Apples to Apples, Pears to Pears in SSS performance Benchmarking

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Abstract

SSS Performance Benchmarking Learning Objectives

- Get a good understanding of the various parameters that influence the performance characteristics of SSDs

- Get a full understanding of the proposed SNIA Performance Measurement Specification

- Provide step-by-step guidance on how to set up a test benchmark that enables comparison among the various SSS devices

SSS = Solid State Storage
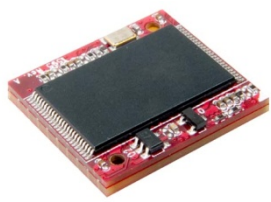

Traditional hard disk drive

Solid state hard drive

- Bandwidth Performance Specifications
  — Sustained Sequential Read: Up to 250 MB/s
  — Sustained Sequential Write: Up to 70 MB/s
- Read and Write IOPS specifications (IOmeter Queue Depth 32)
  — Random 4 KB Reads: Up to 35 K IOPS
  — Random 4 KB Writes: Up to 3 K IOPS

Read/Write Mix?

IOPS?

Sustained?

Block Size?

10 times faster than HDD?

Random?

Up to?

Like other high-performance, enterprise class flash drives, ⬛⬛⬛⬛⬛⬛⬛ drive is being positioned as an alternative to traditional 15,000-rpm serial-attached SCSI (SAS) hard disk drives. ⬛⬛⬛ said its new "performance-optimized" enterprise SSD can process IOPS (input/output per second) more than 10 times faster than the fastest SAS hard drive, with a sequential read rate of 230MB/sec. and a sequential write rate of 180MB/sec.

Performance

Average Access Time	20-120 microseconds
Sustained Read Throughput	220 Mbytes/sec
Sustained Write Throughput	115 Mbytes/sec
Random IOPS Read Operations	45,000 IO/sec sustained
Random IOPS Write Operations	16,000 IO/sec sustained

Increased High Speed Performance

- 800 MByte Full Duplex Burst Rate
- Up to 230 MB/sec Sustained Rate
- Up to 35,000 IOPS
- 30 to 100 µsec Access Time

Table 3: Sustained and Random Read/Write Performance

Parameter	Value
Burst Read	150 MBytes/sec [4]
Burst Write	150 MBytes/sec
Sustained Read	Up to 115 MBytes/sec
Sustained Write	Up to 25 MBytes/sec
Random Read [5]	6100 Input/Output Operations Per Second (IOPS)
Random Write	400 IOPS
Random 67% Read, 33% Write	1120 IOPS

[4] One megabyte, or MByte, equals 1,048,576 bytes.
[5] Random performance values are based on 4 KByte transfers.

Variables influencing Performance

- ◆ Platform
  - Test Hardware (CPU, interface, chipset, etc)
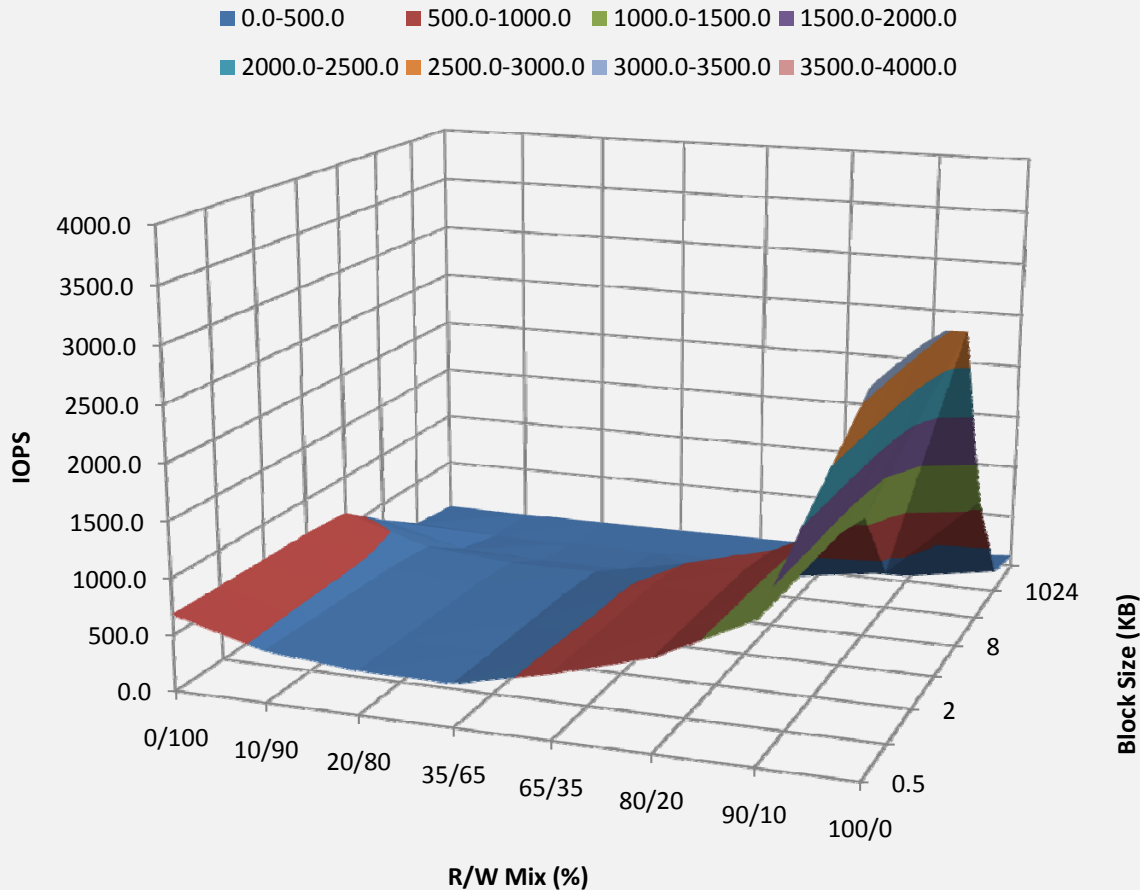 - Software (OS, drivers)
- ◆ SSS Device Architecture
  - Flash geometry, cache, flash management algorithm, etc
- ◆ Workload
  - Write history (Terabytes written, % spares)
  - Random, sequential, read/write mix, etc
  - Preconditioning (Random, sequential, transfer size, etc)
  - Data content
  - TRIM command

The 3 dimensions of SSS performance

3D IOPS Surface Profile

Legend:
- 0.0-500.0
- 500.0-1000.0
- 1000.0-1500.0
- 1500.0-2000.0
- 2000.0-2500.0
- 2500.0-3000.0
- 3000.0-3500.0
- 3500.0-4000.0

IOPS axis: 0.0, 500.0, 1000.0, 1500.0, 2000.0, 2500.0, 3000.0, 3500.0, 4000.0

R/W Mix (%): 0/100, 10/90, 20/80, 35/65, 65/35, 80/20, 90/10, 100/0

Block Size (KB): 0.5, 2, 8, 1024

SSS performance depends on

- ❖ Read/Write Mix
- ❖ Transfer Size
- ❖ Queue Depth (not shown)

Performance States

Performance States for Various SSDs

NM (MLC) · NS (SLC) · JS (SLC) · PSM (MLC) · JM (MLC)

FOB

Transition

Steady State
(desirable test range)
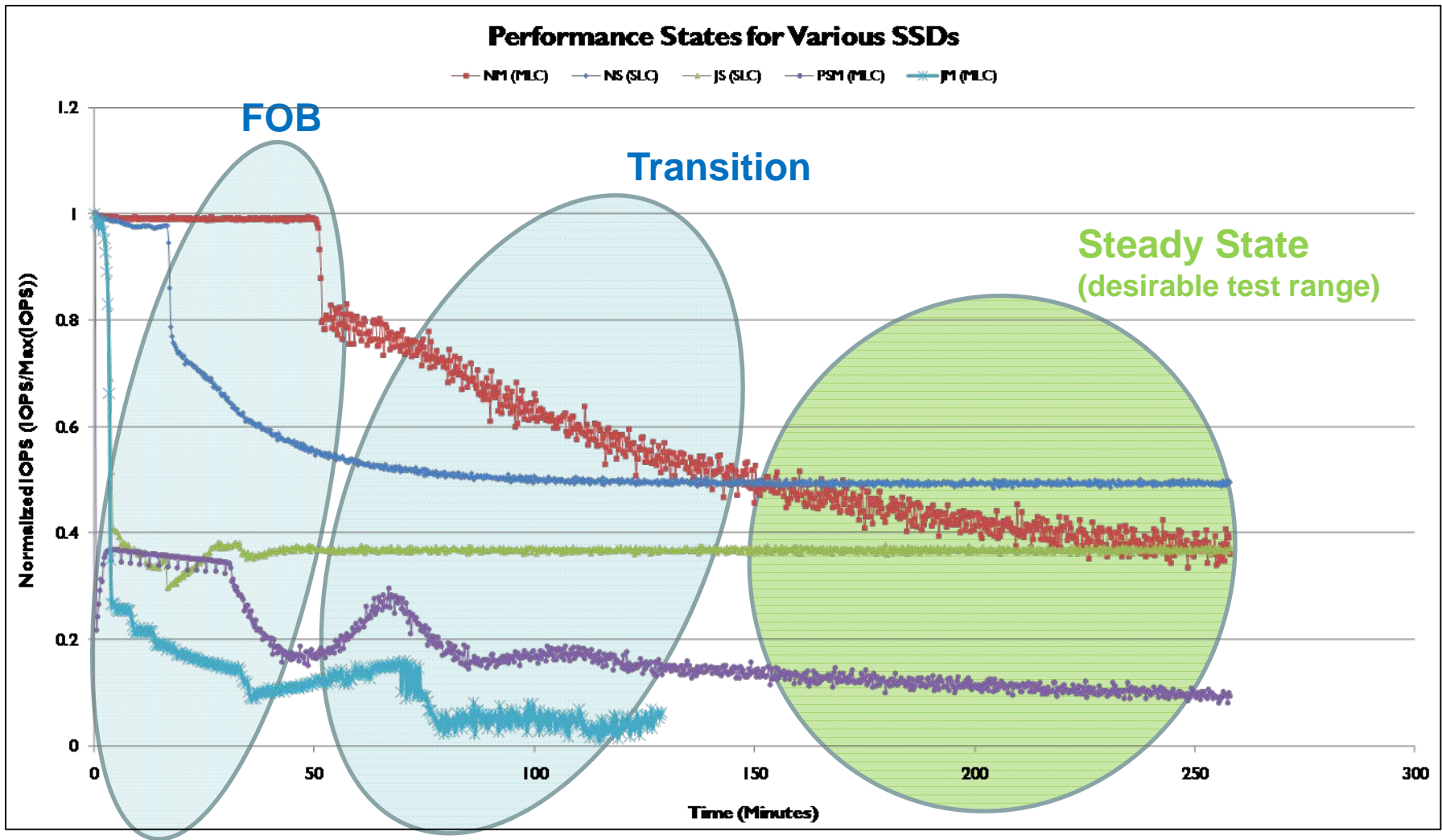
Workload Dependency - 1
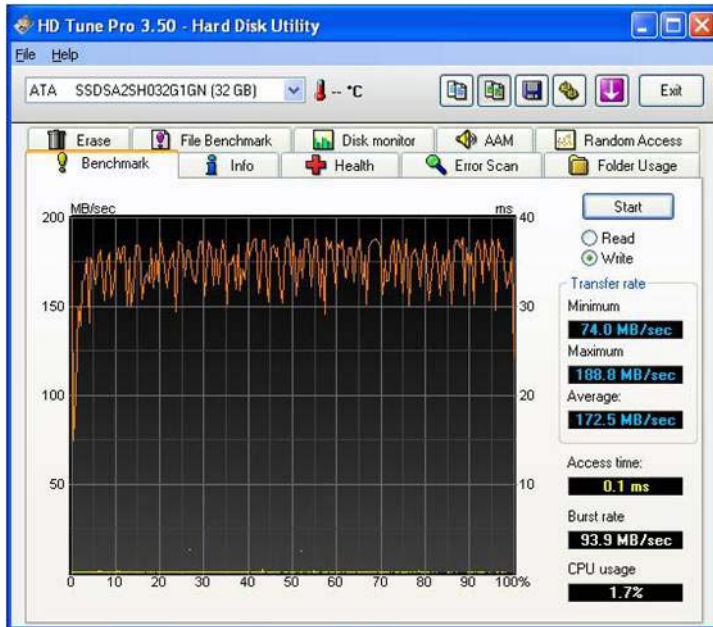
SSD Mfg A

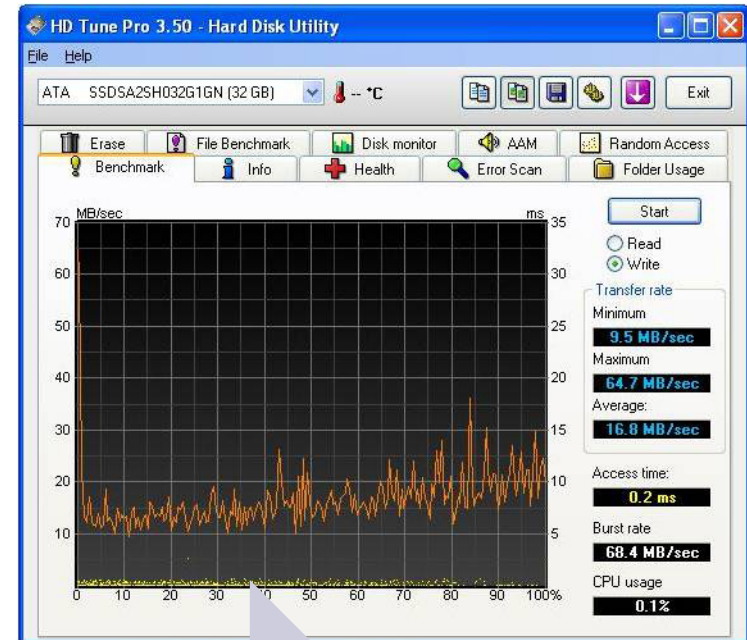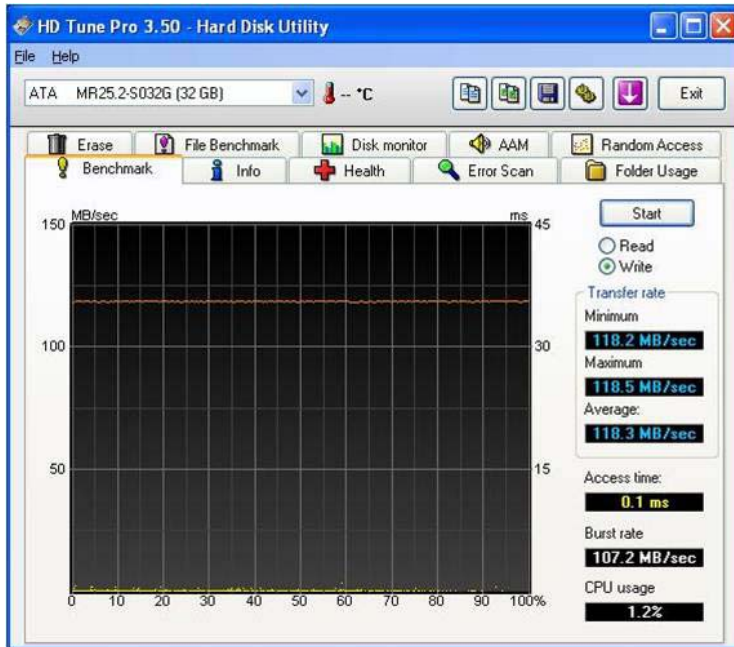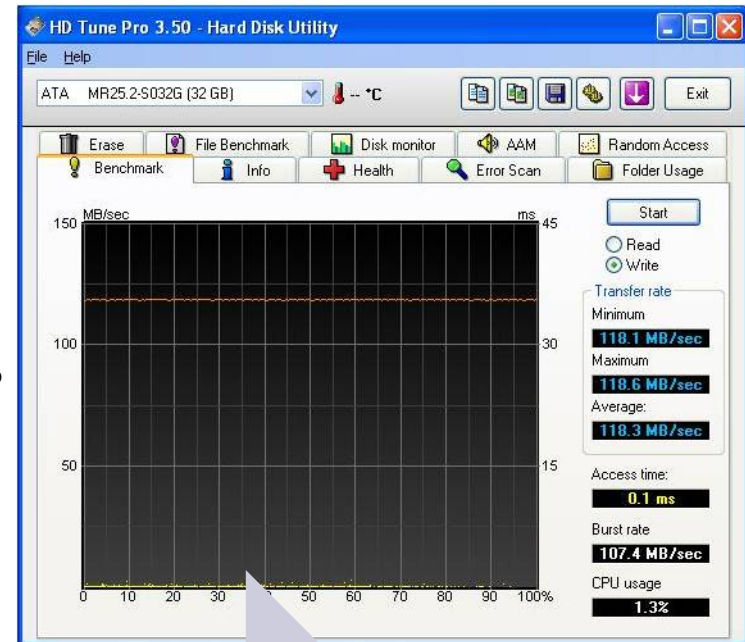| Step 1: HD Tune Pro Sequential Write Test | Step 2: IOMeter Random Write Test | Step 3: HD Tune Pro Sequential Write Test |

Workload dependency - 2

SSD Mfg B

Step 1: HD Tune Pro Sequential Write Test

Step 2: IOMeter Random Write Test

Step 3: HD Tune Pro Sequential Write Test

Dependency on data content

3D IOPS Surface Profile (IOMETER 2008)

Legend:
- 30,000 - 35,000
- 25,000 - 30,000
- 20,000 - 25,000
- 15,000 - 20,000
- 10,000 - 15,000
- 5,000 - 10,000
- 0 - 5,000

Transfer Size (KB): 0.5, 2, 8, 32, 128, 512

R/W Mix %: 100/0, 90/10, 80/20, 65/35, 35/65, 20/80, 10/90, 0/100

IOPS: 0, 5,000, 10,000, 15,000, 20,000, 25,000, 30,000, 35,000
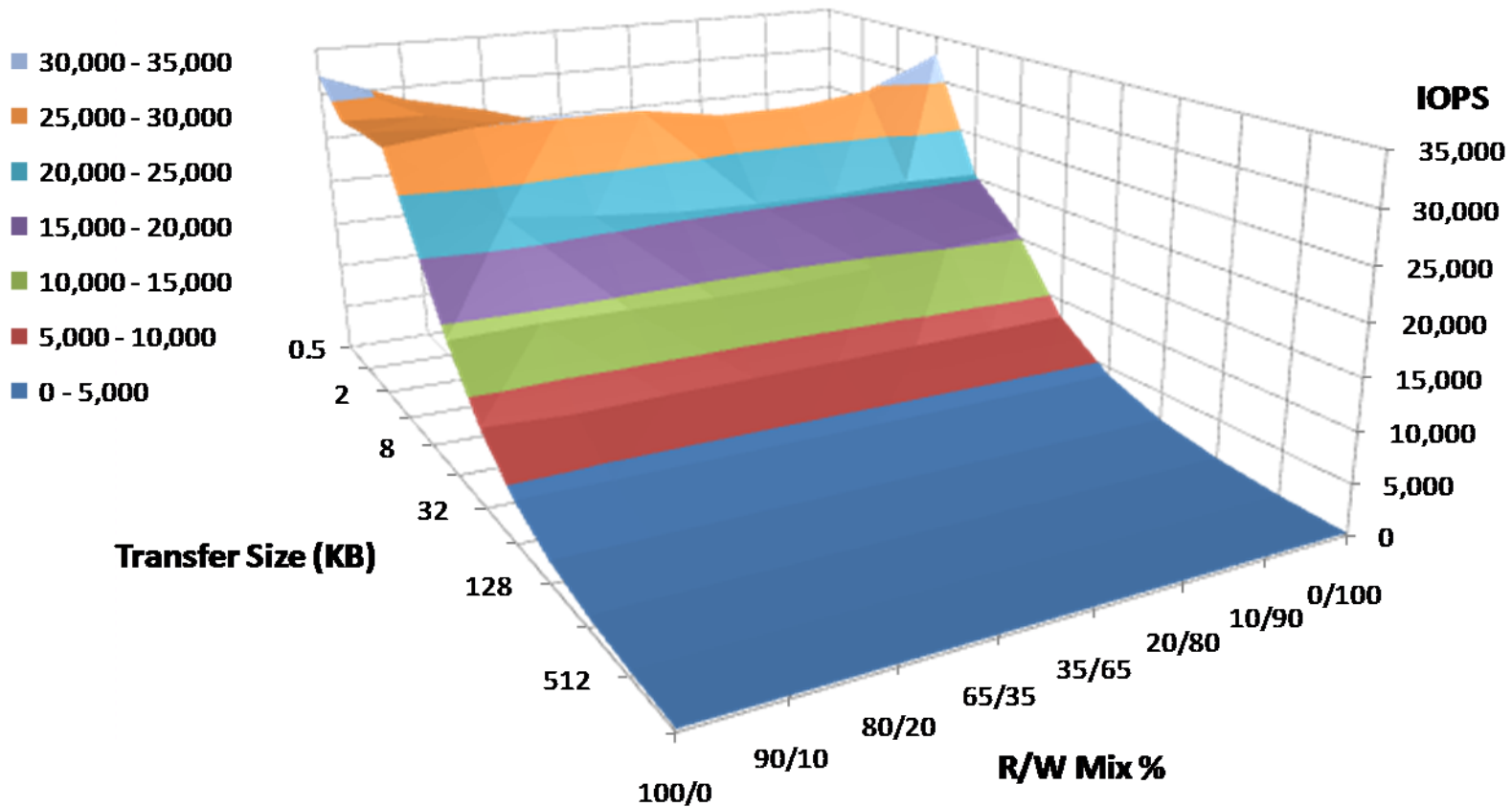
Dependency on data content

3D IOPS Surface Profile (IOMETER 2008)
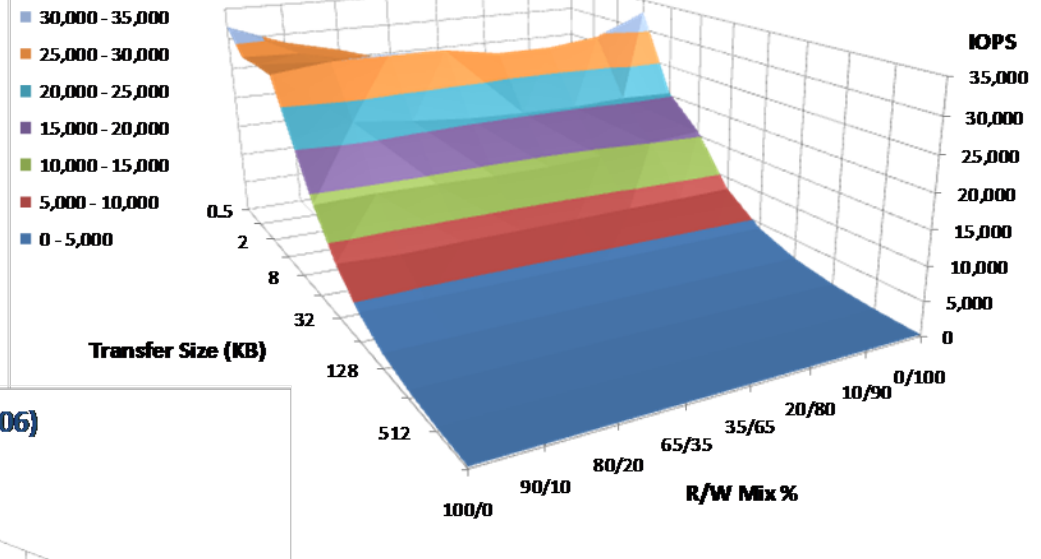
3D IOPS Surface Profile (IOMETER 2006)

Benchmark Suites

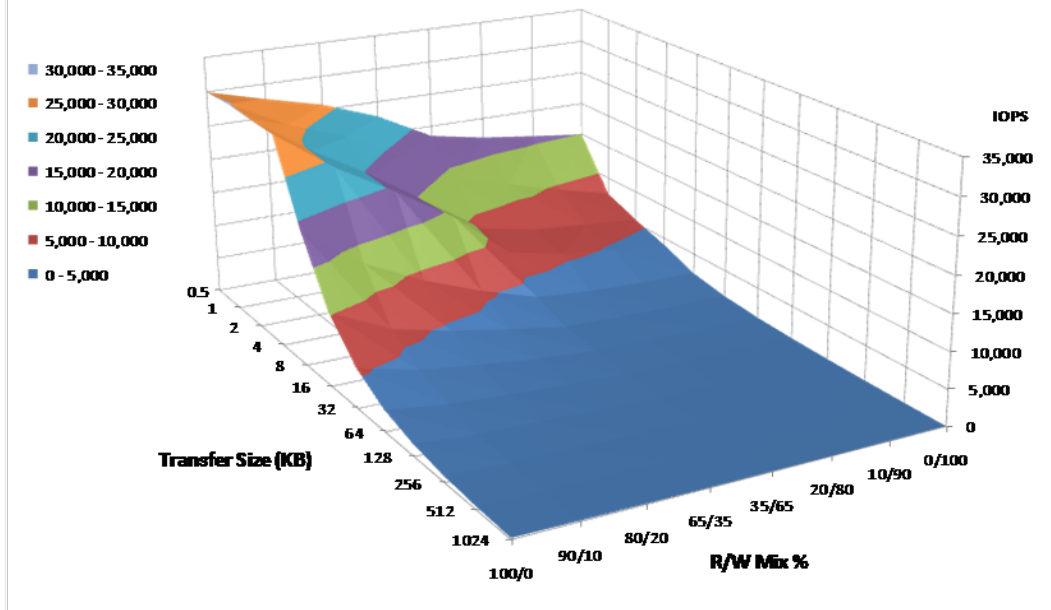|	Test Suite	Commercial/ Client SSD	Enterprise SSD
PCMark	HDD Score, OS and application loading timing, user simulation (surfing web, windows media player, etc)	√	
SysMark	System level test. Measure performance based on response time, score (0-250)		
IOMeter	Server simulate workload		√
HDTach/ H2benchw	Performance stability, performance, Access		√
HD Tune	Performance stability, Sequential/Burst performance, Access Time		
Everest	Random Access Time (Read/Write)	√	√
VDBench	Workload generator, performance on DAS and NAS		√

Type of preconditioning and order of benchmarks can influence results

◆ SNIA Technical Working Group (TWG) created in ea

◆ Sp :edures
to f Solid
St

 ◆

 ◆

 ◆ **Repeatable** – Easy comparison between devices

 ◆ **Practical** – Complete with reasonable time and effort

 ◆ **Accessible** – open specification, 3rd party validation

Scope of SSS Performance Spec

- **Setup and Methodology**
  - Purge
  - Preconditioning
  - Test Parameters

- **Workloads (synthetic)**
  - Client – IOPS, Throughput, Latency
  - Enterprise – IOPS, Throughput, Latency

- **Reporting**
  - Show convergence to steady state
  - Show performance results during steady state

- **Performance Test Platform in development by SSSI Tech Dev Group (2H10)**

Status of SSS Performance Spec

- ◆ V0.x available for public review/comment
  - ◆ www.snia.....

- ◆ Your Feedback is crucial!
  - ◆ Do we test the right things? Do we need others?
  - ◆ Are the reports useful?
  - ◆ Are the procedures clear?
  - ◆ Does this truly give us apples-to-apples performance comparison?

- ◆ Performance Test Platform
  - ◆ Working in SSSI; please join us

Performance Benchmark Steps

1. ## Prepare the Device

   - Purge/Secure erase → put SSS back into "original" state

2. ## Precondition the Device

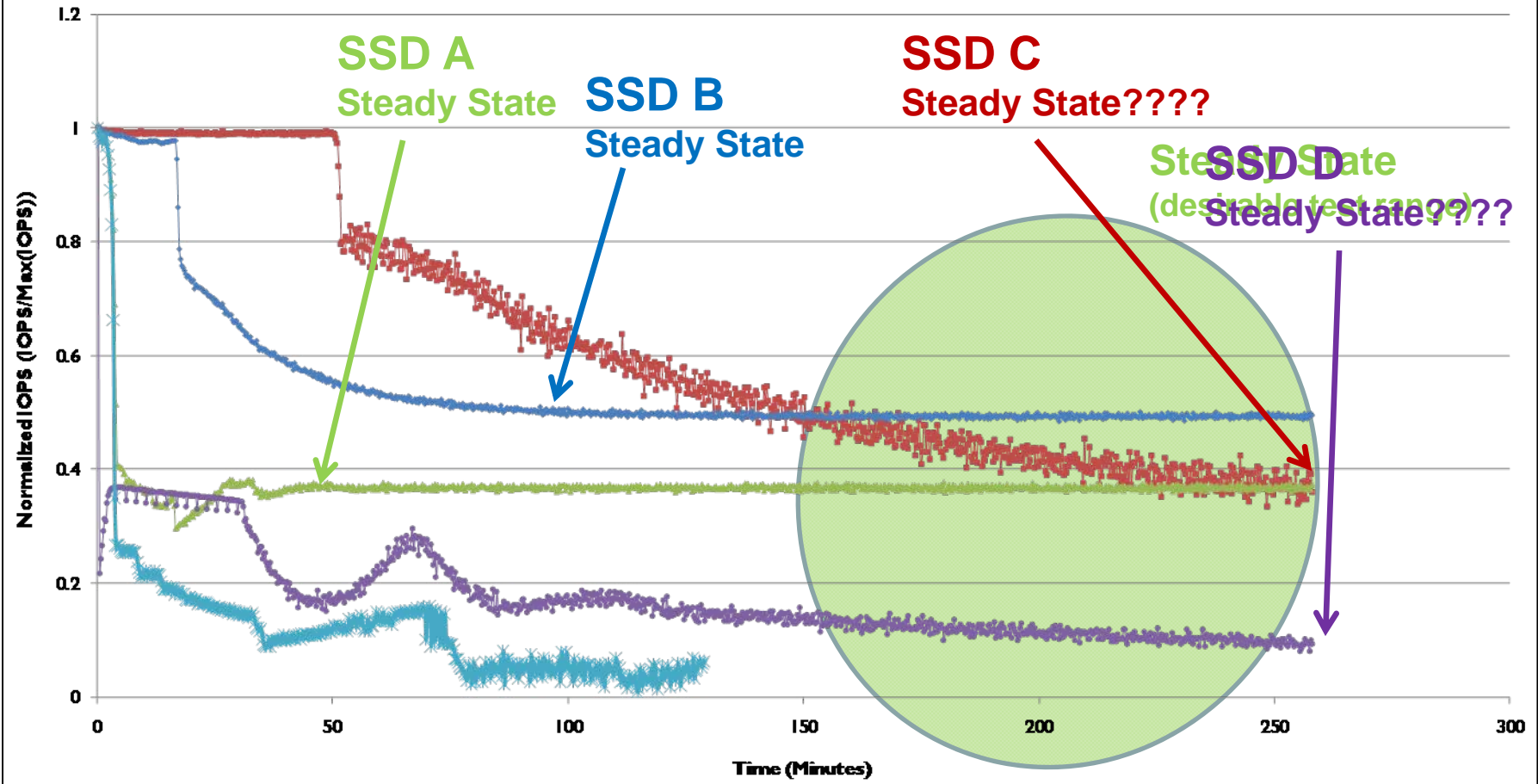   - Write data 2x capacity → bring device to known state

3. ## Steady State Testing

   - Run Test Loop up until steady state is achieved
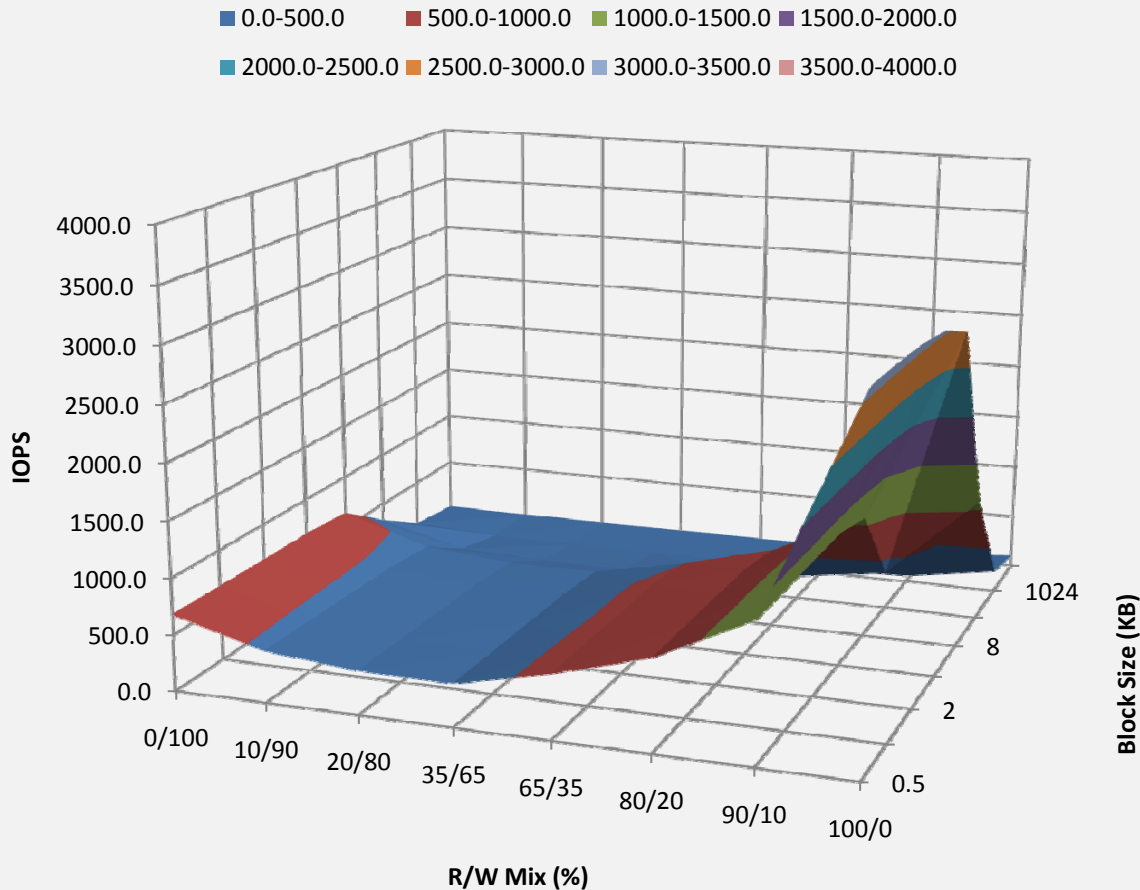   - Performance stays within ± 10% margin in last 5 test loops

4. ## Test Report

   - Show convergence to steady state
   - Show 3D test results

Convergence to Steady State

Steady State reached if performance swing is within 10% margin

SSD A
Steady State

SSD B
Steady State

SSD C
Steady State????

Steady State
(desirable test range)

SSD D
Steady State????

Normalized IOPS (IOPS/Max(OPS))

Time (Minutes)

Test Report

3D IOPS Surface Profile

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- 1000.0-1500.0
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- 2000.0-2500.0
- 2500.0-3000.0
- 3000.0-3500.0
- 3500.0-4000.0

Indicates steady state performance

- Various Block Size
- Various Read/Write mixes

Other Standardization Initiatives

- ## SSSI Group of SNIA
  - Technical Work Group (TWG) → Performance Benchmark Spec
  - Tech Dev Group → Performance Test Platform
- ## JEDEC 64.8
  - Specification for SSD endurance measurement
- ## SSDA
  - Testing of reliability (power cycling, data retention, endurance, etc) and OS compatibility (Windows 7)

Summary

- SSS Performance is dependent on many variables

- Comparing vendors is not trivial → industry standard required

- SNIA Performance Specs allows apples to apples comparison
  - Spec for review at http://www.snia.org/forums/sssi
  - Send your feedback to ssstwg@snia.org

- GET INVOLVED!!

◆ Please send any questions or comments on this presentation to SNIA: tracksolidstate@snia.org

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- SNIA Education Committee

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