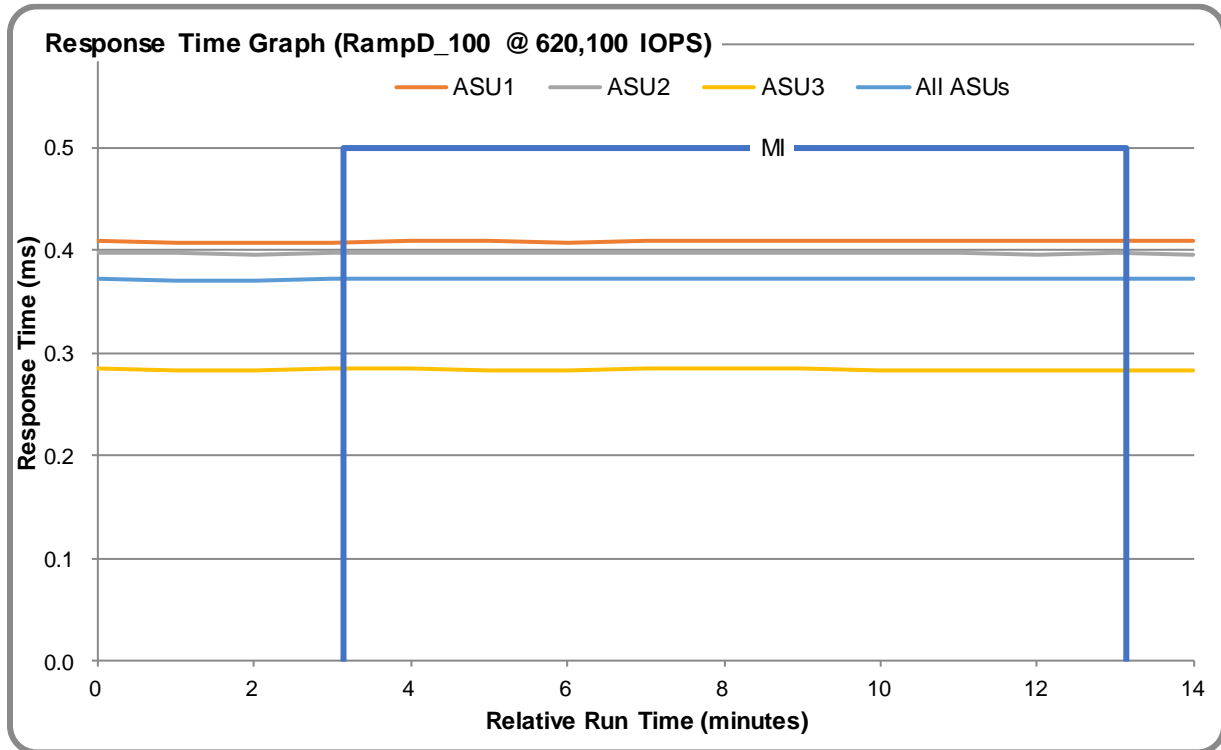
- **SPC1_METRICS_0_Raw_Results.xlsx**

RAMPD_100 – Execution Times

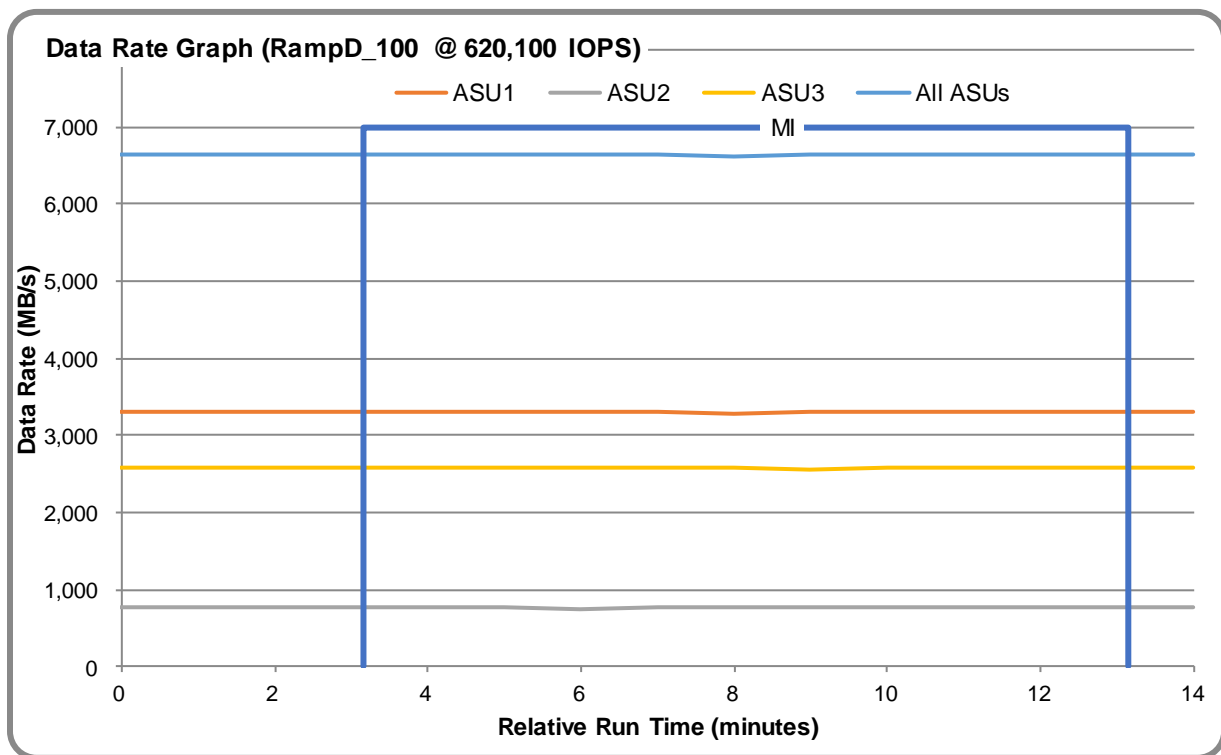| Interval	Start Time	End Time	Duration
Transition Period	13-Dec-17 04:55:31	13-Dec-17 04:58:31	0:03:00.000
Measurement Interval	13-Dec-17 04:58:31	13-Dec-17 05:08:32	0:10:01.000

RAMPD_100 – Throughput Graph
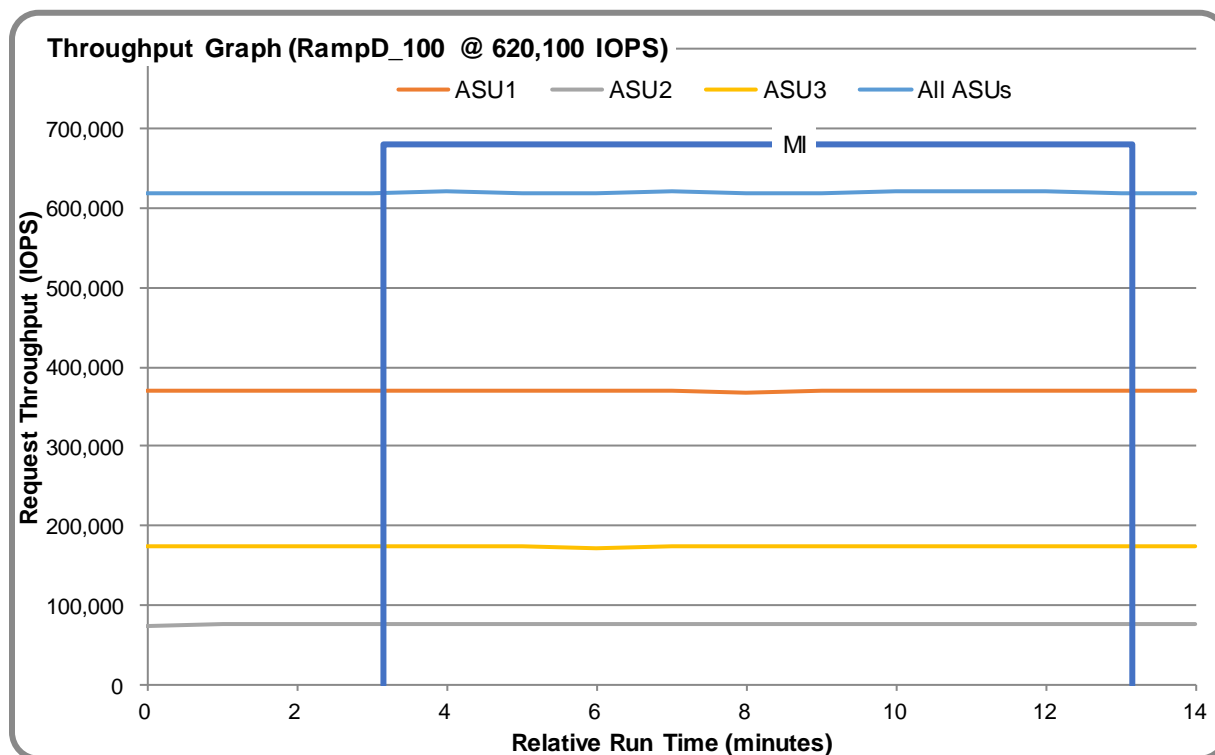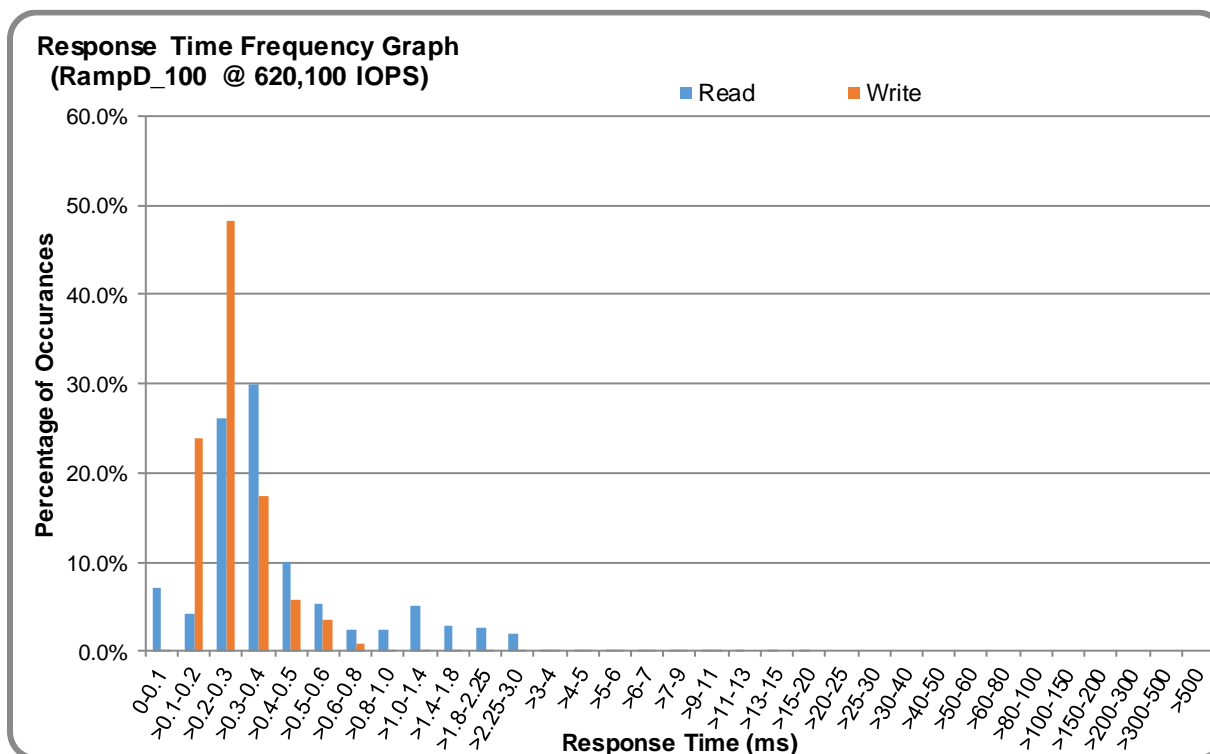
<u>RAMPD_100 – Response Time Graph</u>

<u>RAMPD_100 – Data Rate Graph</u>

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	0.0007	0.0002	0.0006	0.0003	0.0017	0.0004	0.0008	0.0003
Difference	0.022%	0.000%	0.020%	0.010%	0.013%	0.002%	0.011%	0.010%

RAMPD_100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	372,082,142
I/O Requests Completed with Response Time <= 30 ms	372,082,142
I/O Requests Completed with Response Time > 30 ms	0

Response Time Ramp Test
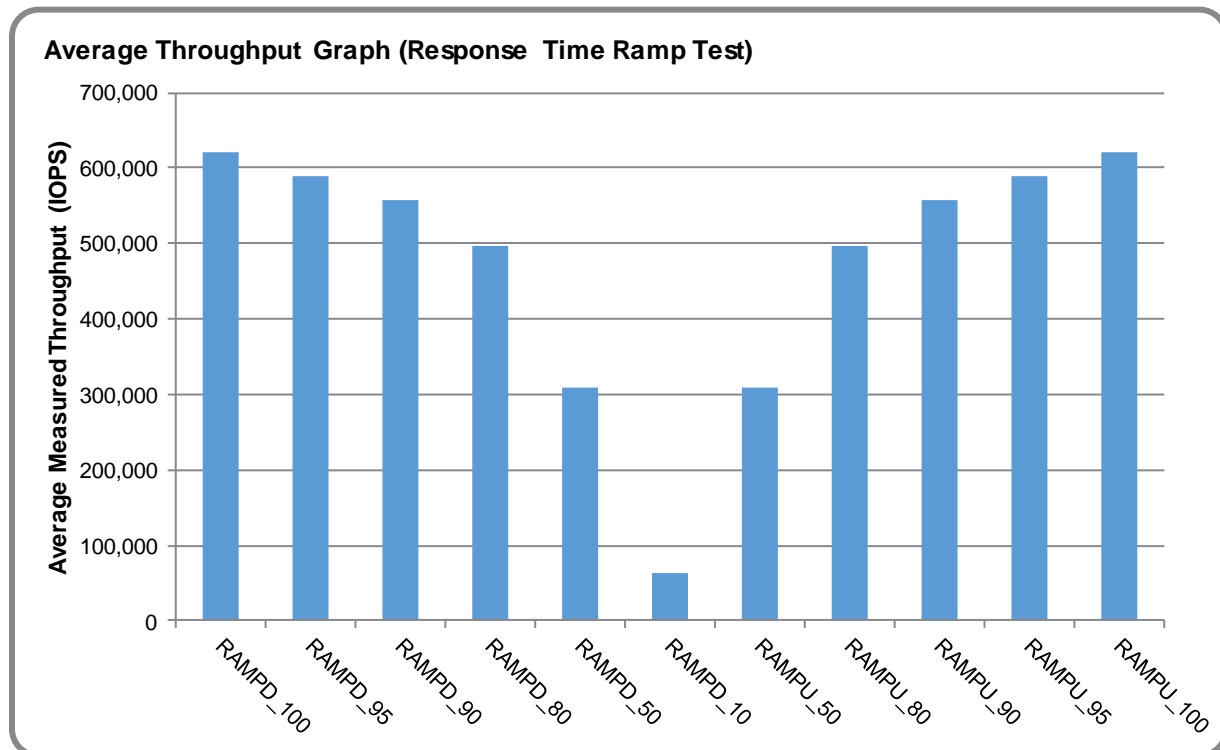
Response Time Ramp Test – Results File

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
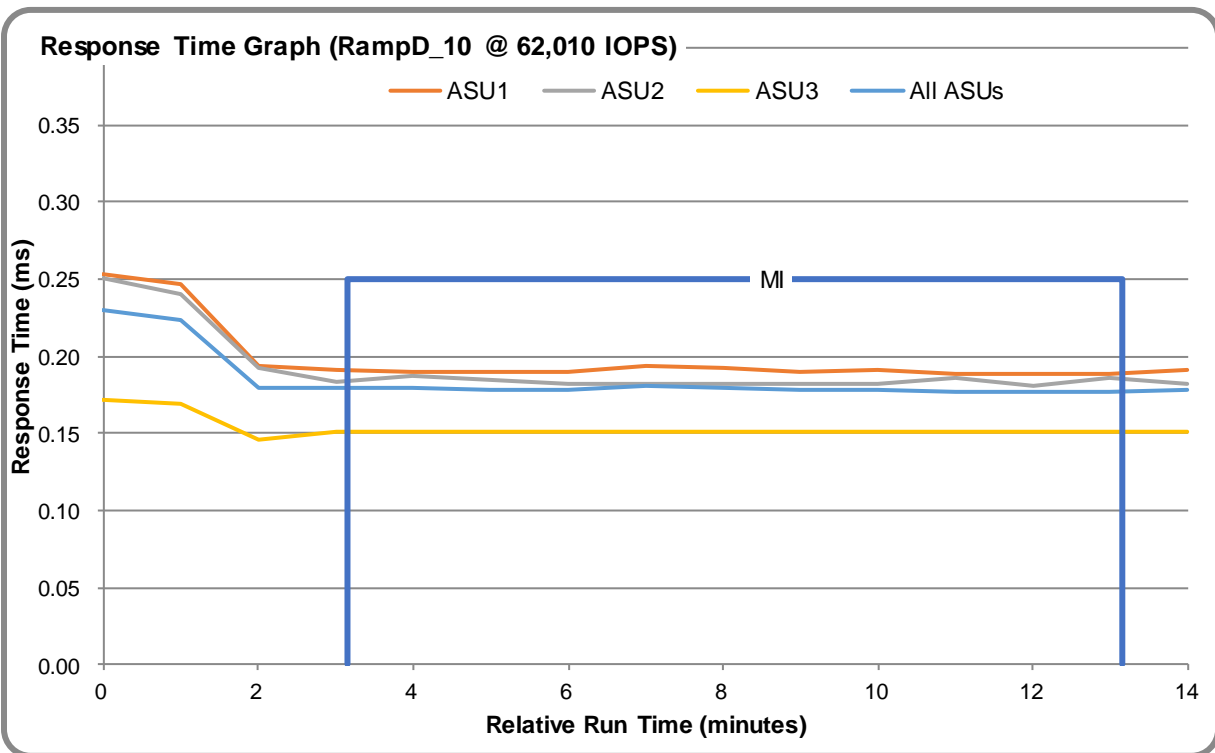
Response Time Ramp Test – Average Response Time Graph

Average Response Time Graph (Response Time Ramp Test)
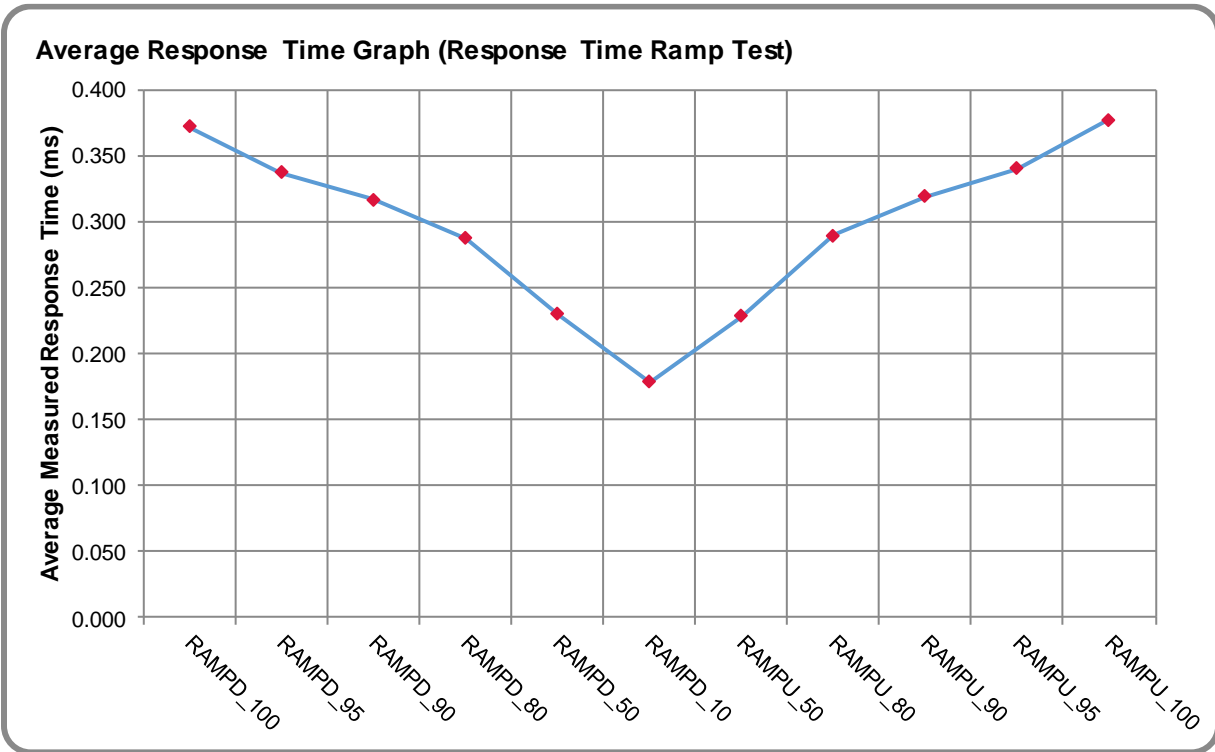
Response Time Ramp Test – RAMPD_10 Response Time Graph

Response Time Graph (RampD_10 @ 62,010 IOPS)

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	620,153.8	62,036.1
REPEAT_1	620,140.4	62,006.5
REPEAT_2	620,097.0	62,012.8

REPEAT_1_100 – Throughput Graph
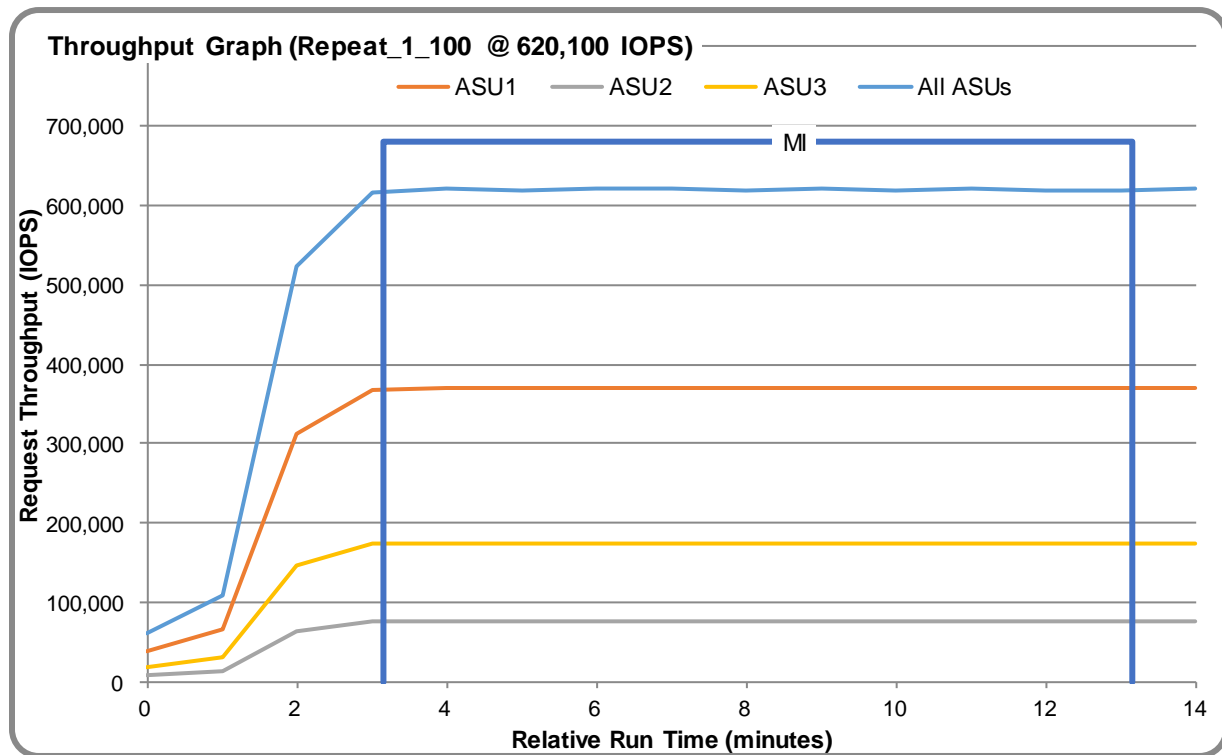
REPEAT_1_100 – Response Time Graph
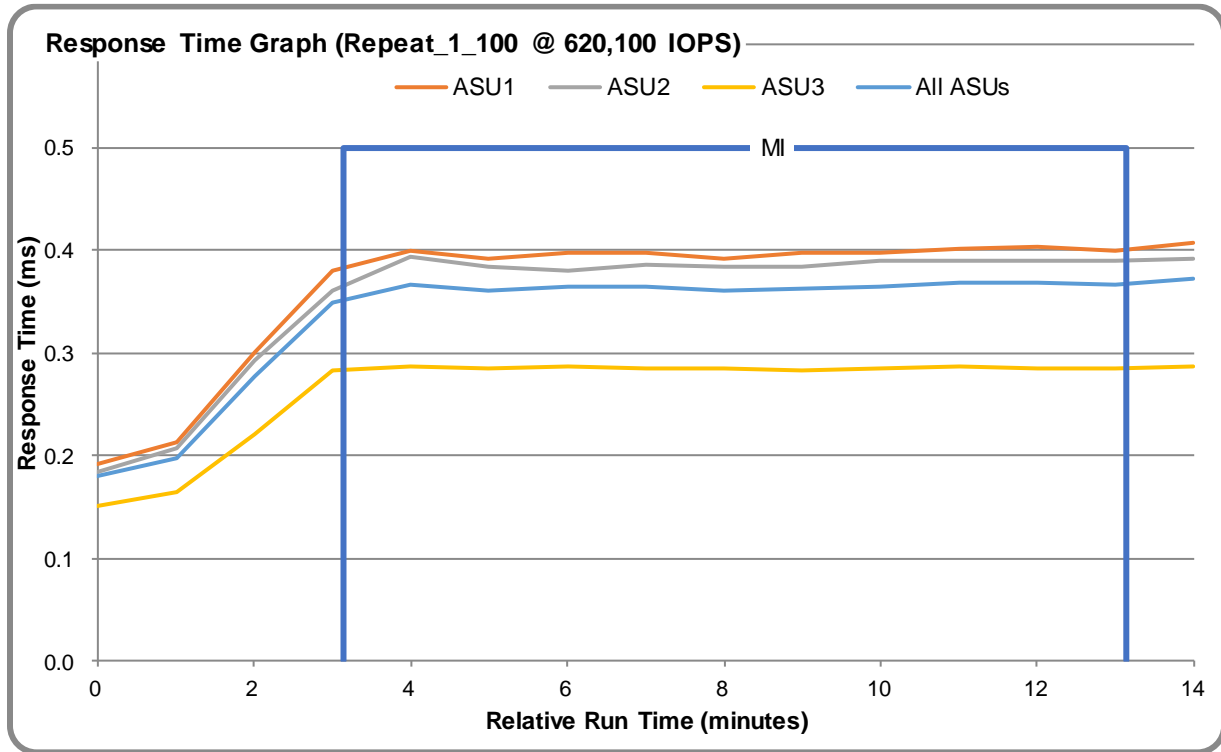
REPEAT_2_100 – Throughput Graph
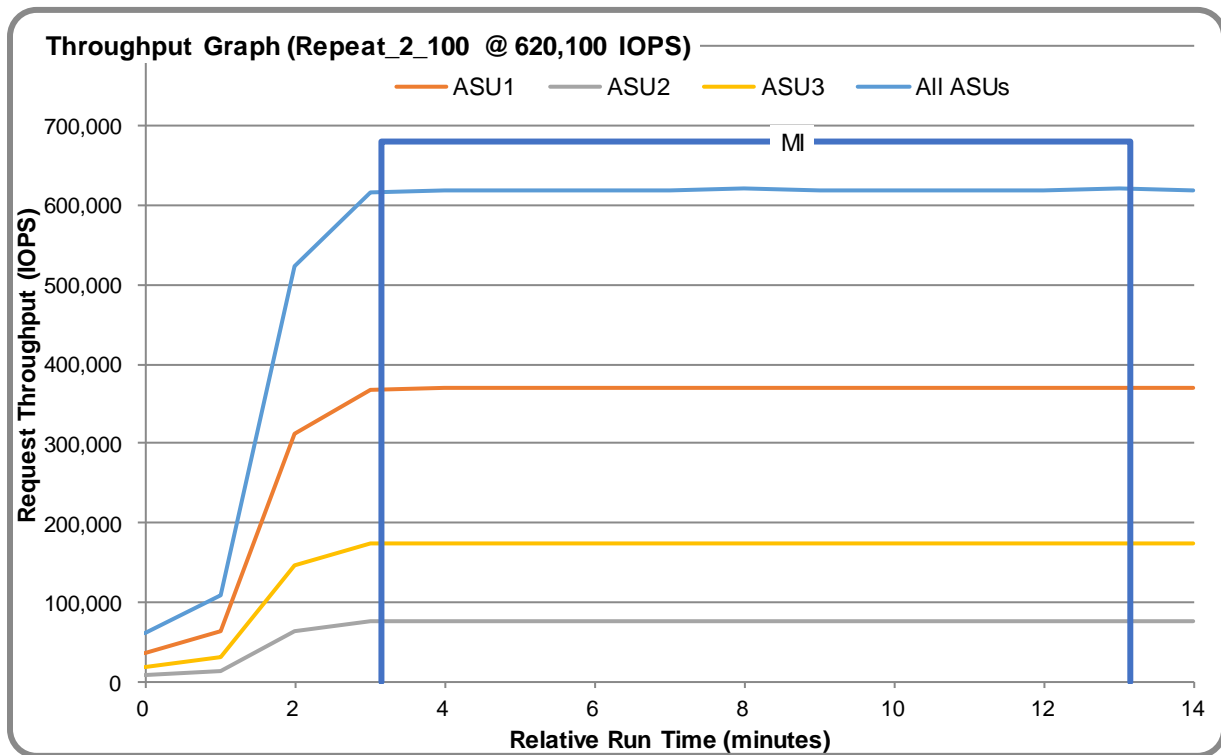
REPEAT_2_100 – Response Time Graph
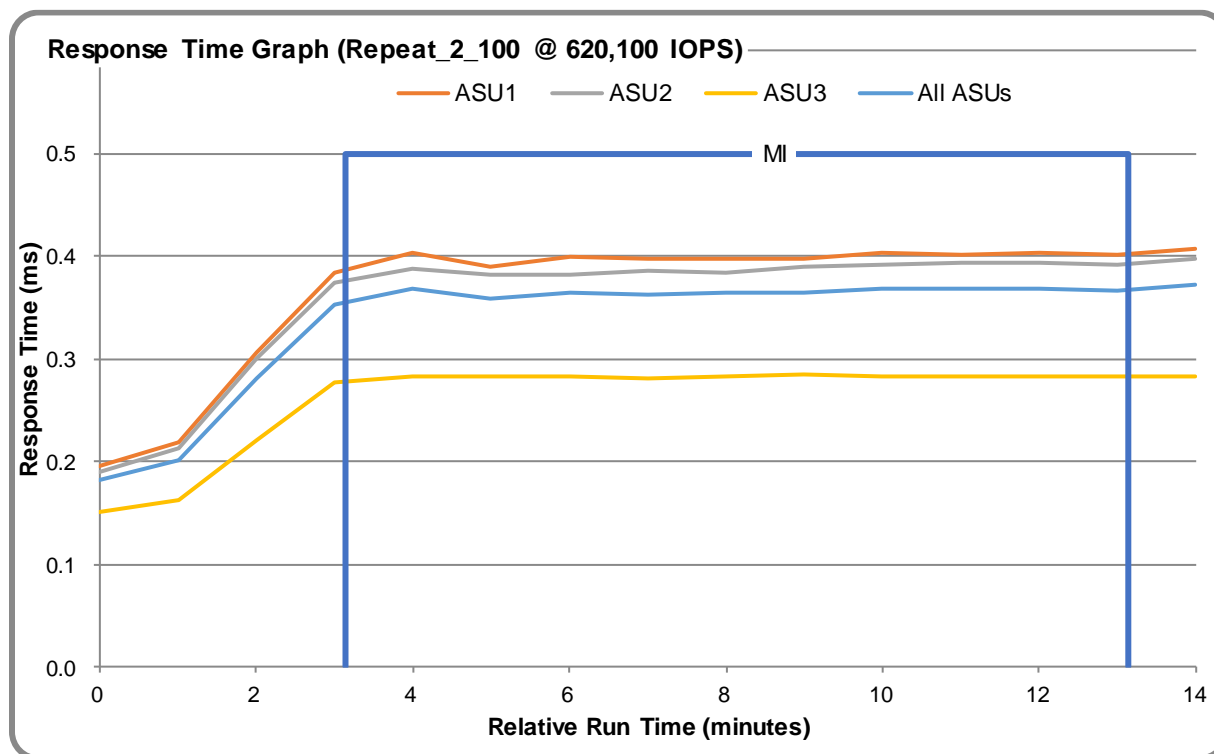
Repeatability Test – Intensity Multiplier

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	0.0008	0.0003	0.0004	0.0003	0.0012	0.0006	0.0006	0.0003
Difference	0.039%	0.002%	0.027%	0.001%	0.053%	0.007%	0.030%	0.001%

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	0.0011	0.0003	0.0005	0.0004	0.0014	0.0006	0.0005	0.0003
Difference	0.039%	0.000%	0.001%	0.018%	0.000%	0.022%	0.020%	0.015%

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	123,212,440
Total Number of Logical Blocks Verified	64,553,844
Total Number of Logical Blocks Overwritten	58,658,596
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 AF650S2 storage systems 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**
doFDRcfg.sh	Shell script to configure the array	/D_Creation
definitions.exp	Procedure definitions	/D_Creation
AF650S2_20171026.exp	Configuration CLI expect script	/D_Creation
showFormatStatus.exp	Check for physical format progress	/D_Creation
AF650S2_20171026makeLV.sh	Linux LVM configuration script	/D_Creation
/E_Inventory	**Configuration inventory**	**Root**
log_BeforeF_JX171212121747.zlg_001.txt	Configuration details before the run	/E_Inventory
log_AfterJ_JX171212121747.zlg_001.txt	Configuration details after the run	/E_Inventory
/F_Generator	**Workload generator**	**root**
SPC1.AF650S2_20171026.asu	ASU configuration file	/F_generator
SPC1.AF650S2_20171026.hst	Host configuration file	/F_generator

# APPENDIX B: THIRD PARTY QUOTATION

All components are directly available through the Test Sponsor.

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 a 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 the red frame below:
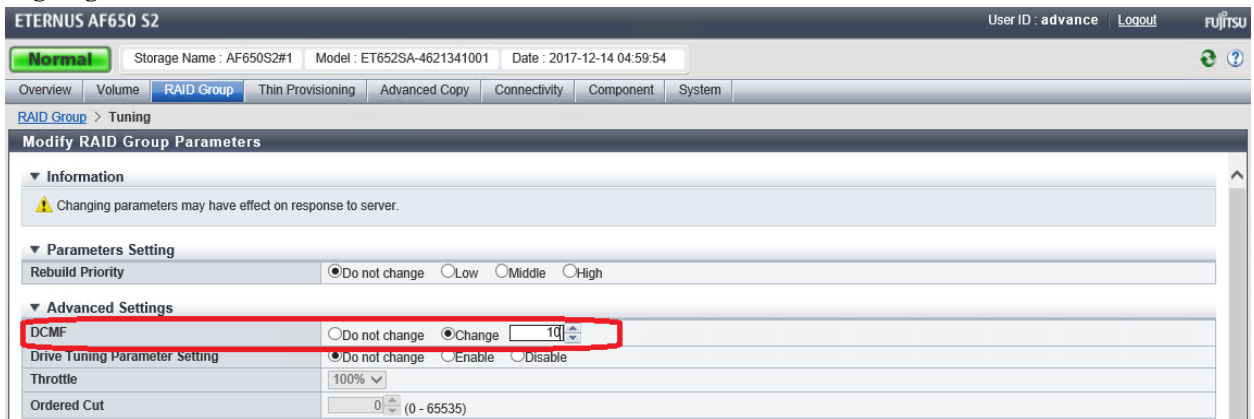
3. Disable Debug Trace
   Following GUI setting was applied.
   System-> System Settings -> Setup Debug Mode: The Master Trace Level was set to Off (Default: Standard)
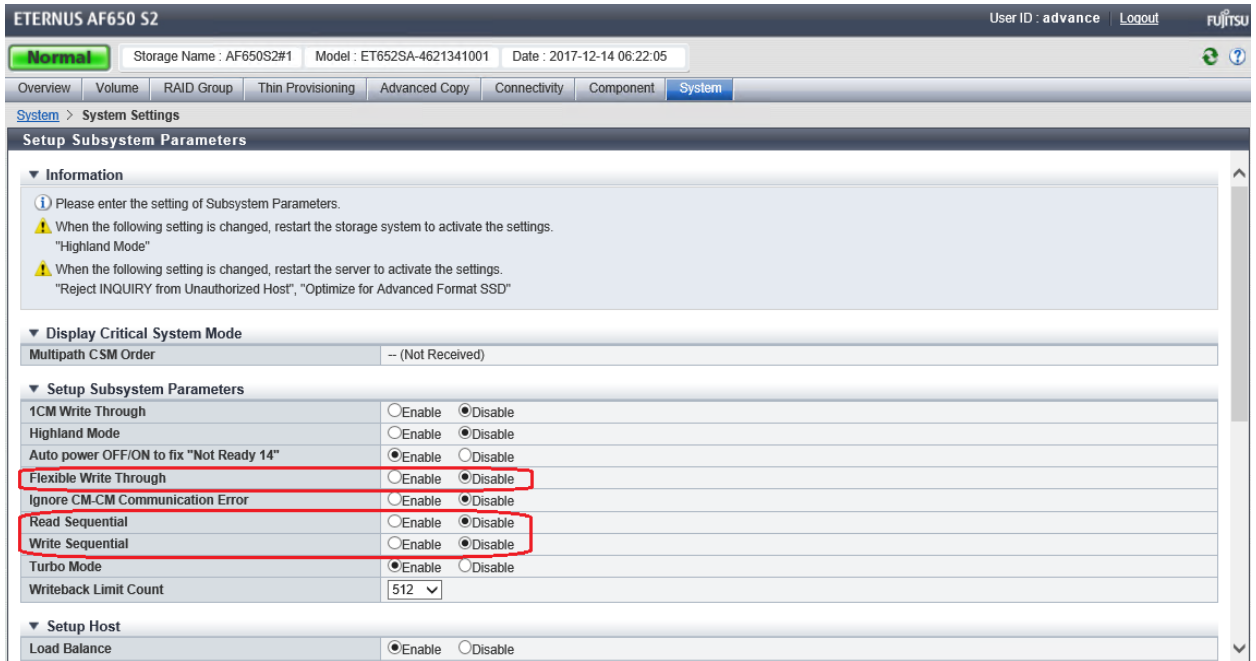
4. Disable Read Sequential/Write Sequential
   Following GUI setting was applied.
   System-> System Settings -> Setup Subsystem Parameters:

   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 S2 SPC-1 configuration.

The 'master' script, **doFDRcfg.sh**, was executed, which in turn, invoked the script, **AF650S2_20171026.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 **AF650S2_20171026.exp** script completed steps 1-4, described below for the 16 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

After deletion of existing configuration, if any, total of 32 RAID Groups were created, according to the configuration plan, **ConfigurationDesign_AF650S2_20171026.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 RG00 through RG31.

Step 2 – Creation of the Logical Volumes

Wide striped logical volumes were created across 2 sets of RAID Groups (each with 16 RAID Groups). Three volumes were created on each of the RAID Groups, one for each of the three ASUs, for a total of 6 logical volumes. The sizes of two volumes created on the 2 sets for ASU-1 and ASU-2 were set to 2630 GiB each. The sizes of the volume on the 2 sets for ASU-3 were set to 580 GiB each.

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 **AF650S2_20171026.exp** script provided mapping to 16 host ports.

The port LUN mapping was assigned for each of the Logical Volumes using four ports on each of the two Channel Adapters (CA) in each of the two Controller Modules (CM). Each of the volumes, which were defined on RAID Groups owned by CM-0, were assigned LUN numbers on the active ports on the two CAs installed on CM-0. Each of the volumes, which were defined on RAID Groups owned by CM-1, were assigned LUN numbers on the active ports on the two CAs installed on CM-1.

Step 5 – Creation of the two-way striped logical volumes.

Built in logical volume manager in Linux is used to stripe each pair of LUNs presented by AF650S2 array.

This is done in 3 steps included in the AF650S2_20171026makeLV.sh script.

1. Create Physical Volumes (PV) for each LUN presented from AF650S2.
```
pvcreate /dev/disk/by-id/scsi-3600000e00d2a0000002a002300000000

pvcreate /dev/disk/by-id/scsi-3600000e00d2a0000002a002300010000

pvcreate /dev/disk/by-id/scsi-3600000e00d2a0000002a002300020000

pvcreate /dev/disk/by-id/scsi-3600000e00d2a0000002a002300030000

pvcreate /dev/disk/by-id/scsi-3600000e00d2a0000002a002300040000

pvcreate /dev/disk/by-id/scsi-3600000e00d2a0000002a002300050000
```

2. Create Three Volume Groups with physical extent size of 32MiB
```
vgcreate -s32m asu1vg /dev/disk/by-id/scsi-
3600000e00d280000002a002300000000 /dev/disk/by-id/scsi-
3600000e00d280000002a002300030000

vgcreate -s32m asu2vg /dev/disk/by-id/scsi-
3600000e00d280000002a003400020000 /dev/disk/by-id/scsi-
3600000e00d280000002a003400050000

vgcreate -s32m asu3vg /dev/disk/by-id/scsi-
3600000e00d280000002a003400010000 /dev/disk/by-id/scsi-
3600000e00d280000002a003400040000
```

3. Create Three Logical Volumes for each ASU with 32MiB Stripe size
```
lvcreate -l 100%VG -i2 -I32768 -n asu1 asu1vg

lvcreate -l 100%VG -i2 -I32768 -n asu2 asu2vg

lvcreate -l 100%VG -i2 -I32768 -n asu3 asu3vg
```

Referenced Scripts

doFDRcfg.sh

definitions.exp

AF650S2_20171026.exp

showFormatStatus.exp

AF650S2_20171026makeLV.sh

APPENDIX E: CONFIGURATION INVENTORY

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

- log_BeforeF_JX171212121747.zlg_001.txt

- log_AfterJ_JX171212121747.zlg_001.txt

APPENDIX F: WORKLOAD GENERATOR

ASU Definition File:

The contents of the ASU Definition file can be found in the Supporting Files.

- SPC1.AF650S2_20171026.asu

Host Definition File:

The contents of the Host Definition file for the four-host configuration used can be found in the Supporting Files.

- SPC1.AF650S2_20171026.hst