SPC Benchmark 1™

Full Disclosure Report

Lenovo
ThinkSystem DE6000H

SPC-1 V3.8

Submission Identifier: A32008

Submitted For Review: November 9, 2018

First Edition – November 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.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
Certified Auditor

Mr. Vincent Kao
Lenovo
7001 Development Drive
Morrisville, NC 27560

November 6, 2018

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

Lenovo ThinkSystem DE6000H

The results were:

SPC-1 IOPS™	**460,011**
SPC-1 Price-Performance™	**$91.76/SPC-1 KIOPS™**
SPC-1 IOPS™ Response Time	0.411 ms
SPC-1 Overall Response Time	0.252 ms
SPC-1 ASU Capacity	9,448 GB
SPC-1 Space Effectiveness Ratio	NA
SPC-1 ASU Price	$4.47/GB
SPC-1 Total System Price	$42,207.87

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 A32008.

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

SPC Benchmark 1™ V3.8   Full Disclosure Report   Submission Identifier: A32008
Lenovo   Submitted for Review: November 9, 2018
ThinkSystem DE6000H

LETTER OF GOOD FAITH

Lenovo.com   8001 Development Drive
                    Morrisville, NC 27560

November 05, 2018

From: Kamran Amini
        VP&GM, Data Center Infrastructure
        Lenovo

Subject: SPC-1 Letter of Good Faith for Lenovo ThinkSystem DE6000H

Lenovo 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 the product are complete, accurate, and in full compliance with version 3.8 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 reporting results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Sincerely,   Date

                                              11/5/2018

Kamran Amini

VP&GM, Data Center Infrastructure
Lenovo
Tel: 919-237-8593
Email: kamini@lenovo.com

SPC BENCHMARK 1™

EXECUTIVE SUMMARY

LENOVO
THINKSYSTEM DE6000H

SPC-1 IOPS™	460,011
SPC-1 Price-Performance™	$91.76/SPC-1 KIOPS™
SPC-1 IOPS™ Response Time	0.411 ms
SPC-1 Overall Response Time	0.252 ms
SPC-1 ASU Capacity	9,448 GB
SPC-1 Space Effectiveness Ratio	NA
SPC-1 ASU Price	$4.47/GB
SPC-1 Total System Price	$42,207.87
Data Protection Level	Protected 1 (RAID-10)
Physical Storage Capacity	19,200 GB
Pricing Currency / Target Country	U.S. Dollars / USA

SPC-1 V3.8

SUBMISSION IDENTIFIER: A32008

SUBMITTED FOR REVIEW: NOVEMBER 9, 2018

Benchmark Configuration Diagram

Host Systems

2x Lenovo ThinkSystem SR630 (each with)
2x Intel Xeon Gold 6148 20-Core CPU 2.4 GHz
256 GB Memory

Tested Storage Configuration
(TSC)

2x Lenovo 430-8e 12Gb SAS External HBA (one per host)

Lenovo ThinkSystem DE6000H
2x Controllers (each with):
   16 GB
   4x 12 Gb SAS Port (SFF-8644) (Front-end)
   2x 12 Gb SAS Port (SFF-8644) (Back-end)
   2x 10 Gb iSCSI or 8/16 FC Port
24x 800 GB SSD

4x 12Gb SAS Cables (2 per host)
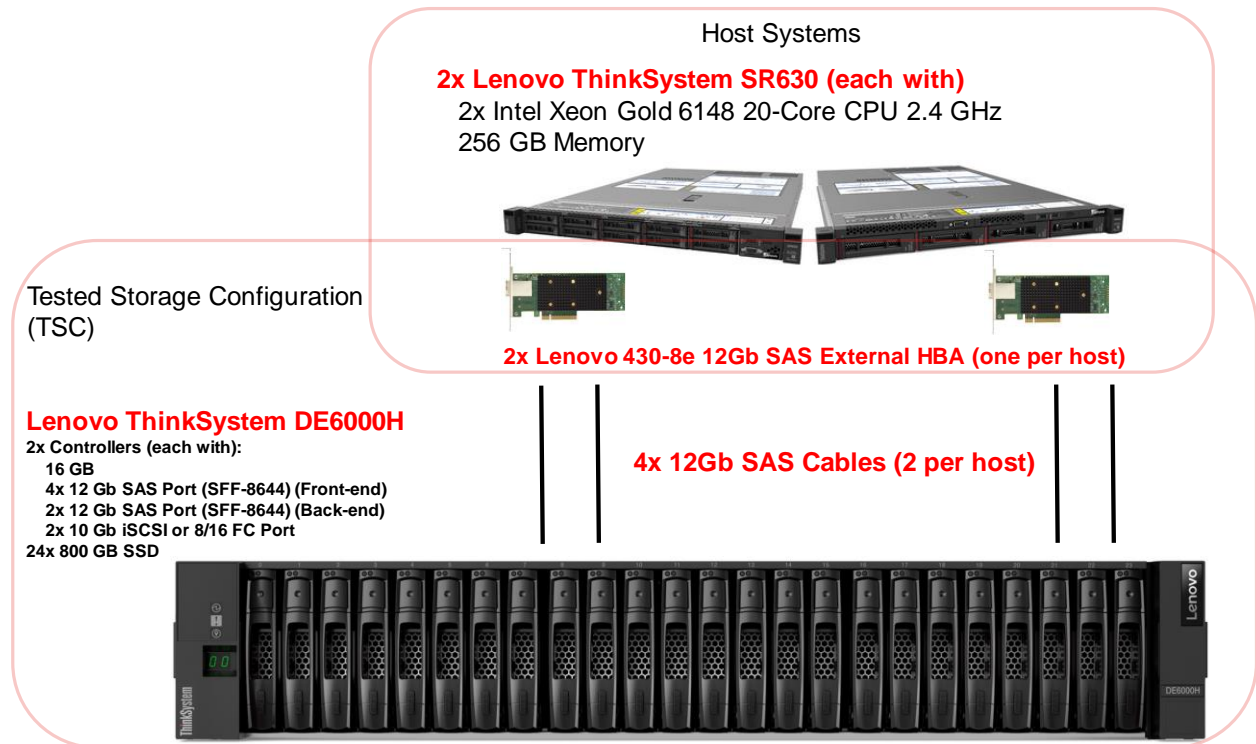
Tested Storage Product Description

Lenovo ThinkSystem DE6000H is a scalable, hybrid mid-range storage system that is designed to provide high performance, simplicity, capacity, security, and high availability for medium to large businesses. The ThinkSystem DE6000H delivers enterprise-class storage management capabilities in a performance-optimized system with a wide choice of host connectivity options, flexible drive configurations, and enhanced data management features. The ThinkSystem DE6000H is a perfect fit for a wide range of enterprise workloads, including big data and analytics, video surveillance, technical computing, backup and recovery, and other storage I/O-intensive applications.

ThinkSystem DE6000H models are available in a 2U rack form-factor with 24 small form-factor (2.5-inch SFF) drives (2U24 SFF) or a 4U rack form-factor with 60 LFF drives (4U60 LFF) and include two controllers, each with 16 GB cache for a system total of 32 GB. Universal 10 Gb iSCSI or 8/16 Gb Fibre Channel (FC) ports provide base host connectivity, and the host interface cards provide additional 12 Gb SAS, 10/25 Gb iSCSI, or 8/16/32 Gb FC connections.

The ThinkSystem DE6000H Storage Array scales up to 240 drives with the attachment of Lenovo ThinkSystem DE240S 2U24 SFF and DE600S 4U60 LFF Expansion Enclosures. It also offers flexible drive configurations with the choice of 2.5-inch (SFF) and 3.5-inch (LFF) form factors, 10 K rpm SAS and 7.2 K rpm NL SAS hard disk drives (HDDs), and SAS solid-state drives (SSDs).

For more details, visit:

https://www.lenovo.com/us/en/data-center/storage/storage-area-network/thinksystem-de-series/c/thinksystem-de-series

Priced Storage Configuration Components

| |
|---|
| **2 x ThinkSystem 430-8E SAS HBA** |
| **1 x ThinkSystem DE6000H, with:**
　　　　2 x Storage Controllers, each with:
　　　　　　　　16 GB cache
　　　　　　　　2 x 12 Gb Front End Ports
　　　　　　　　2 x 12 Gb Back End Connections (not used in this test)
　　　　24 x 800 GB SAS SSD |

Storage Configuration Pricing

Part No.	Description	Source	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
	Hardware & Software						
7Y78A000WW	Lenovo ThinkSystem DE6000H SAS Hybrid Flash Array SFF	1	1	24,999.00	24,999.00	47%	13,249.47
4XB7A14105	Lenovo ThinkSystem DE Series 800GB 3DWD 2.5" SSD 2U24	1	24	2,499.00	59,976.00	55%	26,989.20
00YL847	0.5m External MiniSAS HD 8644/MiniSAS HD 8644 Cable	1	4	49.00	196.00	50%	98.00
7Y37A01090	ThinkSystem 430-8E SAS HBA	1	2	499.00	998.00	45%	548.90
					Hardware & Software Subtotal		40,885.57
	Support & Maintenance						
5PS7A21772	Essential Service - 3Yr 24x7 4Hr Response + YourDrive YourData	1	1	1,889.00	1,889.00	30%	1,322.30
					Support & Maintenance Subtotal		1,322.30
	SPC-1 Total System Price						42,207.87
	SPC-1 IOPS™						460,011
	SPC-1 Price-Performance™ ($/SPC-1 KIOPS™)						**91.76**
	SPC-1 ASU Capacity (GB)						9,448
	SPC-1 ASU Price ($/GB)						**4.47**

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

Availability Date: November 9, 2018.
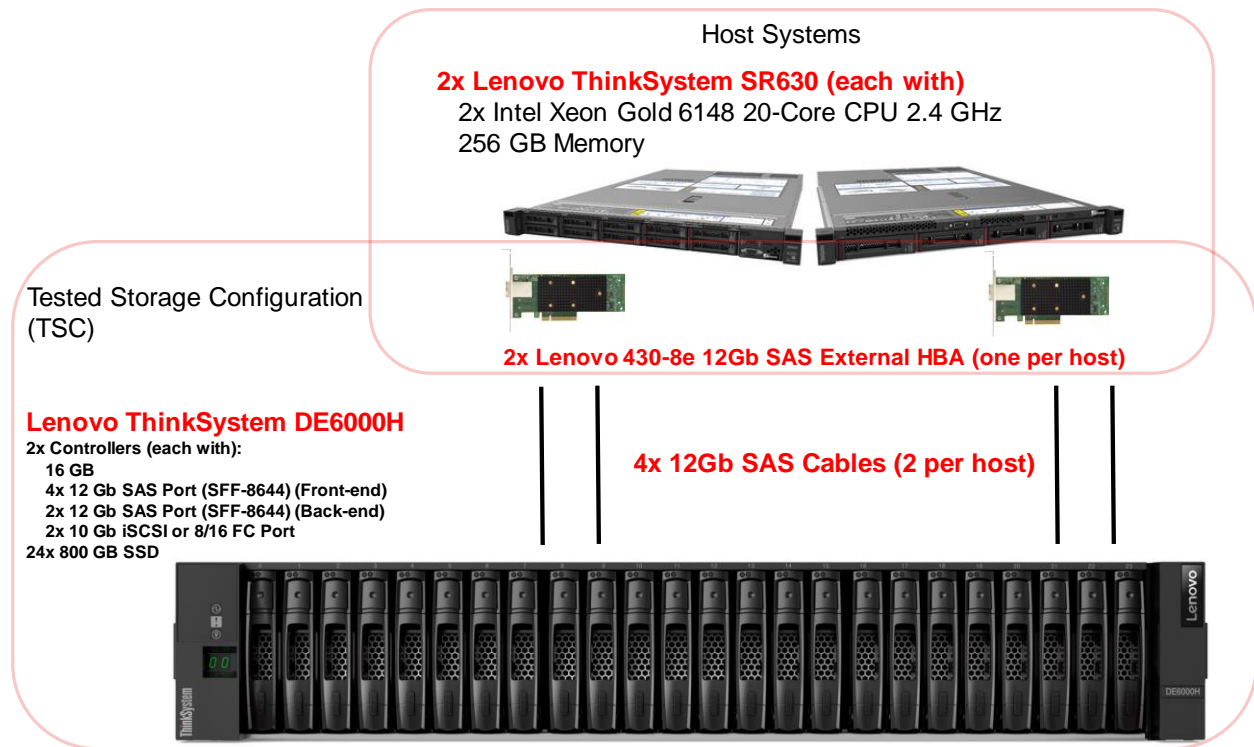
Response Time and Throughput Graph
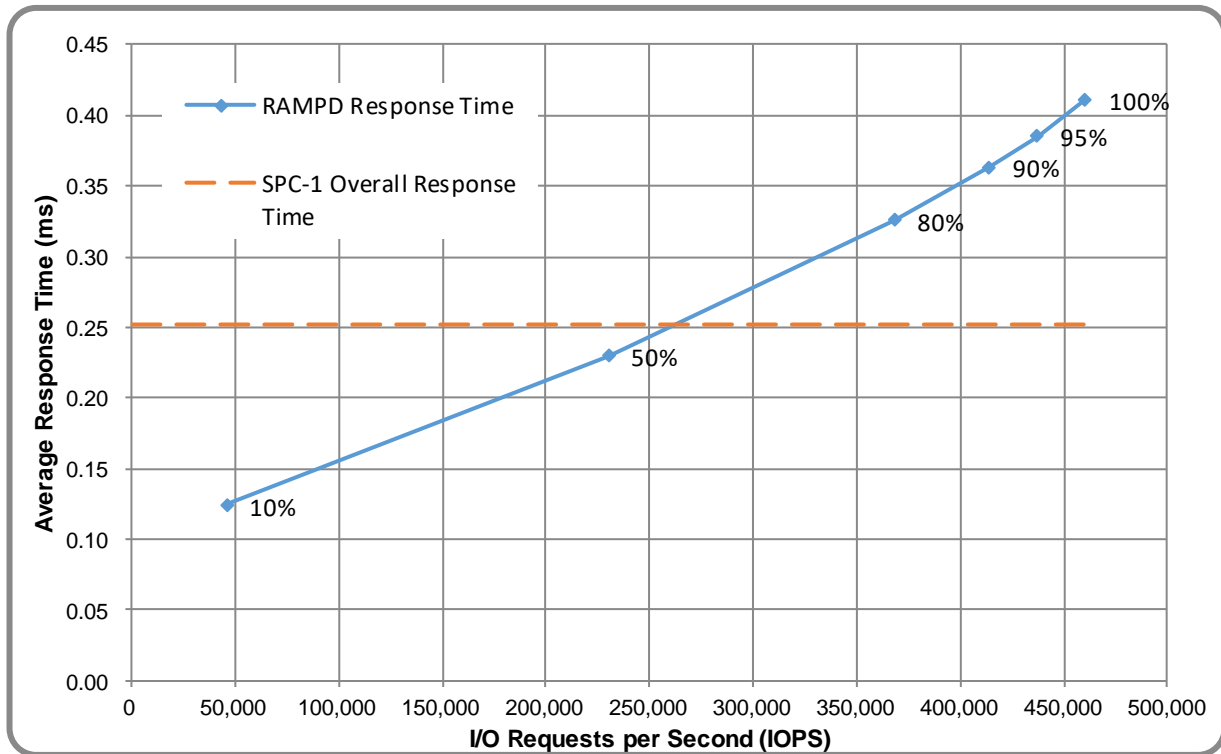
Contact Information	
Test Sponsor Primary Contact	Lenovo – www.lenovo.com Vincent Kao – vkao@lenovo.com
SPC Auditor	InfoSizing – www.sizing.com Doug Johnson – doug@sizing.com

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).

Host Systems

2x Lenovo ThinkSystem SR630 (each with)
2x Intel Xeon Gold 6148 20-Core CPU 2.4 GHz
256 GB Memory

Tested Storage Configuration (TSC)

2x Lenovo 430-8e 12Gb SAS External HBA (one per host)

Lenovo ThinkSystem DE6000H
2x Controllers (each with):
16 GB
4x 12 Gb SAS Port (SFF-8644) (Front-end)
2x 12 Gb SAS Port (SFF-8644) (Back-end)
2x 10 Gb iSCSI or 8/16 FC Port
24x 800 GB SSD

4x 12Gb SAS Cables (2 per host)

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

2 x ThinkSystem SR630, each with:
        2 x Intel Xeon Gold 6148 (2.40 GHz, 20-Core, 27.5 MB L3)
        256 GB Main Memory
        Windows Server 2012 Datacenter Edition

Tested Storage Configuration
2 x ThinkSystem 430-8E SAS HBA

1 x ThinkSystem DE6000H, with:
        2 x Storage Controllers, each with:
                16 GB cache
                2 x 12 Gb Front End Ports
                2 x 12 Gb Back End Connections (not used in this test)
24 x 800 GB SAS SSD

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	1	4,251.7	4,251.7	4,251.7	45.0%	No
ASU-2	1	4,251.7	4,251.7	4,251.7	45.0%	No
ASU-3	1	944.6	944.6	944.6	10.0%	No
SPC-1 ASU Capacity				9,448	*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
SAS SSD	24	800.0	19,200.0
Total Physical Capacity			**19,200**
Physical Capacity Utilization			**49.21%**

Data Protection

The data protection level used for all LVs was **Protected 1 (RAID-10)**, which was accomplished by configuring 2 pools of 12 drives each into 6 RAID-10 arrays.

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.
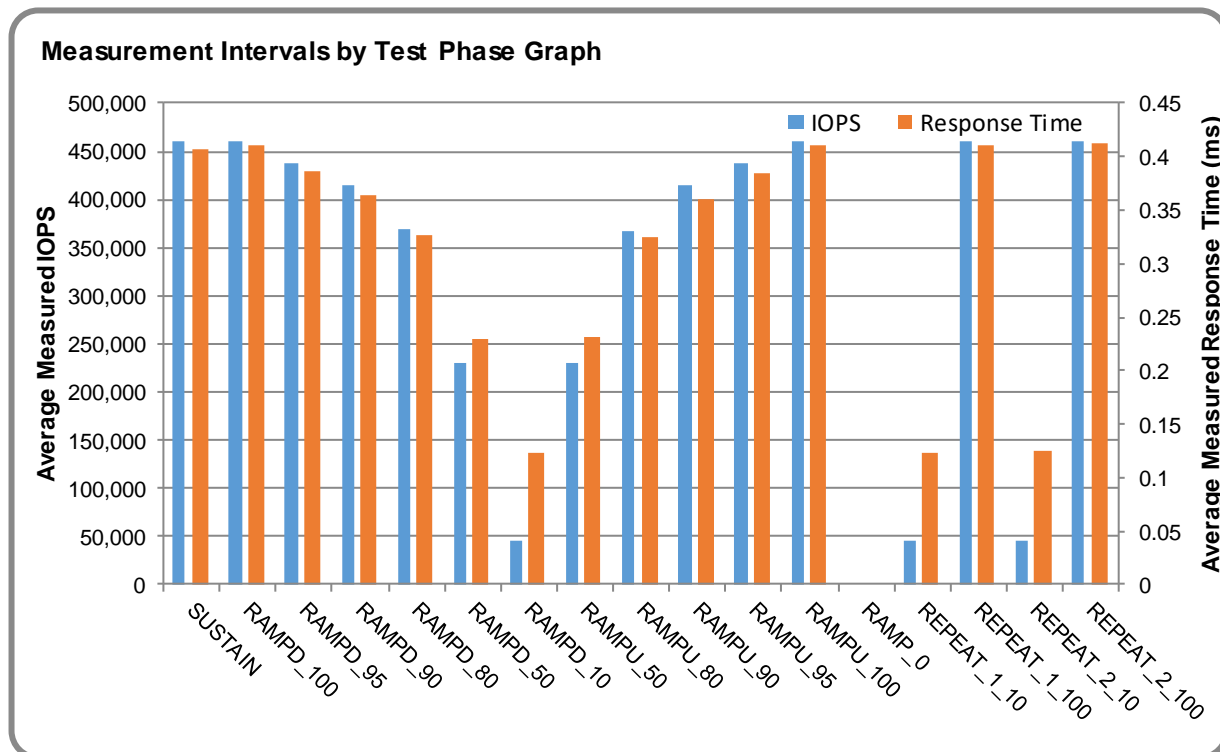
Exception and Waiver

None.

SUSTAIN Test Phase
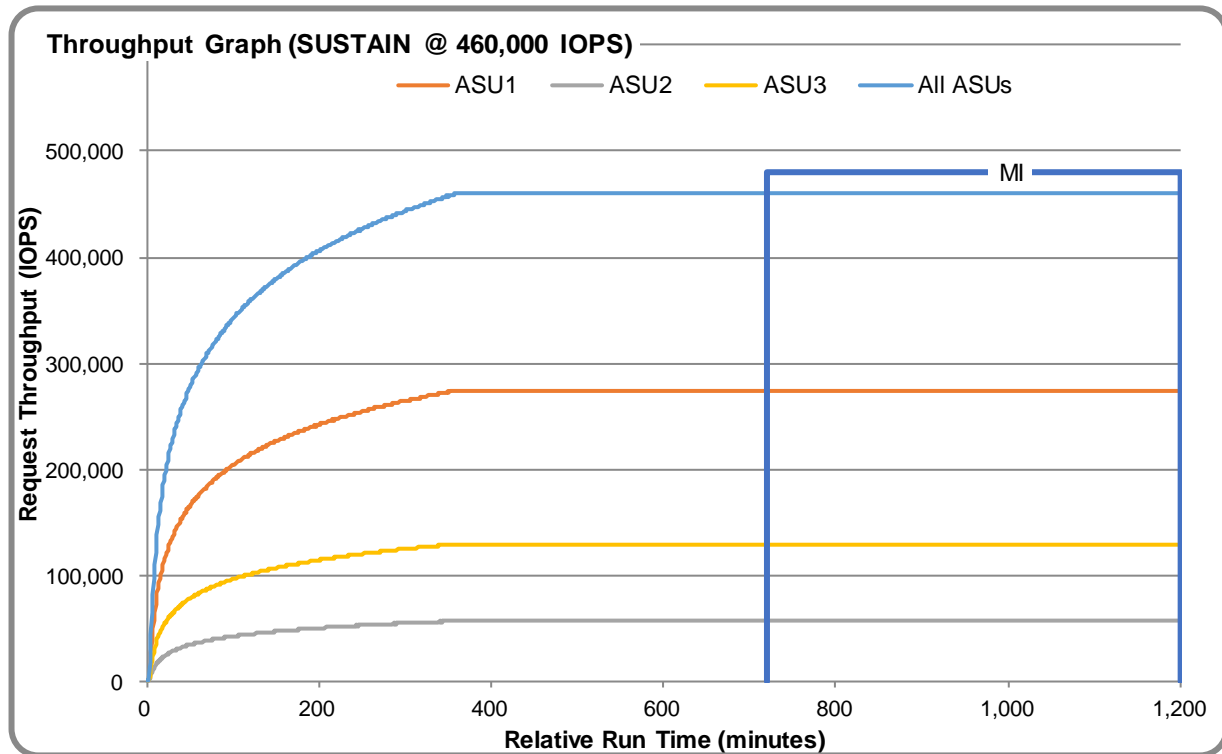
SUSTAIN – Results File

The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:
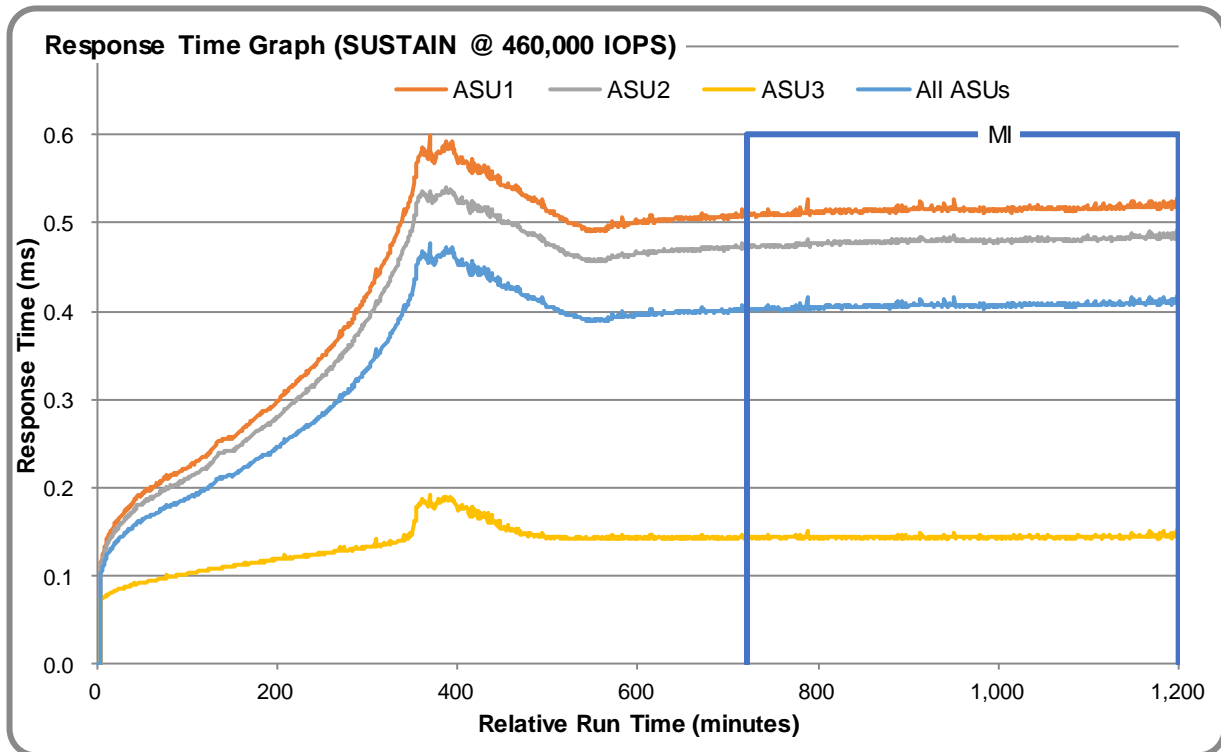
- **SPC1_METRICS_0_Raw_Results.xlsx**

SUSTAIN – Execution Times

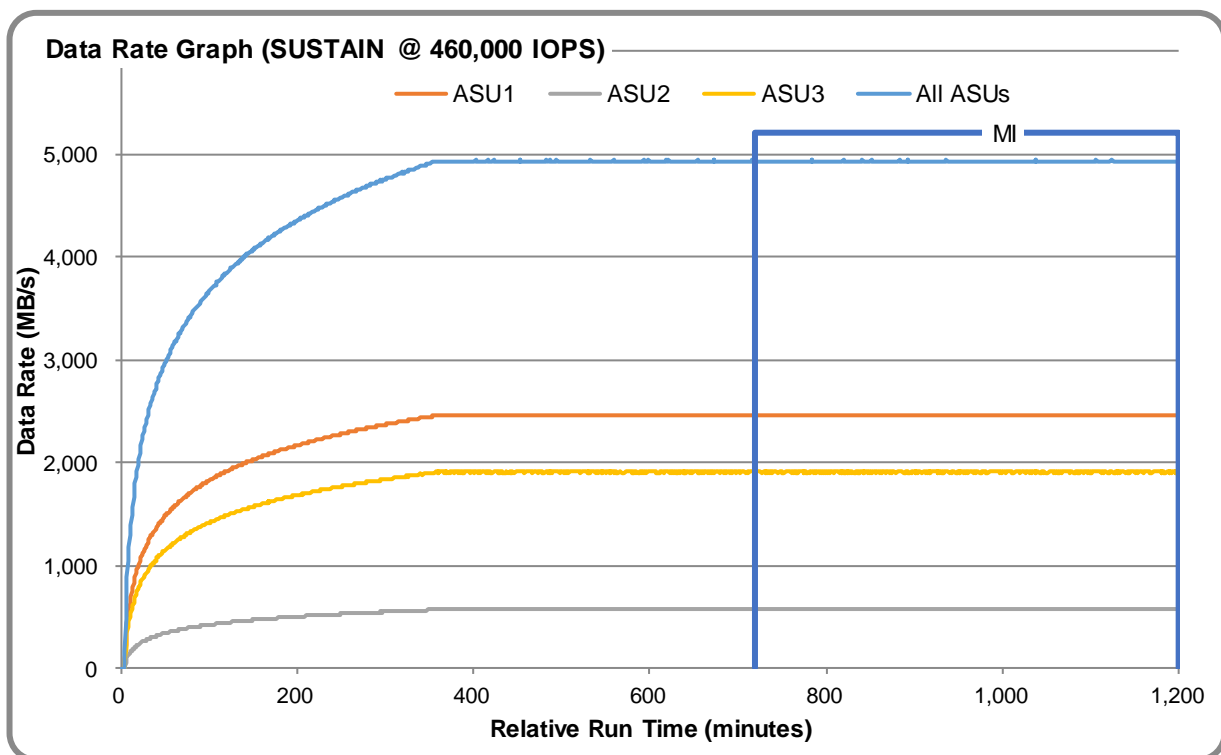| Interval	Start Date & Time	End Date & Time	Duration
Transition Period	24-Oct-18 17:01:40	25-Oct-18 05:01:37	11:59:56
Measurement Interval	25-Oct-18 05:01:37	25-Oct-18 13:01:38	8:00:01

SUSTAIN – Throughput Graph

SUSTAIN – Response Time Graph

Response Time Graph (SUSTAIN @ 460,000 IOPS)

ASU1   ASU2   ASU3   All ASUs

MI

Response Time (ms) vs *Relative Run Time (minutes)*

SUSTAIN – Data Rate Graph

Data Rate Graph (SUSTAIN @ 460,000 IOPS)

ASU1   ASU2   ASU3   All ASUs

MI

Data Rate (MB/s) vs *Relative Run Time (minutes)*

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SUSTAIN – Response Time Frequency Graph

Response Time Frequency Graph (SUSTAIN @ 460,000 IOPS)
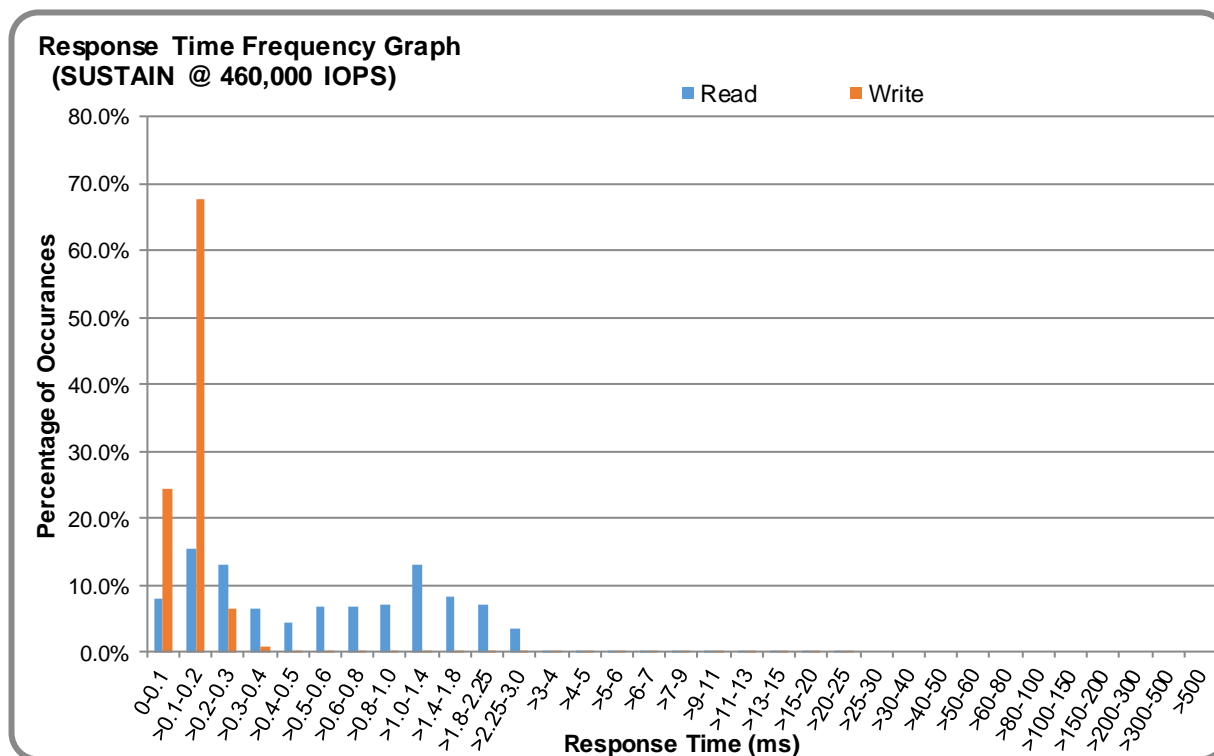
SUSTAIN – Intensity Multiplier

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	0.0010	0.0003	0.0007	0.0004	0.0014	0.0007	0.0010	0.0003
Difference	0.006%	0.000%	0.003%	0.002%	0.001%	0.005%	0.000%	0.004%

RAMPD_100 Test Phase
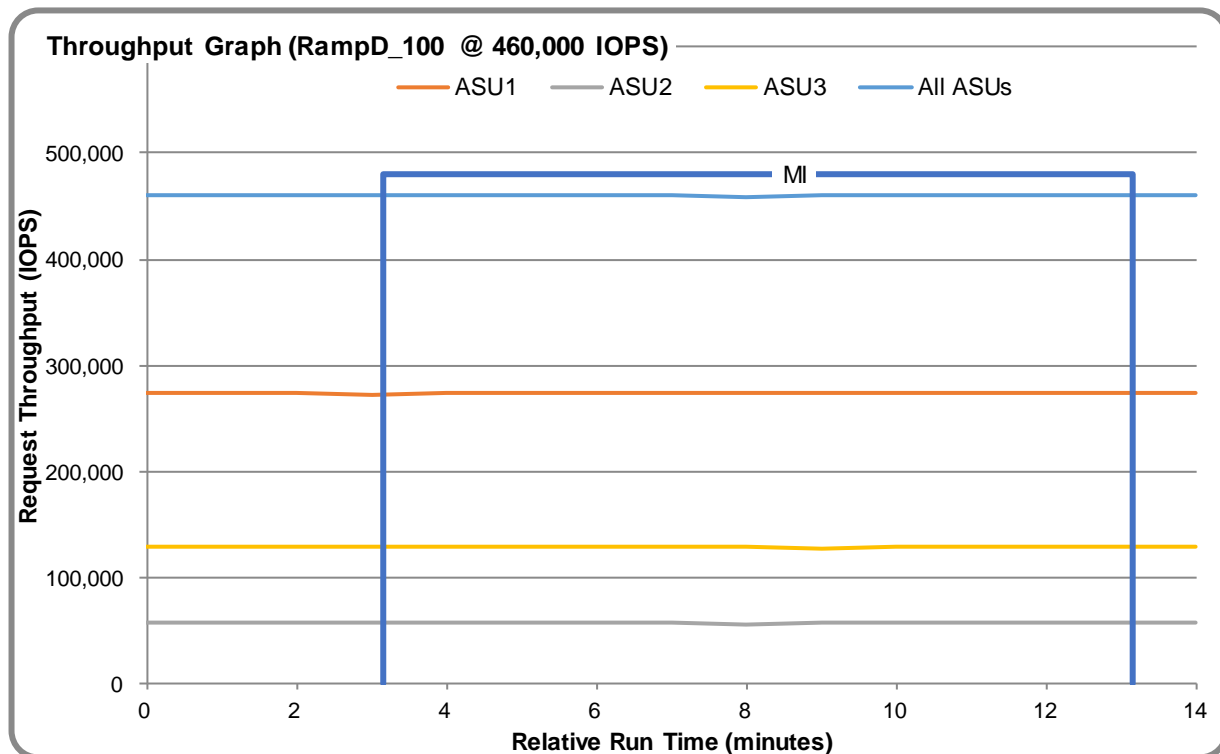
RAMPD_100 – Results File

The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:
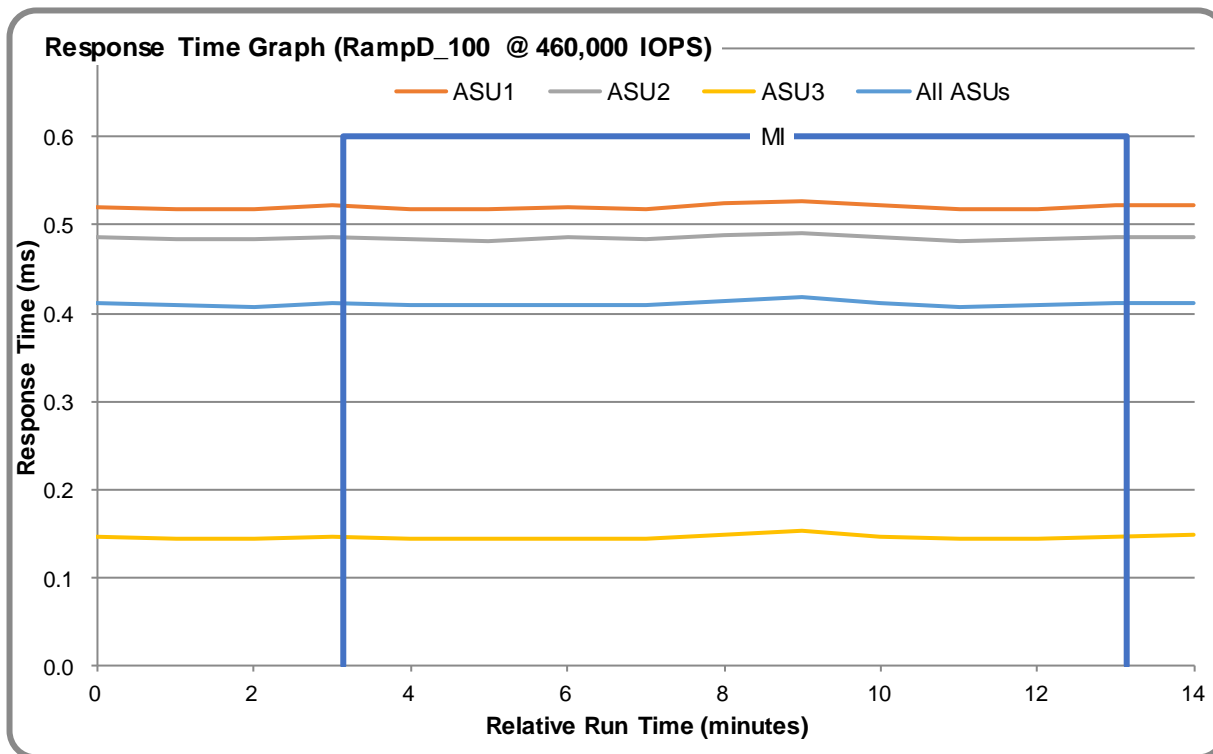
- **SPC1_METRICS_0_Raw_Results.xlsx**

RAMPD_100 – Execution Times

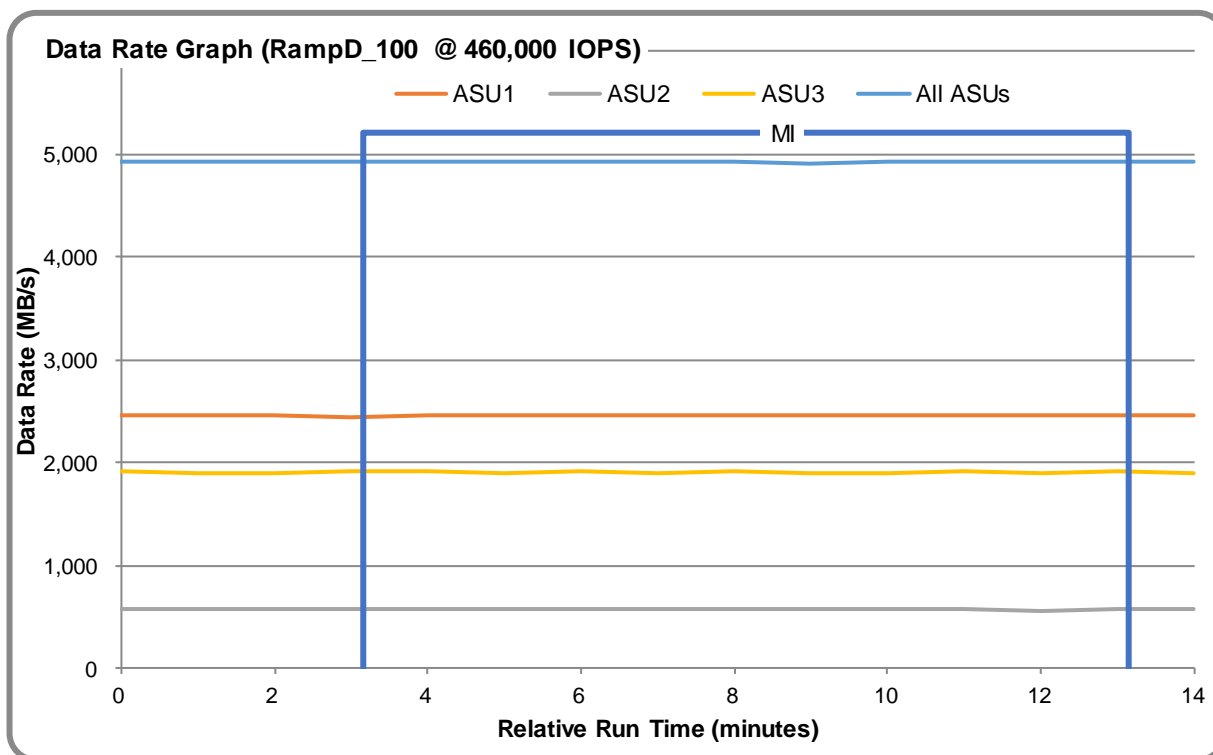| Interval	Start Date & Time	End Date & Time	Duration
Transition Period	25-Oct-18 13:02:37	25-Oct-18 13:05:37	0:03:00
Measurement Interval	25-Oct-18 13:05:37	25-Oct-18 13:15:38	0:10:01

RAMPD_100 – Throughput Graph

RAMPD_100 – Response Time Graph

Response Time Graph (RampD_100 @ 460,000 IOPS)

ASU1   ASU2   ASU3   All ASUs

MI

Response Time (ms)

Relative Run Time (minutes)

RAMPD_100 – Data Rate Graph

Data Rate Graph (RampD_100 @ 460,000 IOPS)

ASU1   ASU2   ASU3   All ASUs

MI

Data Rate (MB/s)

Relative Run Time (minutes)

RAMPD_100 – Response Time Frequency Graph

Response Time Frequency Graph (RampD_100 @ 460,000 IOPS)
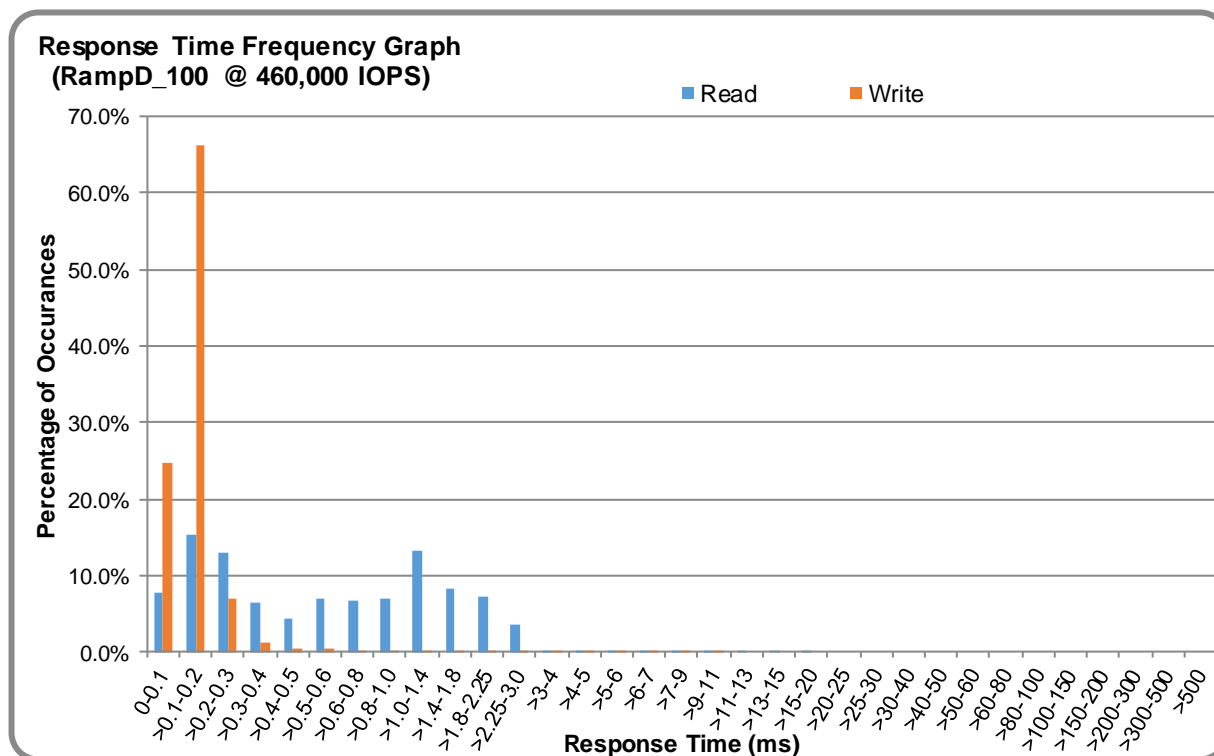
RAMPD_100 – Intensity Multiplier

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	0.0010	0.0002	0.0007	0.0004	0.0012	0.0008	0.0010	0.0002
Difference	0.012%	0.007%	0.017%	0.012%	0.055%	0.020%	0.028%	0.017%

RAMPD_100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	276,004,938
I/O Requests Completed with Response Time <= 30 ms	276,004,937
I/O Requests Completed with Response Time > 30 ms	1

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Response Time Ramp Test

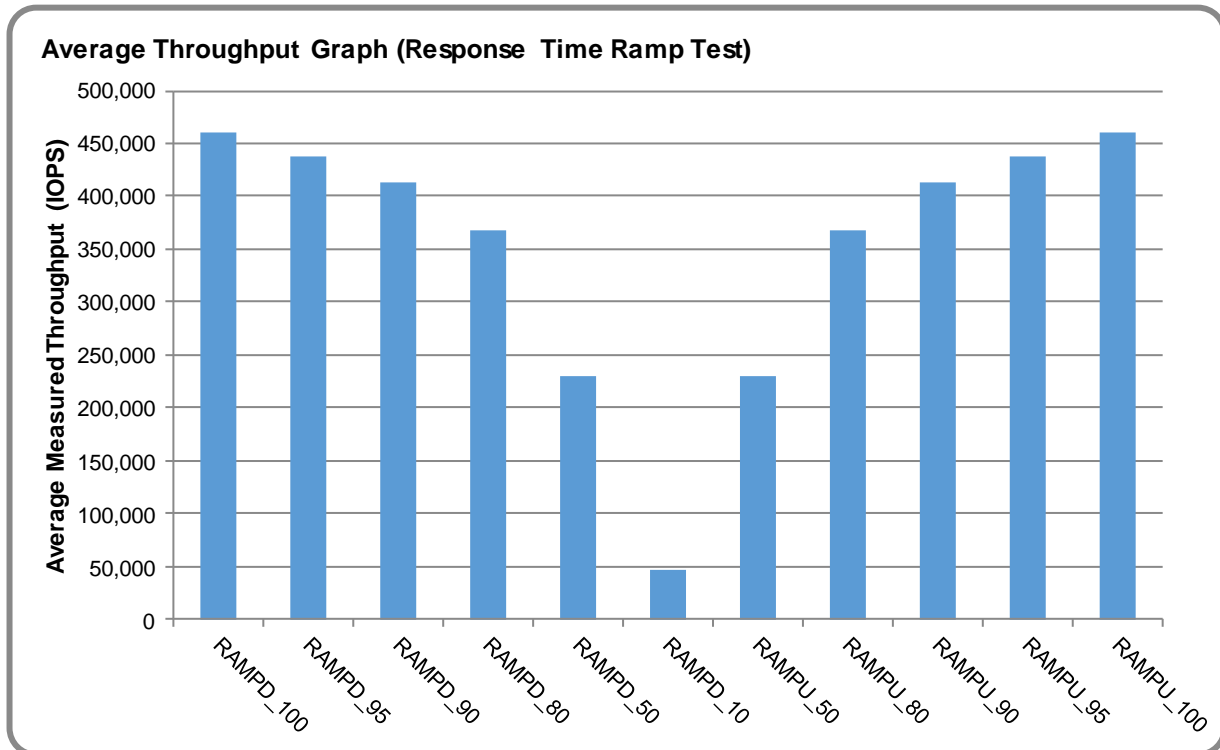## Response Time Ramp Test – Results File

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).
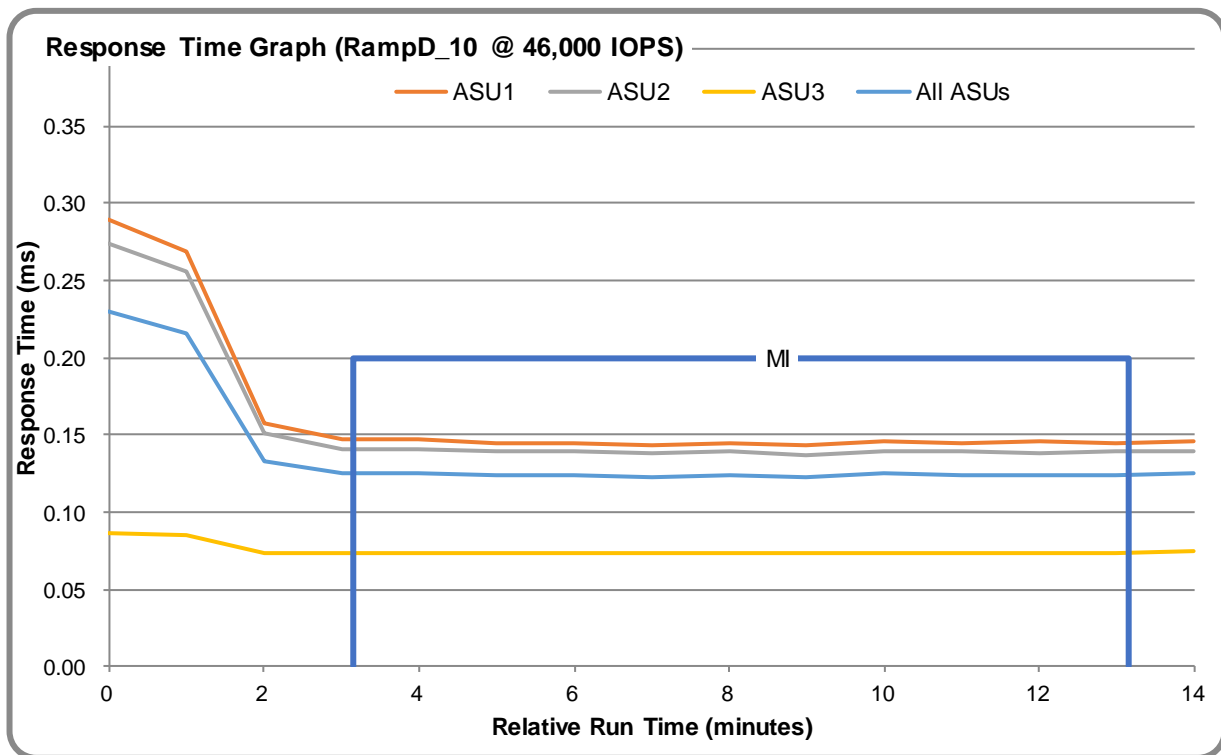
Response Time Ramp Test – Average Throughput Graph

Response Time Ramp Test – Average Response Time Graph

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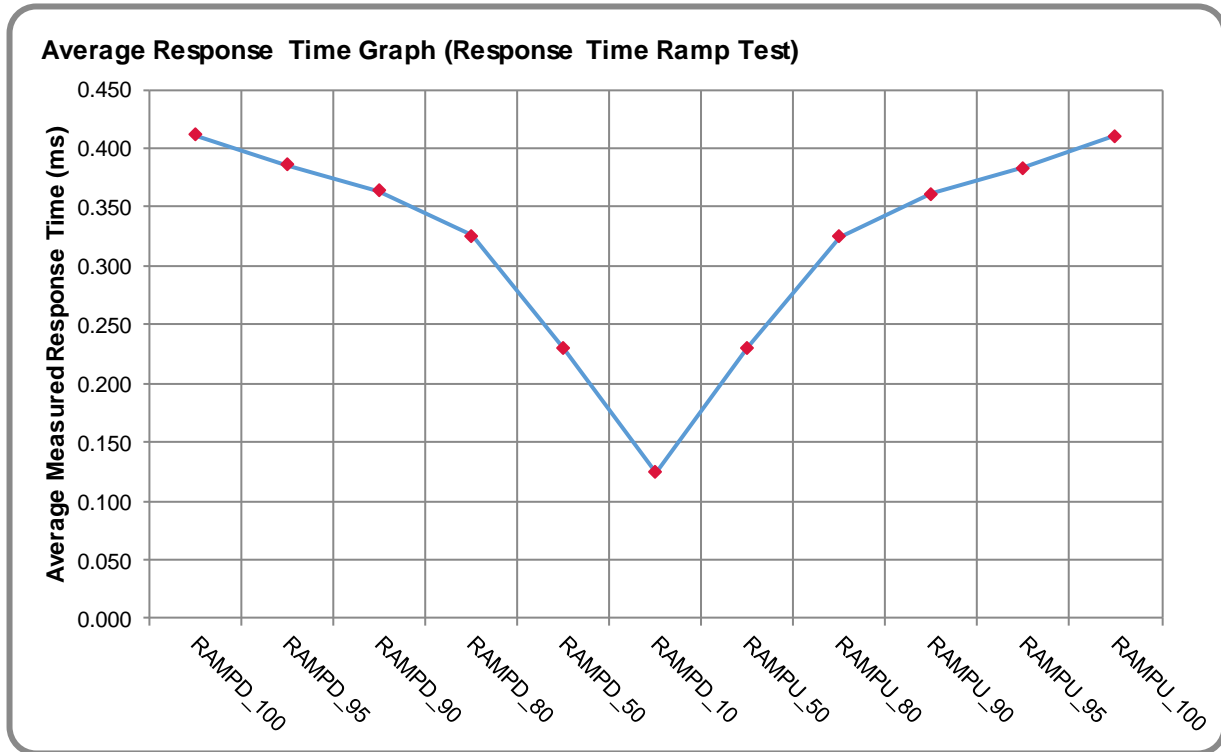
Response Time Ramp Test – RAMPD_10 Response Time Graph

Response Time Graph (RampD_10 @ 46,000 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:
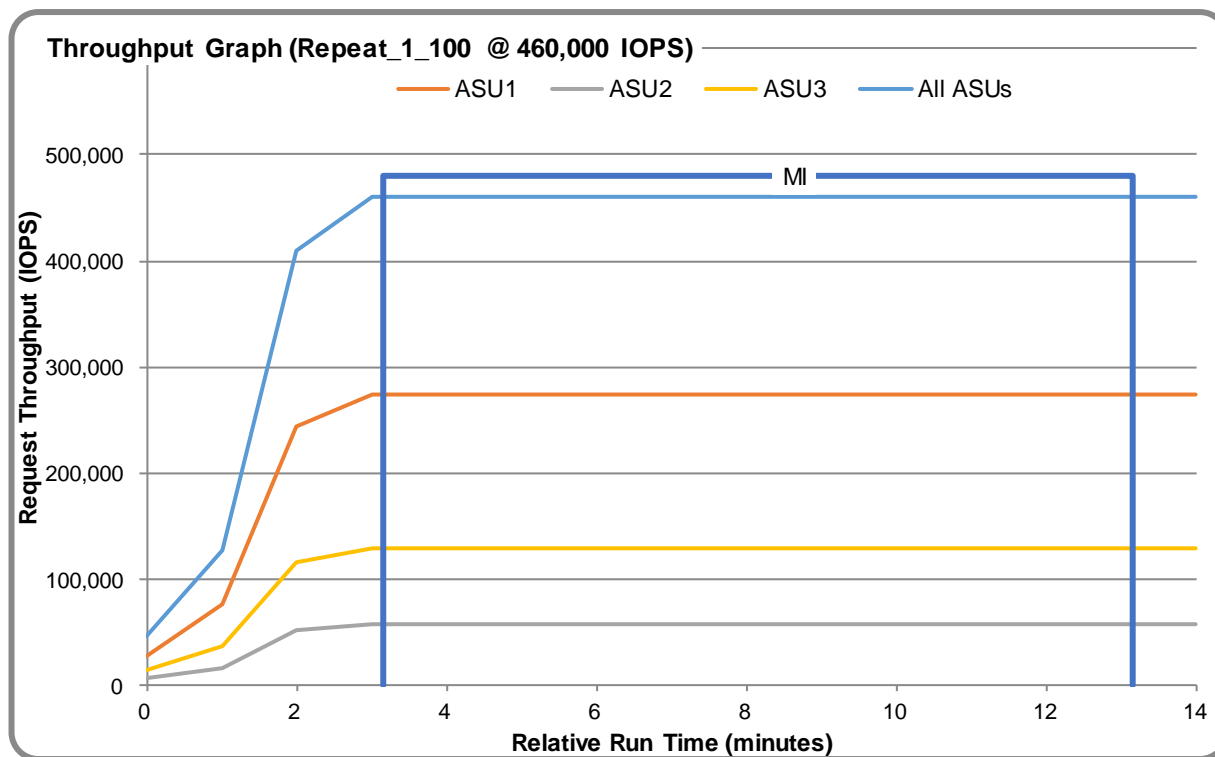
- **SPC1_METRICS_0_Raw_Results.xlsx**
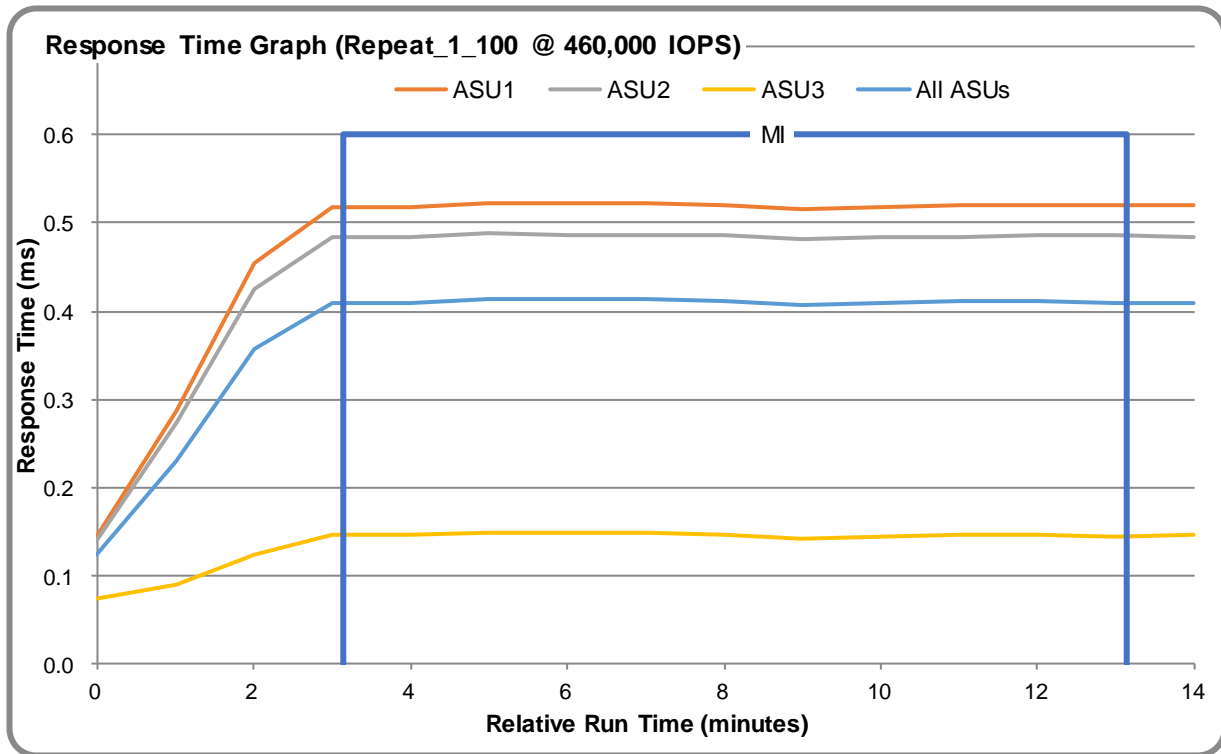
Repeatability Test Results

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

Test Phase	100% IOPS	10% IOPS
RAMPD	460,012.0	46,016.2
REPEAT_1	460,056.1	46,013.1
REPEAT_2	460,076.1	45,999.9

REPEAT_1_100 – Throughput Graph

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REPEAT_1_100 – Response Time Graph

Response Time Graph (Repeat_1_100 @ 460,000 IOPS)

REPEAT_2_100 – Throughput Graph

Throughput Graph (Repeat_2_100 @ 460,000 IOPS)

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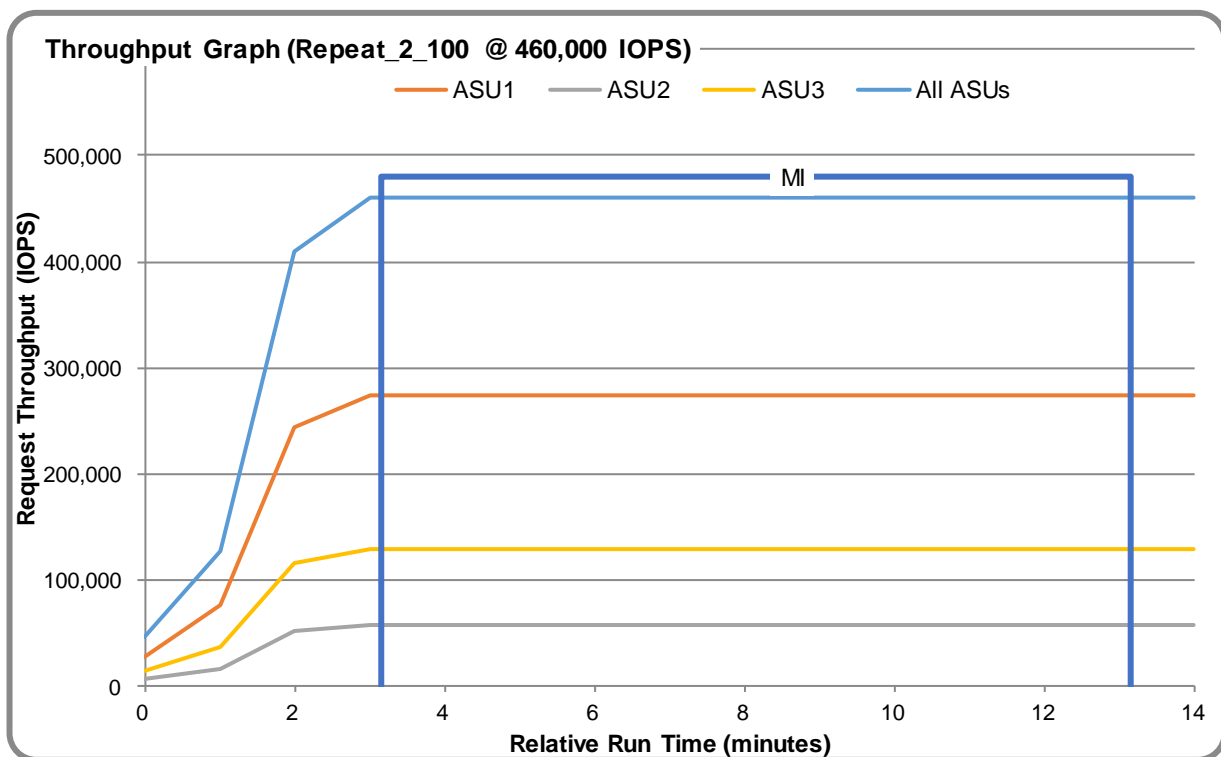
REPEAT_2_100 – Response Time Graph
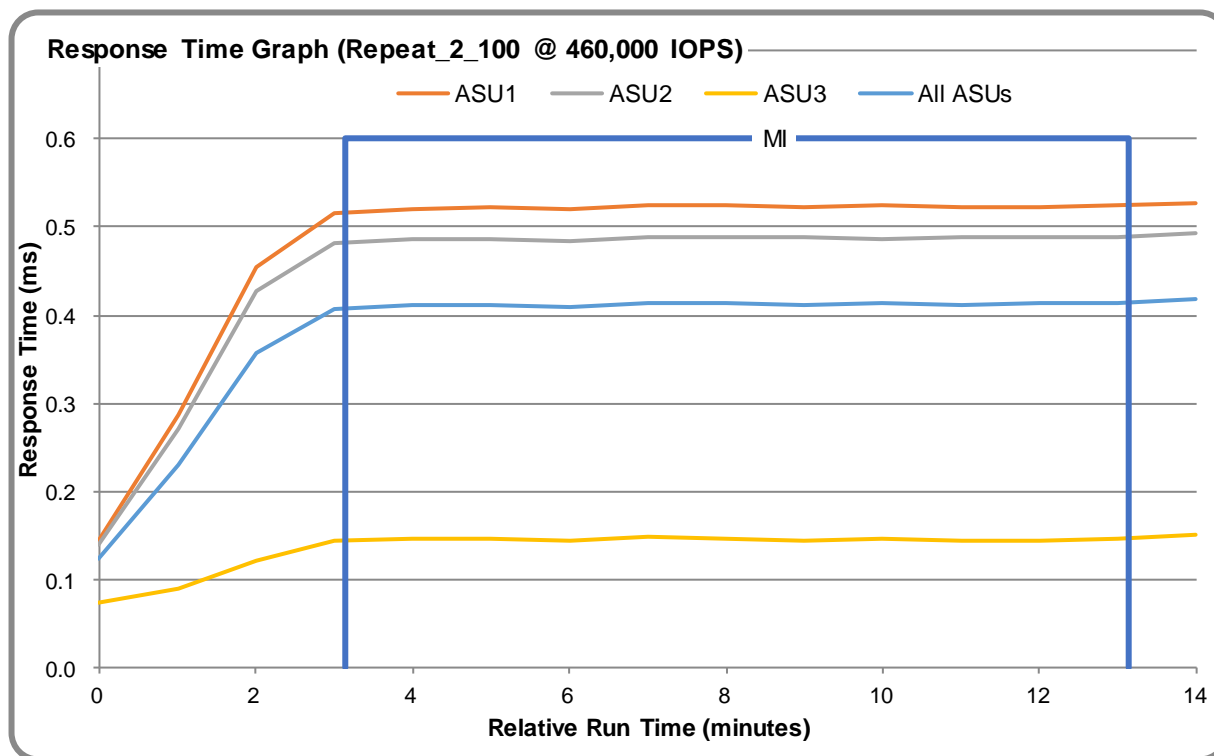
Repeatability Test – Intensity Multiplier

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	0.0010	0.0003	0.0004	0.0003	0.0011	0.0004	0.0009	0.0004
Difference	0.010%	0.013%	0.005%	0.009%	0.017%	0.015%	0.030%	0.005%

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	0.0004	0.0007	0.0002	0.0013	0.0006	0.0012	0.0003
Difference	0.075%	0.003%	0.047%	0.001%	0.022%	0.031%	0.017%	0.009%

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	94,501,580
Total Number of Logical Blocks Verified	90,748,315
Total Number of Logical Blocks Overwritten	3,753,265
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

Each controller mirrors the cache to the other controller. In the case that one controller fails, the other controller can take over ownership of the failed controller's volumes and cached data. The controller has the persistent cache backup flash in which cache contents can be stored for an indefinite period of time. The controller also has a battery with enough capacity to let it write the full contents of the cache memory to the persistent cache backup flash in the event of a power failure.

APPENDIX A: SUPPORTING FILES

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

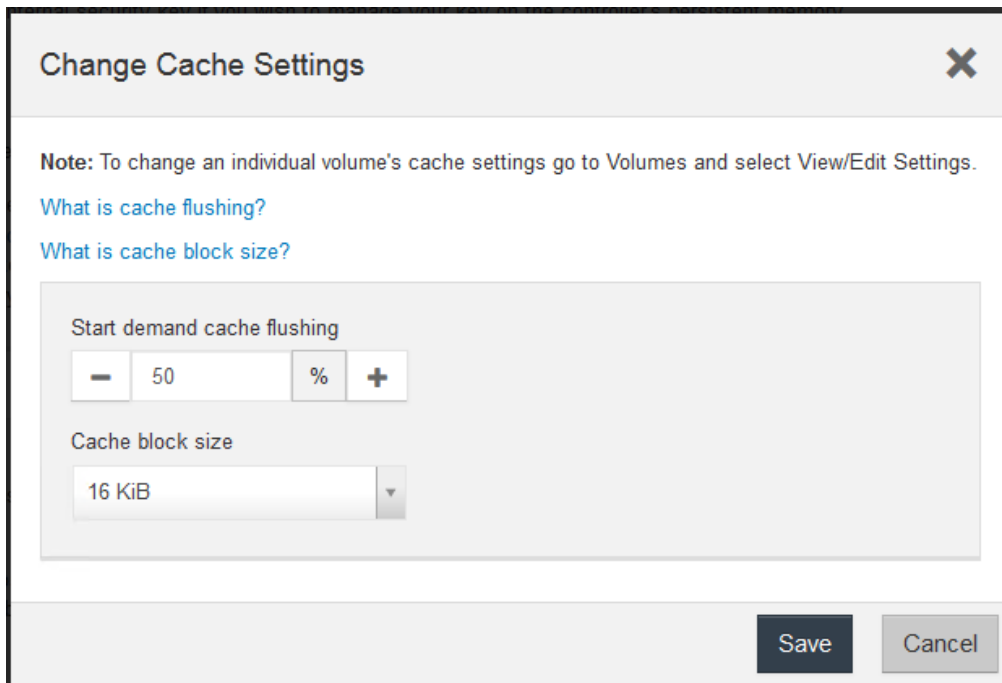| File Name	Description	Location
/SPC1_RESULTS	**Data reduction worksheets**	**root**
SPC1_INIT_0_Raw_Results.xlsx	Raw results for INIT Test Phase	/SPC1_RESULTS
SPC1_METRICS_0_Quick_Look.xlsx	Quick Look Test Run Overview	/SPC1_RESULTS
SPC1_METRICS_0_Raw_Results.xlsx	Raw results for Primary Metrics Test	/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**
storage-array-configuration_1024.cfg	Change array default settings	/C_Tuning
/D_Creation	**Storage configuration creation**	**root**
storage-array-configuration_1024.cfg	Create Volume Groups, Volumes and Mapping	/D_Creation
/E_Inventory	**Configuration inventory**	**root**
/ DE6000H_BEFORE_Run	Configuration before the run	/E_Inventory
/ DE6000H_AFTER_Run	Configuration after the run	/E_Inventory
/F_Generator	**Workload generator**	**Root**
SPC1.asu	ASU configuration file	/F_generator
DE6000_full_run.bat	Execute all test phases exclude PERSIST_2	/F_generator
SPC1_METRICS	12-hour RAMP for SUSTAIN	/F_generator
slave.HST	Dual hosts	/F_generator

APPENDIX B: THIRD PARTY QUOTATION

All components are directly available through the Test Sponsor.

APPENDIX C: TUNING PARAMETERS AND OPTIONS

Array tuning options could be set by script (storage-array-configuration_1024.cfg) or ThinkSystem System Manager GUI (shown here).

1. Change Cache Settings

   Settings > System > Additional Settings > Change Cache Settings

2. Disable Auto Load Balancing

   Settings > System > Additional Settings > Enable/Disable Automatic Load Balancing

   Click Yes to confirm disabling

3. Disable Host Connectivity Report

   Settings > System > Additional Settings > Enable/Disable Host Connectivity Reporting

   Click Yes to confirm disabling

4. Disable AutoSupport

   Support > Support Center > AutoSupport > Enable/Disable AutoSupport Features

APPENDIX D: STORAGE CONFIGURATION CREATION

Storage Array Configuration could be set by script (storage-array-configuration_1024.cfg) or ThinkSystem System Manager GUI (shown here).

1. Create Two RAID 1 Volume Groups (VG0 and VG1)

   Storage > **Pools & Volume Groups > Create** > **Volume group**

   Name ❓

   | VG0 |

   RAID level

   | 1 | ▾ |

   RAID 1 (or "disk mirroring") offers high performance and the best data availability. Select four or more drives to achieve mirroring and striping (known as RAID 10 or RAID 1+0). Free capacity equals half of the drives in the volume group.

   Select a capacity for your volume group ...   Automatically select drives (recommended)

	Media Type	Drive Capacity (GiB)	Shelf	Bay ▲	Speed (RPM)	Logical Sector Size	Secure-Capable	DA Capable
☐	SSD	744.71	0	22	0 RPM	512 bytes	No	Yes
☐	SSD	744.71	0	23	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	3	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	4	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	5	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	6	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	7	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	8	0 RPM	512 bytes	No	Yes
☑	SSD	744.71	0	9	0 RPM	512 bytes	No	Yes

   VG0
   (Optimal) (12 drives, 4438.27 GiB capacity) (RAID 1)

   | 4438.27 GiB |

   Secure-capable No ❓ | DA Yes ❓

   VG1
   (Optimal) (12 drives, 4438.27 GiB capacity) (RAID 1)

   | 4438.27 GiB |

   Secure-capable No ❓ | DA Yes ❓

2. Create Volumes

   Storage > **Volumes > Create** > **Volume**

Name ▲	Status	Assigned To	LUN	Pool/Volume Group	Reported Capacity (GiB)	Allocated Capacity (GiB)	Edit
LUN0	Optimal	Unassigned	None	Volume Group VG0	1980.00	1980.00	✏
LUN1	Optimal	Unassigned	None	Volume Group VG0	1980.00	1980.00	✏
LUN2	Optimal	Unassigned	None	Volume Group VG0	440.00	440.00	✏
LUN3	Optimal	Unassigned	None	Volume Group VG1	1980.00	1980.00	✏
LUN4	Optimal	Unassigned	None	Volume Group VG1	1980.00	1980.00	✏
LUN5	Optimal	Unassigned	None	Volume Group VG1	440.00	440.00	✏

3. Set Volume Ownership

Storage > **Volumes** > **More** > **Change ownership**

Change Volume Ownership ✕

Changing a volume's preferred controller while an application is using it will cause I/O errors UNLESS:

- The volumes are not in use, or
- There is a multi-path driver installed on all hosts using these volumes.

Filter [   ] ❓

Volume Ownership

Volume ▲	Preferred Owner	Current Owner
LUN0	Controller B ▾	Controller B
LUN1	Controller B ▾	Controller B
LUN2	Controller B ▾	Controller B
LUN3	Controller A ▾	Controller A

Type CHANGE OWNERSHIP to confirm that you want to perform this operation.

[Type change ownership]

[Change Ownership]   [Cancel]

4. Set Volume cache settings

Storage > **Volumes > More** > **Change cache settings**

5. Change Media Scan settings

Storage > **Volumes** > **More** > **Change media scan settings**
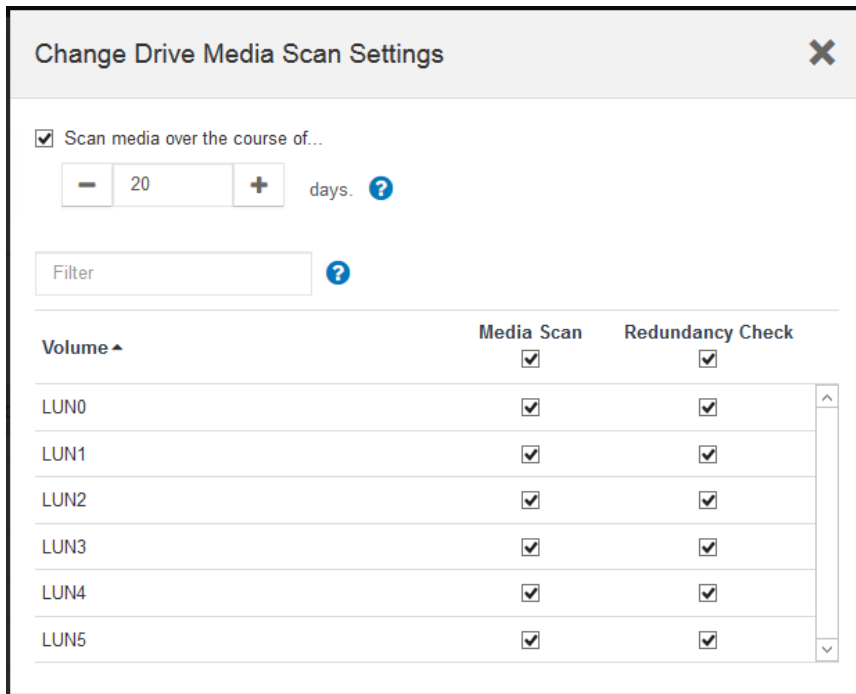
Note: Drive Media Scan is an important background maintenance task. Typical best-practice in production environments is to schedule it for regular intervals during non-peak hours. Drive Media Scan was changed to a long interval during this test as an "ease of benchmarking" practice to avoid scheduling issues.

6. Create Host

Storage > **Hosts > Create** > **Host**

Create Host   ✕

How do I match the host ports to a host?
How do I know which host operating system type is correct?

Name ❓

Host0

Host operating system type

Windows   ▾

Host ports ❓

SAS   ▾

✕ 50:06:05:B0:0C:ED:B1:C0   ✕ 50:06:05:B0:0C:ED:B1:C1   ✕ 50:06:05:B0:0C:ED:B1:00
✕ 50:06:05:B0:0C:ED:B1:01

7. Map six volumes to Host

Storage > **Hosts > Assign Volumes**

Assign Volumes   ✕

Filter   ❓

Select volumes to assign to Host **Host0**...

	Name ▲	Capacity (GiB)	DA Enabled
☑	LUN0	1980.00	Yes
☐	LUN1	1980.00	Yes
☐	LUN2	440.00	Yes
☐	LUN3	1980.00	Yes
☐	LUN4	1980.00	Yes
☐	LUN5	440.00	Yes

Selected rows: 1 of 6

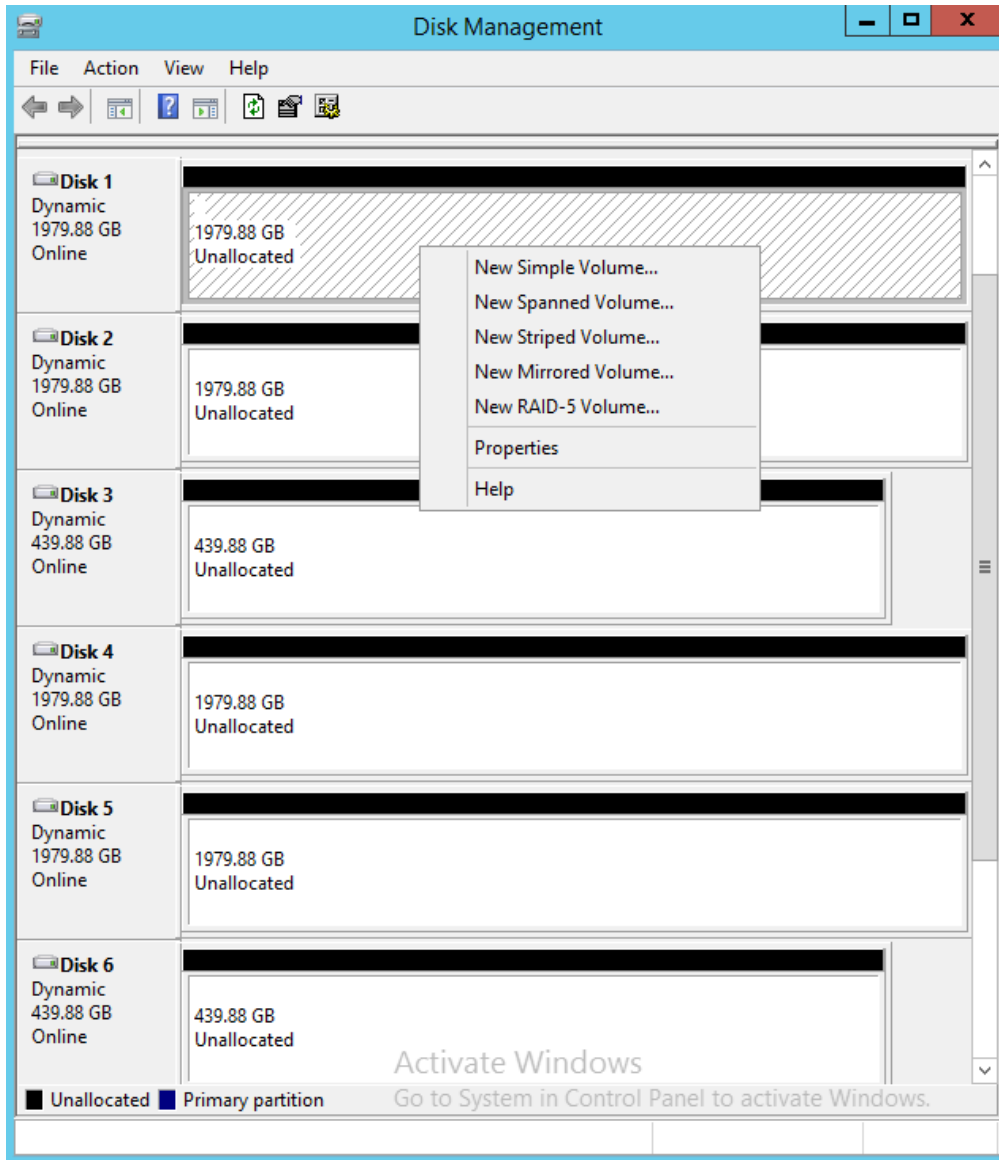| Name ▲	Status	Assigned To	LUN	Pool/ Volume Group	Reported Capacity (GiB)	Allocated Capacity (GiB)	Edit
LUN0	Optimal	Host Host0	0	Volume Group VG0	1980.00	1980.00	✎
LUN1	Optimal	Host Host0	1	Volume Group VG0	1980.00	1980.00	✎
LUN2	Optimal	Host Host0	2	Volume Group VG0	440.00	440.00	✎
LUN3	Optimal	Host Host0	3	Volume Group VG1	1980.00	1980.00	✎
LUN4	Optimal	Host Host0	4	Volume Group VG1	1980.00	1980.00	✎
LUN5	Optimal	Host Host0	5	Volume Group VG1	440.00	440.00	✎

Total rows: 6
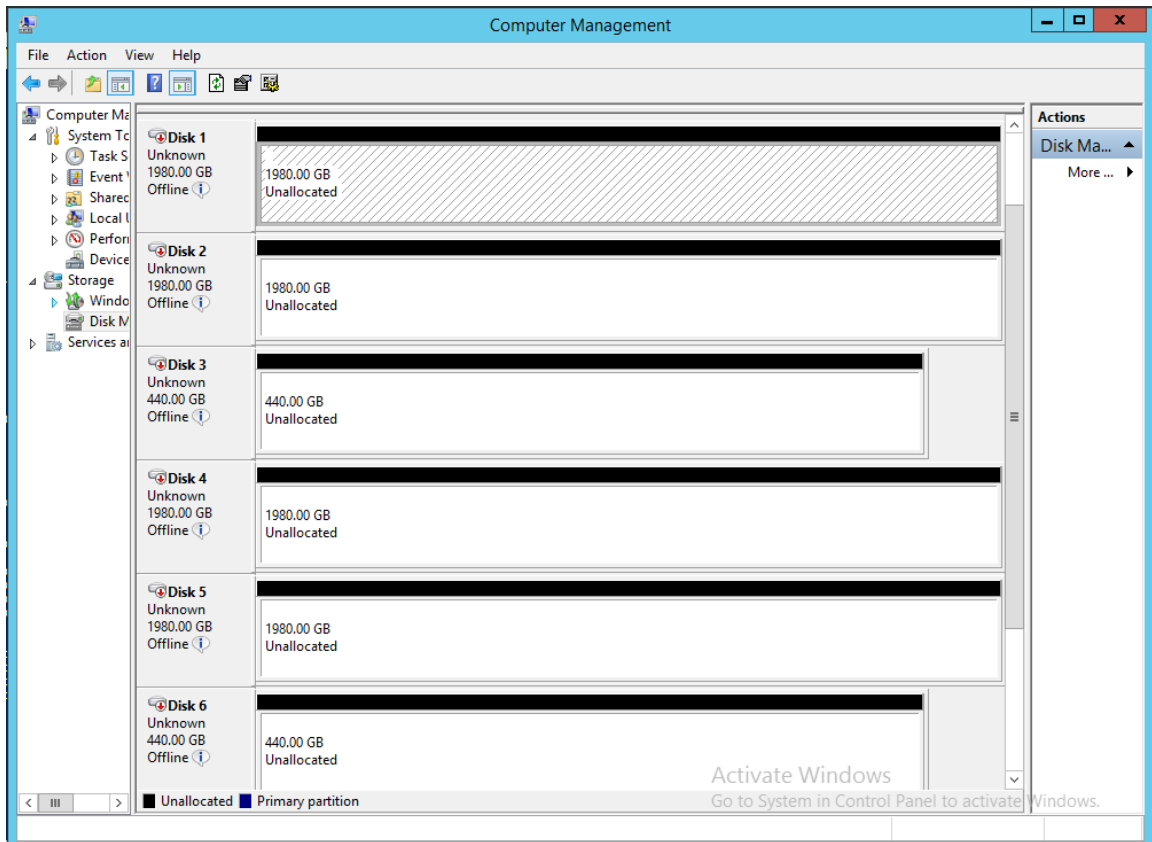
8. Create Windows Striped Volumes
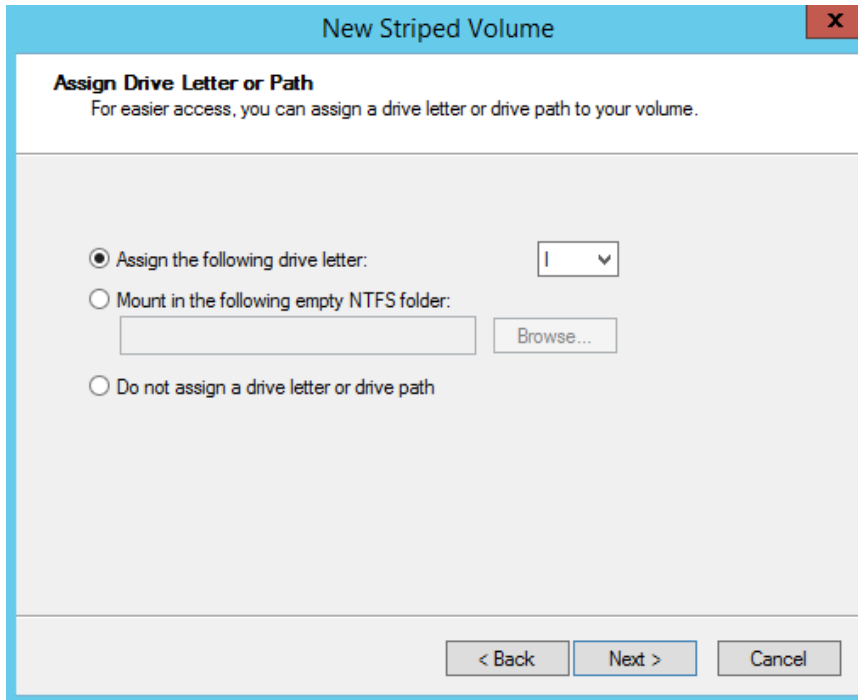   a. On one of the hosts: make volumes Online -> Initialize Disk -> convert to Dynamic Disk
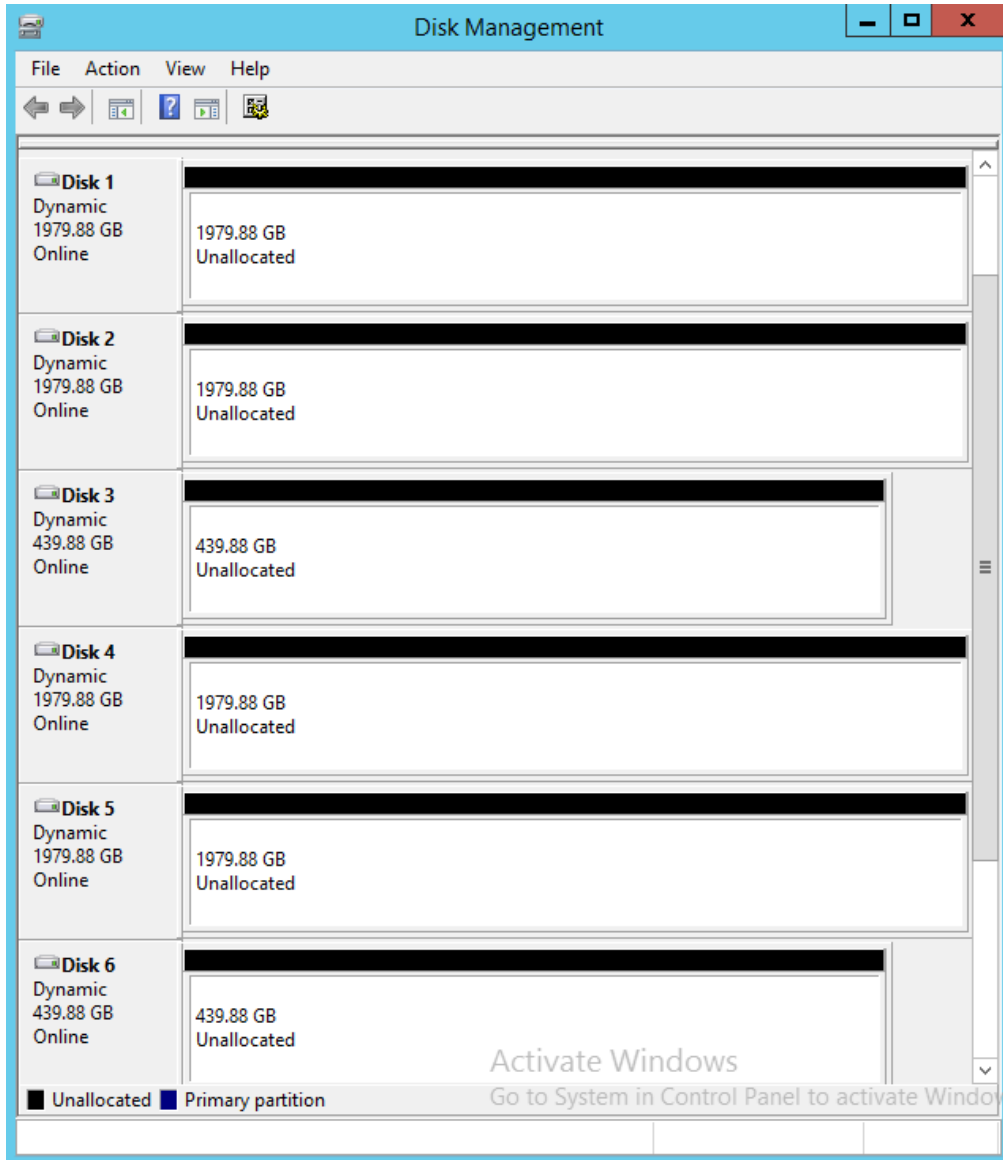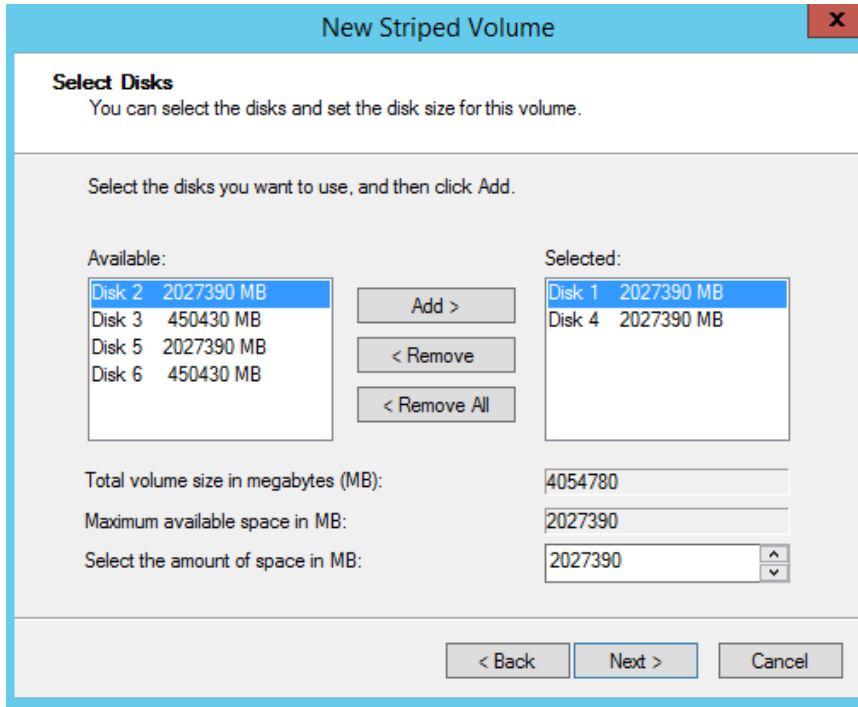
b. New Windows Striped Volumes
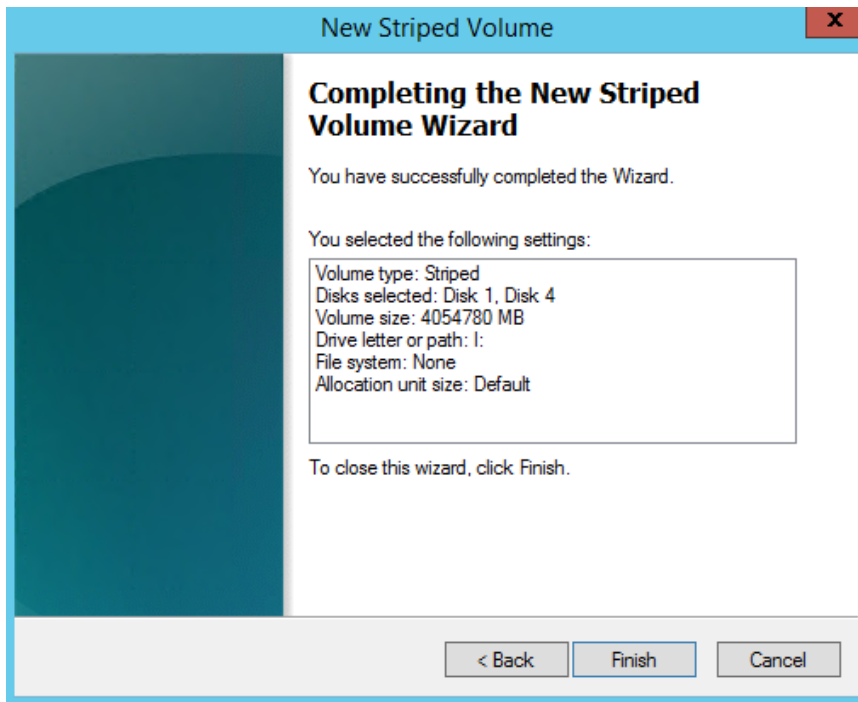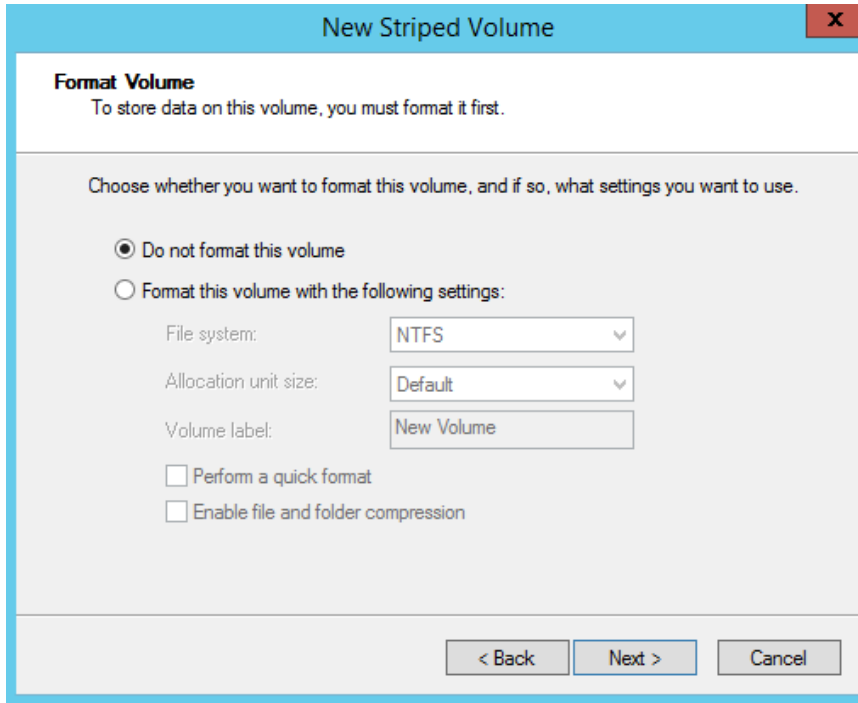
Use Windows Disk Management to create the striped ASU volumes

"Physical Disk"	LUN #	ASU	Drive Letter
1 and 4	0 and 3	ASU-1	I:
2 and 5	1 and 4	ASU-2	J:
3 and 6	2 and 5	ASU-3	K:

New Striped Volume

Select Disks
You can select the disks and set the disk size for this volume.

Select the disks you want to use, and then click Add.

Available:

Disk 2	2027390 MB
Disk 3	450430 MB
Disk 5	2027390 MB
Disk 6	450430 MB

Add >
< Remove
< Remove All

Selected:

Disk 1	2027390 MB
Disk 4	2027390 MB

Total volume size in megabytes (MB):   4054780

Maximum available space in MB: 2027390

Select the amount of space in MB: 2027390

< Back   Next >   Cancel

New Striped Volume

Assign Drive Letter or Path
For easier access, you can assign a drive letter or drive path to your volume.

⦿ Assign the following drive letter: I ⌄

○ Mount in the following empty NTFS folder:

Browse...

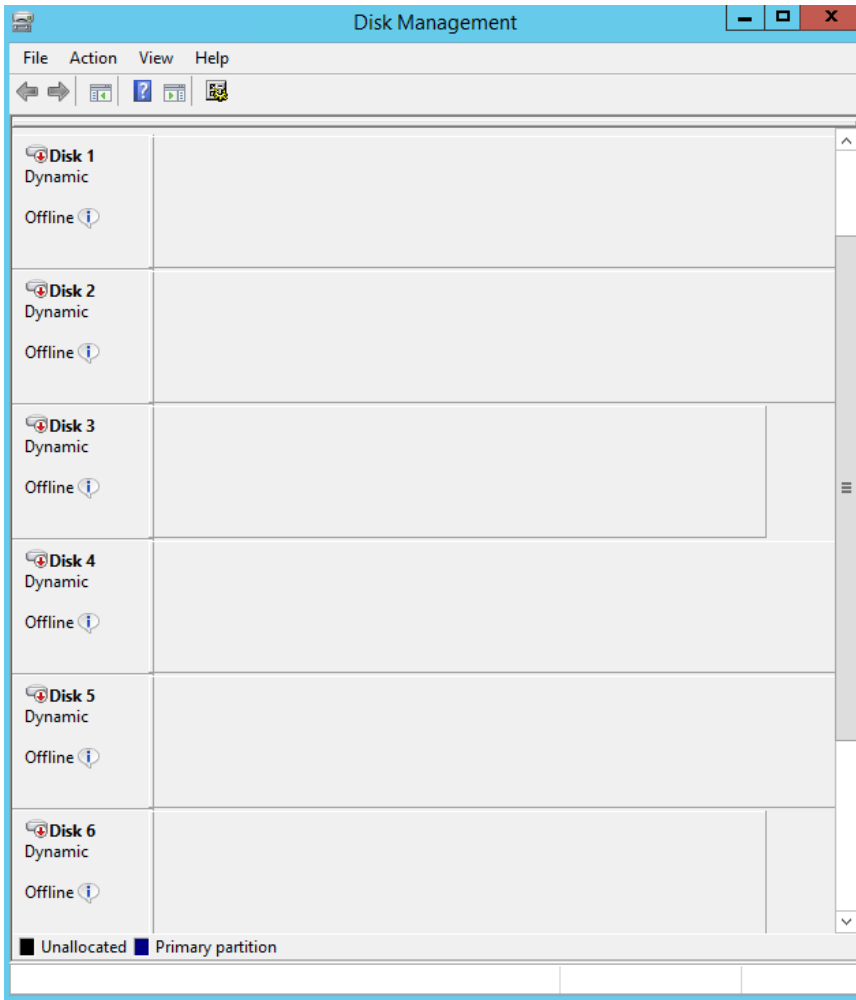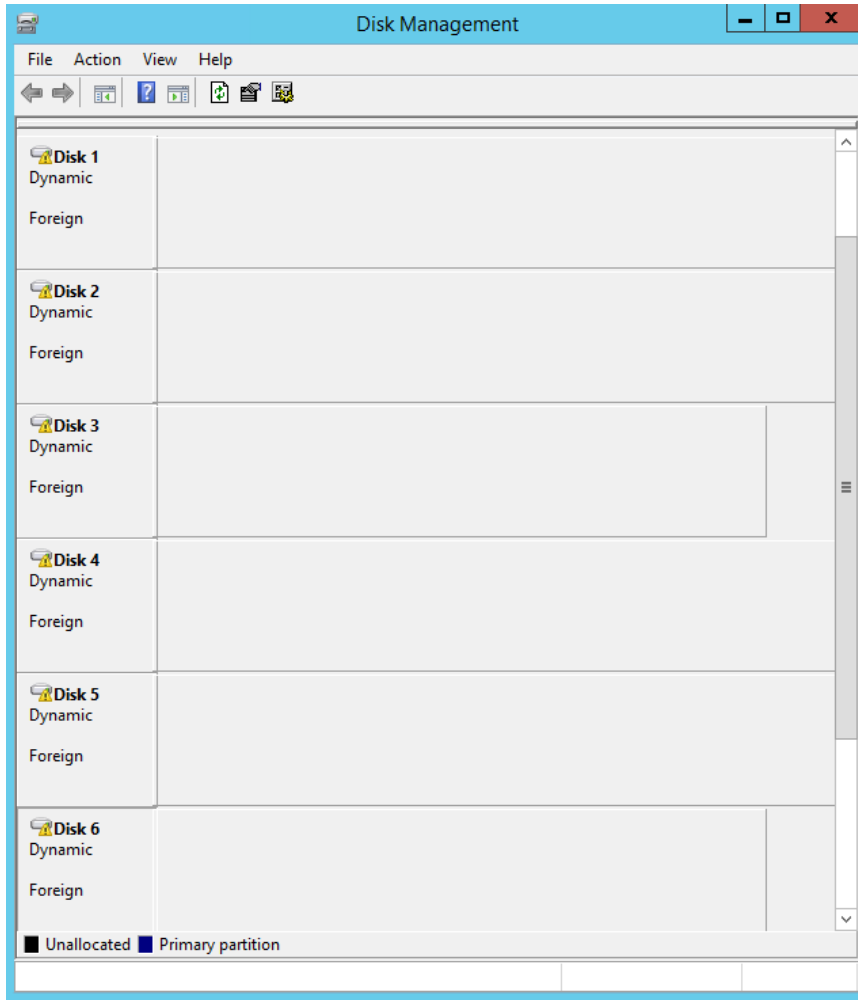○ Do not assign a drive letter or drive path

< Back   Next >   Cancel

c. Repeat steps a. and b. for drives **J:** and **K:**
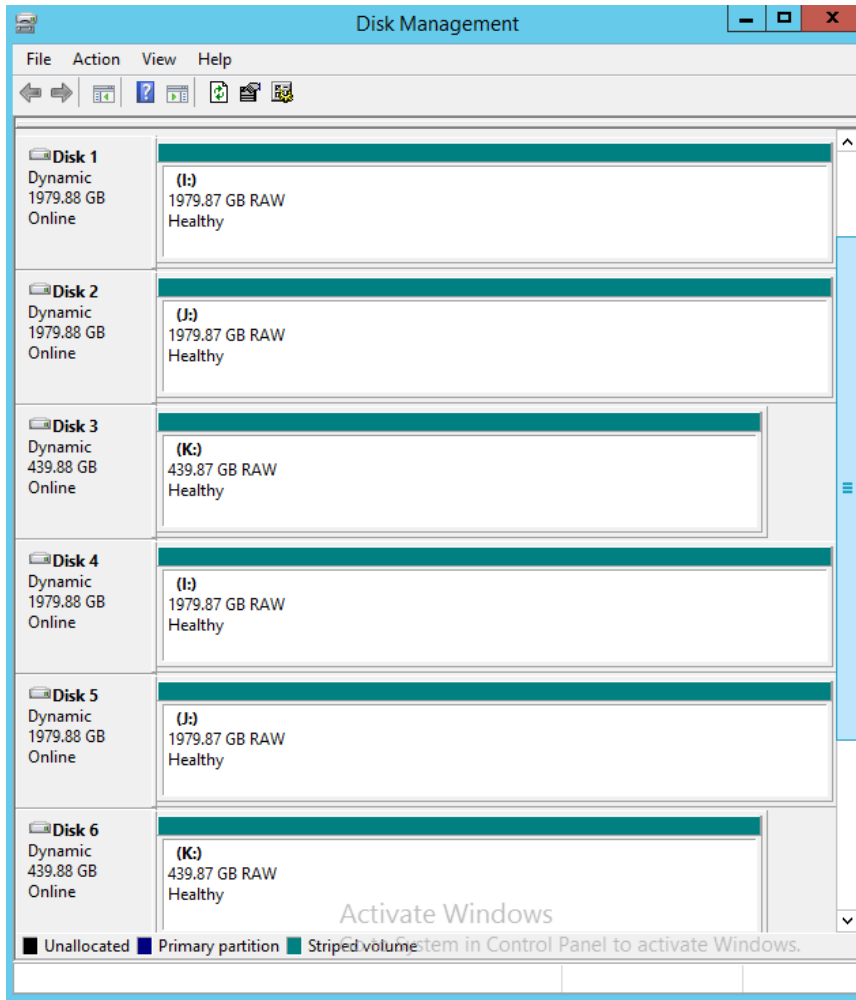
d. One the second host, Rescan Disks in Disk Management

e. Make volumes online and import foreign disks

APPENDIX E: CONFIGURATION INVENTORY

The Test Storage Configuration was collected before and after the test phases. Use ThinkSystem System Manager GUI.

Collect DE6000H info:

Support > **Support Center** > **Support Resources > Launch detailed storage array information > Storage Array Profile**

The outputs of the commands were in the log files (see Appendix A):

/DE6000H_BEFORE_Run

/DE6000H_AFTER_Run

APPENDIX F: WORKLOAD GENERATOR

The ASU Definition file and host parameter file are included in the Supporting Files.

SPC1.asu
```
OFFSET=0
SIZE=0
ASU=1
DEVICE=\\.\i:
ASU=2
DEVICE=\\.\j:
ASU=3
DEVICE=\\.\k:
```

slave.HST
```
PORT=1001
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost

PORT=1002
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost

PORT=1003
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost

PORT=1004
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost

PORT=1005
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost

PORT=1006
WEIGHT=1
STORAGE=SPC1.asu
HOST=localhost

LOGIN=Administrator
PASSWORD=Teamw0rk
EXEC=spc1_v3.0.2.exe
CONFIG=C:\SPC\v302
OUTPUT=C:\SPC\v302
WINDOWS=Y
```

```
PORT=2001
WEIGHT=1
STORAGE=SPC1.asu
HOST=10.241.68.190

LOGIN=Administrator
PASSWORD=Teamw0rk
EXEC=spc1_v3.0.2.exe
CONFIG=C:\SPC\v302
OUTPUT=C:\SPC\v302
WINDOWS=Y
PORT=2002
WEIGHT=1
STORAGE=SPC1.asu
HOST=10.241.68.190

LOGIN=Administrator
PASSWORD=Teamw0rk
EXEC=spc1_v3.0.2.exe
CONFIG=C:\SPC\v302
OUTPUT=C:\SPC\v302
WINDOWS=Y
PORT=2003
WEIGHT=1
STORAGE=SPC1.asu
HOST=10.241.68.190

LOGIN=Administrator
PASSWORD=Teamw0rk
EXEC=spc1_v3.0.2.exe
CONFIG=C:\SPC\v302
OUTPUT=C:\SPC\v302
WINDOWS=Y
PORT=2004
WEIGHT=1
STORAGE=SPC1.asu
HOST=10.241.68.190

LOGIN=Administrator
PASSWORD=Teamw0rk
EXEC=spc1_v3.0.2.exe
CONFIG=C:\SPC\v302
OUTPUT=C:\SPC\v302
WINDOWS=Y
PORT=2005
WEIGHT=1
STORAGE=SPC1.asu
HOST=10.241.68.190

LOGIN=Administrator
PASSWORD=Teamw0rk
EXEC=spc1_v3.0.2.exe
```

```
CONFIG=C:\SPC\v302
OUTPUT=C:\SPC\v302
WINDOWS=Y
PORT=2006
WEIGHT=1
STORAGE=SPC1.asu
HOST=10.241.68.190
```

The full-run of the test used the script ***DE6000_full_run.bat*** and manually invoke the PERSIST_2 after the TSC was restarted.

DE6000_full_run.bat

```
set IOPS=460000
set INIT_IOPS=1200
set PERSIST_IOPS=115000
set OUTPUT=DE6000H_1024
set STORAGE=SPC1.asu
set SPC1=spc1_v3.0.2

%SPC1% -run SPC1_INIT    -output %OUTPUT% -iops %INIT_IOPS% -storage
%STORAGE%
%SPC1% -run SPC1_VERIFY  -output %OUTPUT% -iops 100    -storage
%STORAGE%
%SPC1% -run SPC1_METRICS -output %OUTPUT% -iops %IOPS% -storage
%STORAGE% -master slave.HST
%SPC1% -run SPC1_VERIFY  -output %OUTPUT% -iops 100    -storage
%STORAGE%
%SPC1% -run SPC1_PERSIST_1 -output %OUTPUT% -iops %PERSIST_IOPS% -
storage %STORAGE%
echo "Now Restart the TSC and run:"
echo "DE6000run > .\SPC1_v3.0.2 -run SPC1_PERSIST_2 -output
DE6000H_1024 -iops 115000 -storage SPC1.asu"
```

Manually invoke PERSIST_2:

```
.\SPC1_v3.0.2 -run SPC1_PERSIST_2 -output DE6000H_1024 -iops 115000 -
storage SPC1.asu
```