SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

MACROSAN TECHNOLOGIES Co., LTD.
MS7000G2-MACH

SPC-1 v3.9.1

SUBMISSION IDENTIFIER: A32020

SUBMITTED FOR REVIEW: OCTOBER 27, 2020
First Edition – October 2020

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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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11^*12F, Building A  
Intelligent e-Valley Road No. 482  
quanmo Road, Binjiang District  
Hangzhou, China  

October 26, 2020  

I verified the SPC Benchmark 1™ (SPC-1™ v3.9.1) test execution and performance results of the following Tested Storage Product:

**MS7000G2-Mach**

The results were:

<table>
<thead>
<tr>
<th>SPC-1 IOPS™</th>
<th>11,000,576</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Price-Performance</td>
<td>$385.64/SPC-1 KIOPS™</td>
</tr>
<tr>
<td>SPC-1 Total System Price</td>
<td>4,242,215.40</td>
</tr>
<tr>
<td>SPC-1 IOPS Response Time</td>
<td>0.337 ms</td>
</tr>
<tr>
<td>SPC-1 Overall Response Time</td>
<td>0.264 ms</td>
</tr>
<tr>
<td>SPC-1 ASU Capacity</td>
<td>209,379 GB</td>
</tr>
<tr>
<td>SPC-1 ASU Price</td>
<td>$20.27/GB</td>
</tr>
</tbody>
</table>

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. 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 MacroSAN Technologies Co., Ltd., 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 MacroSAN Technologies Co., Ltd., and can be found at [www.spcresults.org](http://www.spcresults.org) under the Submission Identifier A32020.
The independent audit process conducted by InfoSizing included the verifications of the following items:

- The physical capacity of the data repository (460,800 GB).
- The total capacity of the Application Storage Unit (209,379 GB).
- 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.
- The differences between the tested and the priced configuration, if any.

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

The following benchmark requirements, if any, were waived in accordance with the SPC Policies:

The SPC-1 Specification requires PERSIST1 to be run with the following settings:

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 25% of the workload level of RAMPD_100

At sufficiently high IOPs levels and when run for the required times, the SPC-1 toolkit exhibits anomalous behavior which prevents the PERSIST1 test from completing properly.

The SPC Compliance Review Committee has reviewed this situation and granted permission for the test sponsor to run at reduced settings so that the PERSIST1 test can complete properly.

The following setting were used for this result.

- 3-minute ramp up
- 10-minute measurement Interval
- 1-minute ramp down
- 17% of the workload level of RAMPD_100

Respectfully Yours,

Doug Johnson, Certified SPC Auditor

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

Date: October 26, 2020
From: MacroSAN Technologies Co., Ltd.
To: Doug Johnson, SPC Auditor
PerfLabs, Inc. DBA InfiSizing
63 Leomnde Drive
Leominster, MA 01453-6709 USA

Subject: SPC-1 Letter of Good Faith for the MacroSAN MS7000G2-Mach

MacroSAN Technologies Co., Ltd. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V3.9.1 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: Wang Zhiqiu
President
MacroSAN Technologies Co., Ltd.
**Executive Summary**

**MS7000G2-Mach**

**SPC Benchmark 1™**

**SPC-1 IOPS™**

- **SPC-1 IOPS Response Time**: 11,000,576
- **SPC-1 Overall Response Time**: 0.337 ms

**SPC-1 Price Performance**

- **SPC-1 Total System Price**: $385.64/SPC-1 KIOPS™
- **SPC-1 Overall Discount**: 49.75%

**Currency / Target Country**

- **USD / China**

**Availability Date**

- **Currently Available**

**Extensions**

- SPC-1 Data Reduction: NA
- SPC-1 Encryption: NA
- SPC-1 NDU: NA
- SPC-1 Synchronous Replication: NA
- SPC-1 Snapshot: NA

**Storage Metrics**

- SPC-1 Data Protection Level: Protected 2
- SPC-1 Physical Storage Capacity: 460,800 GB
- SPC-1 ASU Capacity: 209,379 GB
- SPC-1 ASU Price: $20.27/GB

**Priced Storage Configuration Summary**

- **78** QLogic QLE2692 2-port FC HBAs
- **16** MS7000G2-Mach Active-Active Controllers
- **3,072** GB Total Cache (192 GB per controller)
- **256** 16 Gb FC Ports (192 ports used)
- **288** 1,600 GB SSDs
- **4** Brocade 6520 96-port Switches
- **2** 10 Gb Ethernet 16-port Switches
- **1** Management Server
- **1** 24-port 1 Gb Ethernet Switch
- **53** Total RUs

**RAMPD Average Response Time (ms) vs. IOPS**

**SUSTAIN Response Time (ms)**

- **ASU1**
- **ASU2**
- **ASU3**
- **All ASUs**

**RAMPD_100 Response Time (ms)**

- **ASU1**
- **ASU2**
- **ASU3**
- **All ASUs**

**SPC Benchmark 1™ Specification Revision**: v3.9.1

**SPC Benchmark 1™ Workload Generator Revision**: v3.0.2

**Submitted for Review**: October 27, 2020

**Submission Details**: www.storageperformance.org/r/A32020

SPC-1, SPC-1 IOPS, SPC-1 KIOPS, SPC-1 Price Performance, SPC Benchmark 1, and the SPC Logo are trademarks of the Storage Performance Council.
**Discount Details:** The discounts shown are generally available and based on the capacity and total price of the storage configuration purchased.

**Warranty:** Pricing includes Premium service with: 24x7 online support, unlimited software upgrades and bug fixes, and on-site presence of a qualified maintenance engineer within 4 hours of a problem acknowledgement, inside the Target Market.

**Differences Between Tested and Priced Storage Configurations**

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

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
<th>Source</th>
<th>Qty</th>
<th>Unit Price</th>
<th>Ext. Price</th>
<th>Disc.</th>
<th>Disc. Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Suite</td>
<td>Management Suite (1Gb Ethernet 24-port Switch<em>1, Management Sever</em>1, KVM<em>1, Network Cable 1Gbps-3M</em>17)</td>
<td></td>
<td>1</td>
<td>11,420.21</td>
<td>11,420.21</td>
<td>50%</td>
<td>5,710.11</td>
</tr>
<tr>
<td>Ethernet Switch</td>
<td>1Gb Ethernet 24-Port+1Gb Ethernet -16-Port Switch</td>
<td></td>
<td>1</td>
<td>5,534.41</td>
<td>11,068.82</td>
<td>50%</td>
<td>5,534.41</td>
</tr>
<tr>
<td>M51MMF010G</td>
<td>10Gb MultiMode Datacom SFP+ Optical Transceiver</td>
<td></td>
<td>1</td>
<td>417.28</td>
<td>13,352.96</td>
<td>50%</td>
<td>6,676.48</td>
</tr>
<tr>
<td>M57000G2-Mach-384GB</td>
<td>M57000G2-Mach Storage Controllers Unit (Dual Controllers, SU, 384GB cache, 3Y 7x9xNd Basic Sv&amp;Warranty)</td>
<td></td>
<td>1</td>
<td>284,275.26</td>
<td>2,274,202.08</td>
<td>50%</td>
<td>1,137,101.04</td>
</tr>
<tr>
<td>MS2M70D0160M2NEA</td>
<td>1.6TB NVMe SSD Drive(2.5&quot;) for M57000G2-Mach</td>
<td></td>
<td>1</td>
<td>15,461.21</td>
<td>4,452,828.48</td>
<td>50%</td>
<td>2,226,414.24</td>
</tr>
<tr>
<td>I0A4028A</td>
<td>8*16Gb FC I/O Module</td>
<td></td>
<td>1</td>
<td>10,514.73</td>
<td>337,335.36</td>
<td>50%</td>
<td>168,667.68</td>
</tr>
<tr>
<td>LIS_M57000_MACH_BASE_STD</td>
<td>MacroSAN ODSP for Multi Control - M57000G2-Mach Storage Management Software (Basic Storage Management, CRAD, support FC&amp;iSCSI, System Monitoring and Warning)</td>
<td></td>
<td>1</td>
<td>34,260.62</td>
<td>34,260.62</td>
<td>50%</td>
<td>17,130.31</td>
</tr>
<tr>
<td>LIS_M57000_MACH_2C_EXPAND</td>
<td>MacroSAN ODSP-M57000G2-Mach Storage System Management Software -2 Controllers EXPAND</td>
<td></td>
<td>1</td>
<td>22,409.02</td>
<td>157,423.14</td>
<td>50%</td>
<td>78,711.57</td>
</tr>
<tr>
<td>MS11MMF010G</td>
<td>10Gb MultiMode Datacom SFP+ Optical Transceiver</td>
<td></td>
<td>1</td>
<td>417.28</td>
<td>13,352.96</td>
<td>50%</td>
<td>6,676.48</td>
</tr>
<tr>
<td>DLC05-DLC05-2M02-LS/0.2</td>
<td>10M Fiber Cable(Multimode, LC-LC)</td>
<td></td>
<td>1</td>
<td>17.57</td>
<td>562.24</td>
<td>50%</td>
<td>281.12</td>
</tr>
<tr>
<td>QLogic QLE2692</td>
<td>Qlogic QLE2692 HBA Card, PCIE, 16Gbps 2-Ports, Fiber Channel Multimode LC Optic Interface</td>
<td></td>
<td>1</td>
<td>3,953.15</td>
<td>308,345.70</td>
<td>50%</td>
<td>154,172.85</td>
</tr>
<tr>
<td>FS6520</td>
<td>Brocade 6520 16Gbps FC Switch with 96 available ports, including 96*16Gbps SFPs, Double-Power Supply, AC</td>
<td></td>
<td>1</td>
<td>189,985.36</td>
<td>759,941.44</td>
<td>50%</td>
<td>379,970.72</td>
</tr>
</tbody>
</table>

**Discount Details:** The discounts shown are generally available and based on the capacity and total price of the storage configuration purchased.

**Warranty:** Pricing includes Premium service with: 24x7 online support, unlimited software upgrades and bug fixes, and on-site presence of a qualified maintenance engineer within 4 hours of a problem acknowledgement, inside the Target Market.

**Differences Between Tested and Priced Storage Configurations**

There were no differences between the TSC and the Priced Storage Configuration.
**Publication Details**

This section provides contact information for the test sponsor and auditor, a revision history of this document, and a description of any exceptions or waivers associated with this publication.

**Contact Information**

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Sponsor Primary Contact</td>
<td>MacroSAN Technologies Co., Ltd. Yi Shen</td>
<td><a href="http://www.macrosan.com/en/">www.macrosan.com/en/</a> <a href="mailto:shenyi@macrosan.com">shenyi@macrosan.com</a></td>
</tr>
<tr>
<td>SPC Auditor</td>
<td>InfoSizing Doug Johnson</td>
<td><a href="http://www.sizing.com">www.sizing.com</a> <a href="mailto:doug@sizing.com">doug@sizing.com</a></td>
</tr>
</tbody>
</table>

**Revision Information**

<table>
<thead>
<tr>
<th>Date</th>
<th>FDR Revision</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 27, 2020</td>
<td>First Edition</td>
<td>Initial Publication</td>
</tr>
</tbody>
</table>

**Exceptions and Waivers**

The SPC-1 Specification requires PERSIST1 to be run with the following settings:

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 25% of the workload level of RAMPD_100

At sufficiently high IOPs levels and when run for the required times, the SPC-1 toolkit exhibits anomalous behavior which prevents the PERSIST1 test from completing properly.

The SPC Compliance Review Committee has reviewed this situation and granted permission for the test sponsor to run at reduced settings so that the PERSIST1 test can complete properly.

The following setting were used for this result.

- 3-minute ramp up
- 10-minute measurement interval
- 1-minute ramp down
- 17% of the workload level of RAMPD_100
CONFIGURATION INFORMATION

Tested Storage Product Description

MacroSAN MS7000G2-Mach is an all-flash storage array based on NVMe protocol newly launched by MacroSAN Technologies, which uses NVMe SSD as storage medium. MS7000G2-Mach storage products adopt a brand-new hardware architecture and software algorithm for the NVMe protocol, release the performance of flash memory particles in all directions, and provide several times the read and write performance of traditional flash memory arrays. The MacroSAN MS7000G2-Mach all-flash storage product can provide extreme performance, comprehensive data protection and full product lifecycle solutions for key services such as data center IO-intensive and delay sensitivity.

Host System and Tested Storage Configuration Components

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

<table>
<thead>
<tr>
<th>Host Systems</th>
<th>Tested Storage Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>39 x Sugon I620-G30, each with: 2 x Intel® Xeon® Silver 4116 CPU (2.1 GHz, 12-Core, 16.5 MB L3) (20 host systems) 2 x Intel® Xeon® Silver 4214 CPU (2.2 GHz, 12-Core, 16.5 MB L3) (19 host systems) 64 GB Main Memory (all host systems) CentOS Linux Release 7.4.1708 (all host systems)</td>
<td>78 x QLogic QLE2692 2-port HBAs 16 x MS7000G2-Mach Active-Active Controllers, each with: 192 GB cache (3.072 GB total) 32 x 8-port 16 Gbps FC I/O modules (256 ports total, 192 used) 8 x 4-port 10 Gb Ethernet 8 x 5U Internal Enclosures, each with: 36 x 1,600 GB SSDs (288 total)</td>
</tr>
<tr>
<td>2 x 10 Gb Ethernet 16-port switches 1 x 1 Gb Ethernet 24-port switch 1 x Management Server</td>
<td></td>
</tr>
</tbody>
</table>

Component Changes in Revised Full Disclosure Report

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

<table>
<thead>
<tr>
<th>Original Component</th>
<th>Revised Component</th>
<th>Description of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>Initial submission</td>
</tr>
</tbody>
</table>
Configuration Diagnostics

**BC/TSC Configuration Diagram**

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

**Storage Network Configuration**

The Tested Storage Configuration (TSC) comprised an external storage subsystem of eight MacroSAN MS7000G2 Storage Controller Units, each with two storage controllers. They were driven by 39 host systems (Sugon I620-G30). Each host had one 16 Gb FC connection to each of four Brocade 6520 switches (156 total connections). Each of the 16 storage controllers had three 16 Gb FC connections to each of the four Brocade switches (192 total connections).
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.

<table>
<thead>
<tr>
<th>LV per ASU</th>
<th>LV Capacity</th>
<th>Used per LV</th>
<th>Total per ASU</th>
<th>% ASU Capacity</th>
<th>Optimized*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASU-1</td>
<td>30</td>
<td>3,140.6</td>
<td>3,140.6</td>
<td>94,220.8</td>
<td>45.0%</td>
</tr>
<tr>
<td>ASU-2</td>
<td>3</td>
<td>31,406.9</td>
<td>31,406.9</td>
<td>94,220.8</td>
<td>45.0%</td>
</tr>
<tr>
<td>ASU-3</td>
<td>3</td>
<td>6,979.3</td>
<td>6,979.3</td>
<td>20,937.9</td>
<td>10.0%</td>
</tr>
</tbody>
</table>

SPC-1 ASU Capacity 209,379

*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.

<table>
<thead>
<tr>
<th>Devices</th>
<th>Count</th>
<th>Physical Capacity</th>
<th>Total Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVMe SSD</td>
<td>288</td>
<td>1,600.0</td>
<td>460,800.0</td>
</tr>
<tr>
<td><strong>Total Physical Capacity</strong></td>
<td></td>
<td></td>
<td>460,800</td>
</tr>
<tr>
<td><strong>Physical Capacity Utilization</strong></td>
<td></td>
<td></td>
<td>45.44%</td>
</tr>
</tbody>
</table>

Data Protection

The data protection level used for all LVs was Protected 2 (RAID10), which was accomplished by configuring 48 pools, each 6 drives, into 48 RAID-10 arrays.
components and access paths from the Host systems to the Storage Devices were redundant.

**Space Optimization Information**

**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.

<table>
<thead>
<tr>
<th>Physical Free Space Measurement</th>
<th>Free Space (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>After Logical Volume Creation</td>
<td>NA</td>
</tr>
<tr>
<td>After ASU Pre-Fill</td>
<td>NA</td>
</tr>
<tr>
<td>After Repeatability Test Phase</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Space Optimization Metrics**

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

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-1 Space Optimization Ratio</td>
<td>NA</td>
</tr>
<tr>
<td>SPC-1 Space Effectiveness Ratio</td>
<td>NA</td>
</tr>
</tbody>
</table>
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).

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.
Response Time vs. Throughput Graph

The following graph presents the average Response Times versus the average IOPS for RAMPD_100 to RAMPD_10.

ASU Pre-Fill

The following table provides a summary of the Pre-Fill performed on the ASU prior to testing.

<table>
<thead>
<tr>
<th>ASU Pre-Fill Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Time</td>
</tr>
<tr>
<td>End Time</td>
</tr>
<tr>
<td>Duration</td>
</tr>
<tr>
<td>Requested IOP Level</td>
</tr>
<tr>
<td>Observed IOP Level</td>
</tr>
</tbody>
</table>

For additional details see the Supporting Files.
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

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date &amp; Time</th>
<th>End Date &amp; Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Interval</td>
<td>19-Oct-20 19:35:06</td>
<td>20-Oct-20 03:35:07</td>
<td>8:00:01</td>
</tr>
</tbody>
</table>

SUSTAIN – Throughput Graph

[Throughput Graph Image]

- Throughput Graph (SUSTAIN @ 11,000,000 IOPS)

- ASU1
- ASU2
- ASU3
- All ASUs
**SUSTAIN – Response Time Graph**

![Response Time Graph (SUSTAIN @ 11,000,000 IOPS)](image)

**SUSTAIN – Data Rate Graph**

![Data Rate Graph (SUSTAIN @ 11,000,000 IOPS)](image)
SUSTAIN – Response Time Frequency Graph

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.

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0002</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0001</td>
</tr>
<tr>
<td>Difference</td>
<td>0.005%</td>
<td>0.001%</td>
<td>0.005%</td>
<td>0.001%</td>
<td>0.004%</td>
<td>0.004%</td>
<td>0.003%</td>
<td>0.001%</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Interval</th>
<th>Start Date &amp; Time</th>
<th>End Date &amp; Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Period</td>
<td>20-Oct-20 03:36:06</td>
<td>20-Oct-20 03:46:06</td>
<td>0:10:00</td>
</tr>
</tbody>
</table>

RAMPD_100 – Throughput Graph

![Throughput Graph (RampD_100 @ 11,000,000 IOPS)](chart.png)
RAMPD_100 – Response Time Graph

Response Time Graph (RampD_100 @ 11,000,000 IOPS)

RAMPD_100 – Data Rate Graph

Data Rate Graph (RampD_100 @ 11,000,000 IOPS)
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.

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0002</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0001</td>
</tr>
<tr>
<td>Difference</td>
<td>0.000%</td>
<td>0.000%</td>
<td>0.003%</td>
<td>0.001%</td>
<td>0.014%</td>
<td>0.000%</td>
<td>0.005%</td>
<td>0.000%</td>
</tr>
</tbody>
</table>

RAMPD_100 – I/O Request Summary

| I/O Requests Completed in the Measurement Interval | 6,600,371,143 |
| I/O Requests Completed with Response Time <= 30 ms | 6,600,336,752 |
| I/O Requests Completed with Response Time > 30 ms | 34,391 |
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

![Average Throughput Graph (Response Time Ramp Test)](image)
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.

<table>
<thead>
<tr>
<th>Test Phase</th>
<th>100% IOPS</th>
<th>10% IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMPD</td>
<td>11,000,576.6</td>
<td>1,100,070.7</td>
</tr>
<tr>
<td>REPEAT_1</td>
<td>11,000,748.4</td>
<td>1,099,995.0</td>
</tr>
<tr>
<td>REPEAT_2</td>
<td>11,000,561.9</td>
<td>1,100,060.4</td>
</tr>
</tbody>
</table>

REPEAT_1_100 – Throughput Graph

![Throughput Graph (Repeat_1_100 @ 11,000,000 IOPS)](image)
**REPEAT_1_100 – Response Time Graph**

- **Response Time Graph (Repeat_1_100 @ 11,000,000 IOPS)**
  - ASU1
  - ASU2
  - ASU3
  - All ASUs

**REPEAT_2_100 – Throughput Graph**

- **Throughput Graph (Repeat_2_100 @ 11,000,000 IOPS)**
  - ASU1
  - ASU2
  - ASU3
  - All ASUs
**REPEAT_2_100 – Response Time Graph**

![Response Time Graph (Repeat_2_100 @ 11,000,000 IOPS)](image)

### Repeatability Test – Intensity Multiplier

The following tables list 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

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0003</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0001</td>
</tr>
<tr>
<td>Difference</td>
<td>0.003%</td>
<td>0.003%</td>
<td>0.001%</td>
<td>0.002%</td>
<td>0.011%</td>
<td>0.007%</td>
<td>0.003%</td>
<td>0.003%</td>
</tr>
</tbody>
</table>

#### REPEAT_2_100 Test Phase

<table>
<thead>
<tr>
<th></th>
<th>ASU1-1</th>
<th>ASU1-2</th>
<th>ASU1-3</th>
<th>ASU1-4</th>
<th>ASU2-1</th>
<th>ASU2-2</th>
<th>ASU2-3</th>
<th>ASU3-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Measured</td>
<td>0.0350</td>
<td>0.2810</td>
<td>0.0700</td>
<td>0.2100</td>
<td>0.0180</td>
<td>0.0700</td>
<td>0.0350</td>
<td>0.2810</td>
</tr>
<tr>
<td>Variation</td>
<td>0.0002</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0002</td>
<td>0.0003</td>
<td>0.0001</td>
</tr>
<tr>
<td>Difference</td>
<td>0.004%</td>
<td>0.000%</td>
<td>0.002%</td>
<td>0.002%</td>
<td>0.001%</td>
<td>0.002%</td>
<td>0.008%</td>
<td>0.002%</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Data Persistence Test Phase: Persist1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Logical Blocks Written</td>
<td>1,544,784,565</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Verified</td>
<td>754,816,683</td>
</tr>
<tr>
<td>Total Number of Logical Blocks Overwritten</td>
<td>789,967,882</td>
</tr>
<tr>
<td>Total Number of Logical Blocks that Failed Verification</td>
<td>0</td>
</tr>
<tr>
<td>Time Duration for Writing Test Logical Blocks (sec.)</td>
<td>601</td>
</tr>
<tr>
<td>Size in bytes of each Logical Block</td>
<td>8,192</td>
</tr>
<tr>
<td>Number of Failed I/O Requests in the process of the Test</td>
<td>0</td>
</tr>
</tbody>
</table>

Committed Data Persistence Implementation

Each Node of MS7000G2-Mach has six system disks and three batteries in the Storage Processor Unit where the two Active-Active Controllers reside. When a failure occurs and the Storage Processor Unit loses power, the controllers can flush the data in the cache to the system disks for permanent preservation with the built-in battery. When the Node is started again, the data on the system disk will be recovered automatically.
## APPENDIX A: SUPPORTING FILES

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

<table>
<thead>
<tr>
<th>File Name</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>/SPC1_RESULTS</td>
<td>Data reduction worksheets</td>
<td>root</td>
</tr>
<tr>
<td>SPC1_INIT_0_Raw_Results.xlsx</td>
<td>Raw results for INIT Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Quick_Look.xlsx</td>
<td>Quick Look Test Run Overview</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Raw_Results.xlsx</td>
<td>Raw results for Primary Metrics Test</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_METRICS_0_Summary_Results.xlsx</td>
<td>Primary Metrics Summary</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_1_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST1 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_PERSIST_2_0_Raw_Results.xlsx</td>
<td>Raw results for PERSIST2 Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_Run_Set_Overview.xlsx</td>
<td>Run Set Overview Worksheet</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_0_Raw_Results.xlsx</td>
<td>Raw results for first VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>SPC1_VERIFY_1_Raw_Results.xlsx</td>
<td>Raw results for second VERIFY Test Phase</td>
<td>/SPC1_RESULTS</td>
</tr>
<tr>
<td>/C_Tuning</td>
<td>Tuning parameters and options</td>
<td>root</td>
</tr>
<tr>
<td>aio-max-nr.sh</td>
<td>Set maximum asynchronous I/O</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>nr_request.sh</td>
<td>Increase disk queue depth</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>scheduler.sh</td>
<td>Change the I/O scheduler</td>
<td>/C_Tuning</td>
</tr>
<tr>
<td>/D_Creation</td>
<td>Storage configuration creation</td>
<td>root</td>
</tr>
<tr>
<td>init_MS7000G2-Mach.sh</td>
<td>Create the storage environment</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>mkllvm_MS7000G2-Mach.sh</td>
<td>Create the logical volumes</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>lvm-active.sh</td>
<td>Activate the logical volumes</td>
<td>/D_Creation</td>
</tr>
<tr>
<td>/E_Inventory</td>
<td>Configuration inventory</td>
<td>root</td>
</tr>
<tr>
<td>profile_MS7000G2-Mach.sh</td>
<td>Captures storage devices profiles</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>profile_start_MS7000G2-Mach.txt</td>
<td>List of storage devices before INIT</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>profile_end_MS7000G2-Mach.txt</td>
<td>List of storage devices after restart</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>volume_list.sh</td>
<td>Captures list of logical volumes</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>volume_listing_start.txt</td>
<td>List of logical volumes before INIT</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>volume_listing_end.txt</td>
<td>List of logical volumes after restart</td>
<td>/E_Inventory</td>
</tr>
<tr>
<td>/F_Generator</td>
<td>Workload generator</td>
<td>root</td>
</tr>
<tr>
<td>40p.HST</td>
<td>Host configuration file</td>
<td>/F_generator</td>
</tr>
<tr>
<td>slave_asu.asu</td>
<td>Defines LUNS hosting the ASUs</td>
<td>/F_generator</td>
</tr>
<tr>
<td>MS7000G2-Mach_test_phase1.sh</td>
<td>Execute test phases up to VERIFY_1</td>
<td>/F_generator</td>
</tr>
<tr>
<td>MS7000G2-Mach_test_phase2.sh</td>
<td>Execute PERSIST_1</td>
<td>/F_generator</td>
</tr>
<tr>
<td>MS7000G2-Mach_test_phase3.sh</td>
<td>Execute PERSIST_2</td>
<td>/F_generator</td>
</tr>
</tbody>
</table>
APPENDIX B: THIRD PARTY QUOTATION

All components are available directly through the Test Sponsor (MacroSAN Technologies Co., Ltd.).
APPENDIX C: TUNING PARAMETERS AND OPTIONS

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

- `aio-max-nr.sh` to set the maximum asynchronous I/O
- `nr_request.sh` to increase the disk queue depth
- `scheduler.sh` to change the I/O scheduler

The scripts described above are included in the Supporting Files (see Appendix A).
APPENDIX D: STORAGE CONFIGURATION CREATION

Step 1: Create Storage Pool, RAIDs, LUNs, Clients, Mapping and deploy LUNs.

Execute the init_MS7000G2-Mach.sh script on either of the Storage Controllers via a CLI session to complete the following:

1. Create 6 storage pool for each Node.
2. Create 48 RAID10, each Node has 6 RAID10
3. Create 384 LUNs (8 LUNs in per RAID10, ALL LUNs have a capacity of 520GB).
4. Create 156 Clients each Node.
5. Add Host System FC Initiators to Clients (1 Initiator per Client)
6. Create Storage Targets to Clients (6 Target per Client and each Target is associated with 1 FC port)
7. Add LUNs to Targets (4 LUNs per Target)

Step 2: Create Volumes on the Master Host System

Configure the multipath.conf file and enable the multipath service. Execute the mkIvm_MS7000g2-Mach.sh script on the Master Host System to create 36 logical volumes as follows:

1. Create Physical Volume
Create 384 physical volumes using the pvcreate command.

2. Create Volumes Groups
Create 3 volume groups using the vgcreate command as follows:
Create vg1 using the following 128 physical volumes: 
Create vg2 using the following 128 physical volumes:
/dev/mapper/mpathfhq
/dev/mapper/mpathfgg
/dev/mapper/mpathfgu
/dev/mapper/mpathfgn
/dev/mapper/mpathfi
/dev/mapper/mpathfhc
/dev/mapper/mpathfhx
/dev/mapper/mpathfgx
/dev/mapper/mpathfda
/dev/mapper/mpathfcw
/dev/mapper/mpathfdj
/dev/mapper/mpathcr
/dev/mapper/mpathezk
/dev/mapper/mptheyw
/dev/mapper/mpathezl
/dev/mapper/mptheyt
/dev/mapper/mpathfji
/dev/mapper/mpathfic
/dev/mapper/mpathfjl
/dev/mapper/mpathfhu
/dev/mapper/mpathfjy
/dev/mapper/mpathfw
/dev/mapper/mpathfki
/dev/mapper/mpathfht
/dev/mapper/mpathfeay
/dev/mapper/mpathfdm
/dev/mapper/mpathfed
/dev/mapper/mpathfd
/dev/mapper/mpathfbae
/dev/mapper/mpathezo
/dev/mapper/mpathfab
/dev/mapper/mpathezz
/dev/mapper/mpathfw
/dev/mapper/mpathfj
/dev/mapper/mpathfkn
/dev/mapper/mpathfip
/dev/mapper/mpathfmf
/dev/mapper/mpathfpl
/dev/mapper/mpathfms
/dev/mapper/mpathfkp
/dev/mapper/mpathfqq
/dev/mapper/mpathfes
/dev/mapper/mpathfev
/dev/mapper/mpathfej
/dev/mapper/mpathfbi
/dev/mapper/mpathfaq
/dev/mapper/mpathfav
/dev/mapper/mpathfat
/dev/mapper/mpathfh
/dev/mapper/mpathfmk
/dev/mapper/mpathfmr
/dev/mapper/mpathfnb
/dev/mapper/mpathfmg
/dev/mapper/mpathfmy
/dev/mapper/mpathflq
/dev/mapper/mpathfnl
/dev/mapper/mpathffk
/dev/mapper/mpathffu
/dev/mapper/mpathfff
/dev/mapper/mpathfgd
/dev/mapper/mpathfca
/dev/mapper/mpathezu
/dev/mapper/mpathfuu
/dev/mapper/mpatheuf
/dev/mapper/mpatheux
/dev/mapper/mpathez
/dev/mapper/mpathezu
/dev/mapper/mpatheu
/dev/mapper/mpatheux
/dev/mapper/mpatheu
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
/dev/mapper/mpatheux
Create vg3 using the following 128 physical volumes:
/dev/mapper/mpathfhn
/dev/mapper/mpathfhj /dev/mapper/mpathfhw /dev/mapper/mpathfhp /dev/mapper/mpathfid
/dev/mapper/mpathfgo /dev/mapper/mpathfhz /dev/mapper/mpathfgy/dev/mapper/mpathfdh
/dev/mapper/mpathfcn /dev/mapper/mpathfdk /dev/mapper/mpathfcs /dev/mapper/mpatheyz
/dev/mapper/mpatheyx /dev/mapper/mpathezm /dev/mapper/mpatheyu
/dev/mapper/mpatheyb /dev/mapper/mpathfhf /dev/mapper/mpathfjm /dev/mapper/mpathfhv
/dev/mapper/mpathfjr /dev/mapper/mpathfhj /dev/mapper/mpathfkk /dev/mapper/mpathfhw
/dev/mapper/mpathfdv /dev/mapper/mpathfdr /dev/mapper/mpathfee /dev/mapper/mpathfdg
/dev/mapper/mpathfaf /dev/mapper/mpathfep /dev/mapper/mpathfac /dev/mapper/mpathfaoa
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/dev/mapper/mpathfdp /dev/mapper/mpathfg /dev/mapper/mpathfde /dev/mapper/mpathfax
/dev/mapper/mpathezh /dev/mapper/mpatheza /dev/mapper/mpathezu /dev/mapper/mpathfl
/dev/mapper/mpathfit /dev/mapper/mpathfbr /dev/mapper/mpathfin /dev/mapper/mpathfml
/dev/mapper/mpathffx /dev/mapper/mpathfmr /dev/mapper/mpathfku
/dev/mapper/mpathffl /dev/mapper/mpathfp /dev/mapper/mpathfy /dev/mapper/mpathfem
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/dev/mapper/mpathfez /dev/mapper/mpathfzh /dev/mapper/mpathffe /dev/mapper/mpathfnc
/dev/mapper/mpathfal /dev/mapper/mpathfbl /dev/mapper/mpathfao /dev/mapper/mpathfbs

3. Create Logical Volumes

Create 10 logical volumes, which capacity is 2925 GB, on vg1 for ASU-1.
Create 10 logical volumes, which capacity is 2925 GB, on vg2 for ASU-1.
Create 10 logical volumes, which capacity is 2925 GB, on vg3 for ASU-1.
Create 1 logical volume, which capacity is 29250 GB, on vg1 for ASU-2.
Create 1 logical volume, which capacity is 29250 GB, on vg2 for ASU-2.
Create 1 logical volume, which capacity is 29250 GB, on vg3 for ASU-2.
Create 1 logical volume, which capacity is 6500 GB, on vg1 for ASU-3.
Create 1 logical volume, which capacity is 6500 GB, on vg2 for ASU-3.
Create 1 logical volume, which capacity is 6500 GB, on vg3 for ASU-3.

4. Activate each Logical Volume
Execute the lvm-active on the Slave Host Systems, the script will make each logical volume available (activate).

Step 3: Change the Scheduler on each Host System, change the nr_request, aio on each Host System
Execute the scheduler.sh script on each Host System to change the scheduler of each block device from cfq to noop.
Execute the nr_request.sh script on each Host System to change the nr_request of each block device from 64 to 1024.
Execute the aio-max-nr.sh script on each Host System to change the aio-max-nr to 1048576.
APPENDIX E: CONFIGURATION INVENTORY

An inventory of the TSC was collected during the execution of the scripts MS7000G2-Mach_test_phase1.sh and MS7000G2-Mach_test_phase3.sh. The following log files were generated.

- profile_start_MS7000G2-Mach.txt – list of configured storage before the INIT phase
- volume_listing_start.txt – list of configured volumes before the INIT phase
- profile_end_MS7000G2-Mach.txt – list of configured storage after TSC restart
- volume_listing_end.txt – list of configured volumes after TSC restart

The above log files are included in the Supporting Files (see Appendix A).
APPENDIX F: WORKLOAD GENERATOR

The host parameters for the SPC-1 workload generator were defined using the script 40p.HST.

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

The initial test phases of the benchmark are executed using the scripts MS7000G2-Mach_test_phase1.sh. The PERSIST_1 phase is invoked by the script MS7000G2-Mach_test_phase2.sh. This is followed by a full shutdown and power down of the TSC. Once the TSC has been restarted, the PERSIST_2 test phase is executed using the script MS7000G2-Mach_test_phase3.sh.

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