True Cost-of-Test for SSD High Volume Manufacturing and Large Scale Quality and Reliability Organizations

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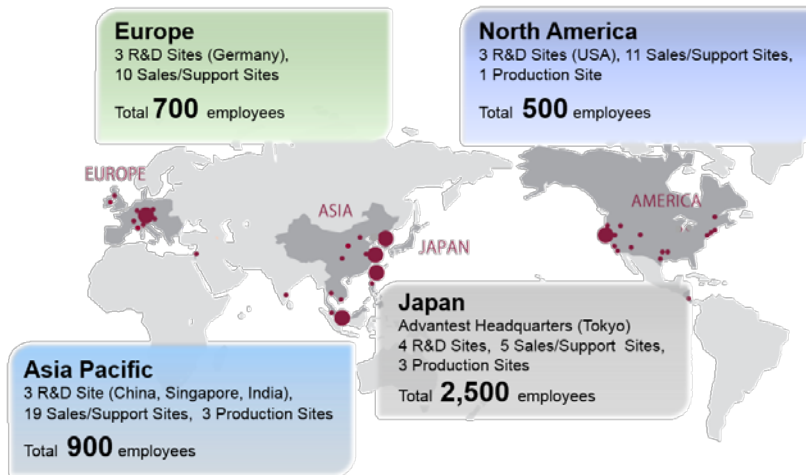
SSD Industry Consultant

MKW Ventures

ADVANTEST®

A different perspective on Testing

At a glance

Founded: 1954, Tokyo Japan
Sales: ¥ 163.3B (~$1.5B)
No. of employees: 4,600
R&D Spending: ¥29.9B (~$250M)

Worldwide Presence

Europe
3 R&D Sites (Germany),
10 Sales/Support Sites

Total **700** employees

North America
3 R&D Sites (USA), 11 Sales/Support Sites,
1 Production Site

Total **500** employees

EUROPE

ASIA

JAPAN

AMERICA

Japan
Advantest Headquarters (Tokyo)
4 R&D Sites, 5 Sales/Support Sites,
3 Production Sites

Total **2,500** employees

Asia Pacific
3 R&D Site (China, Singapore, India),
19 Sales/Support Sites, 3 Production Sites

Total **900** employees

Businesses
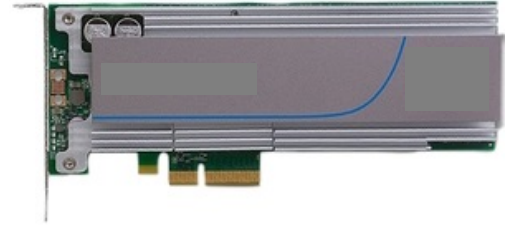
Semiconductor Test

Mechatronics
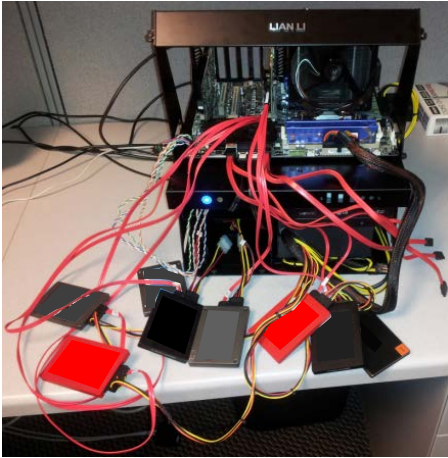
SSD Test

Services, Support & Others

Which SSD is Better?


OR

Which SSD Tester is Better?

OR

COT vs TCO definitions

- COT = purchase price of tester / throughput
- TCO = COT + Costs of Operation

"When choosing among alternatives in a purchasing decision, buyers should look not just at an item's short-term price, which is its purchase price, but also at its long-term price, which is its total cost of ownership."
— Investopedia on the definition of TCO

Price vs COT vs TCO Analysis
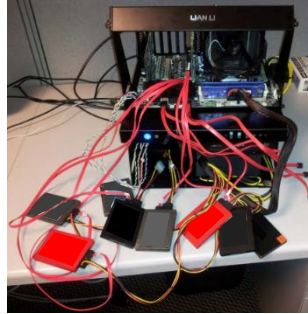
Throughput Impact on COT

Simple COT model

		Tester A	Tester B
a-1	Tester price [hypothetical]	$500,000	$750,000
a	**Tester cost per hour**	**$11.42**	**$17.12**
	5 year depreciation		
b	Tester parallelism [DUTs / system]	500	500
c-1	Baseline test time [h]	10	10
c-2	Performance improvement	100%	200%
c	Effective test time [h]	10	5
d	Utilization	80%	80%
e	Test cell UPH (Units Per Hour) = b * c / d	40	80
f	**Cost per DUT = a / e**	**$0.29**	**$0.21**
	COT reduction	0%	25%

Equipment cost to test ~3M units / year

	Tester A	Tester B
Units per tester per year	350400	700800
# of testers for 2.8M units / year	7.99	4.00
# of testers purchased	8	4
Tester investment	**$4,000,000**	**$3,000,000**

PCIe Multi-site Efficiency

7-day JESD219 Workload Run
Eight PCIe Gen 2 8-lane DUTs in parallel, measure average IO/s & MB/s per DUT
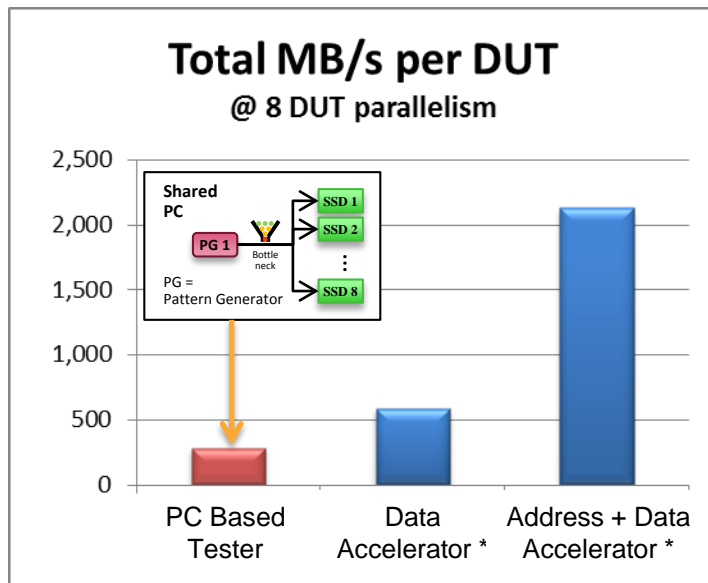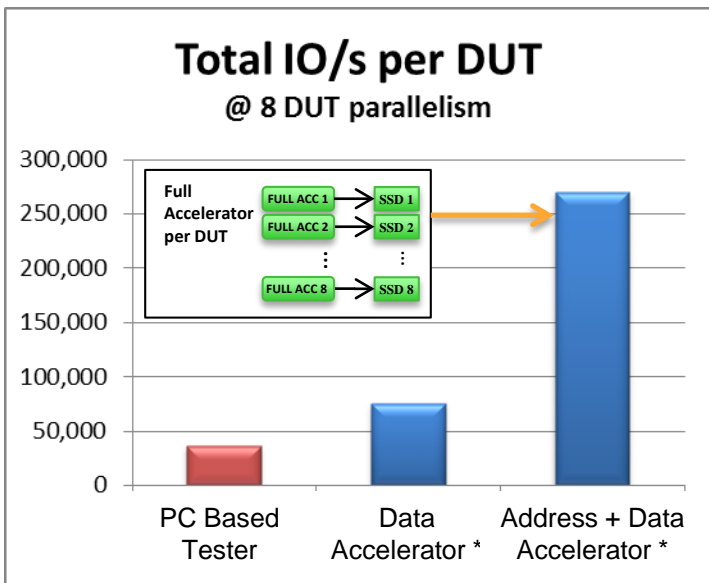
Measured on Advantest MPT3000 w/ Full Accelerator

Simple TCO Analysis

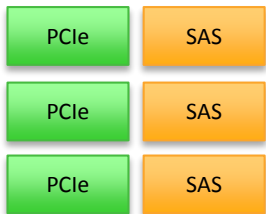|		Tester A	Tester B
a-1	Tester price [hypothetical]	$ 500,000	$ 750,000
a-2	# of testers for 2.8M units / year	8	4
a-3	Total test cell price = a-1 * a-2	$ 4,000,000	$ 3,000,000
a	Test cell cost per hour	$ 91.32	$ 68.49
	5 year depreciation		
b-1	Consumables [cables, load boards] per Tester	$ 100,000	$ 100,000
	1 year lifetime		
b-2	Total consumable costs = a-2 * b-1	$ 800,000	$ 400,000
b	Consumable hourly cost	$ 91.32	$ 45.66
c-1	Power consumption [tester - hypothetical]	6.4 kVA	6.4 kVA
c-2	Power per hour	$ 0.96	$ 0.96
	$0.15 per kWh		
c-3	Floor space [hypothetical]	20 m²	20 m²
c-4	Floor space cost per hour	$ 1.64	$ 1.64
	$60/m²/month		
c-5	Operator cost per hour	$ 4.80	$ 2.40
	1 operator works 5 testers		
c	Hourly facilities cost = (c-2 + c-4 + c5) * a-2	$ 59.23	$ 20.02
d	Estimated hourly cost = a + b + c	$ 241.88	$ 134.17
e-1	Per Tester Parallelism	500 DUTs	500 DUTs
e	Total Parallelism = a-2 * e-1	4000 DUTs	2000 DUTs
f-1	Baseline test time [h]	10 h	10 h
f-2	Performance improvement	100%	200%
f	Effective test time [h]	10 h	5 h
g	Utilization	80%	80%
h	Test cell UPH	320	320
	= e * f / g		
i	Cost per DUT = f / j	$ 0.76	$ 0.42
	TCO reduction	0%	45%

Additional Factors
- Per Tester Operational Costs
  - Consumable costs
  - Power costs
  - Floor space costs
  - Operator Costs
- Number of Testers to test 2.8M units / year

Other TCO considerations

|	QUAL	HVM
Testing	Very Long Test Times More Capability / Cost	Short to Long Test Times Cost Sensitive / Less Capability
Service & Support	High Volume Manufacturing experience Worldwide footprint Additional services, e.g. test program, design services, etc.	
	Contact 5dx8h, next day onsite Spares: Regional	Same or better than QUAL Spares: Local or onsite
Financial Stability	Important	Very Important
	Resources / Scale to meet customer ramp(s) Ongoing investment in R&D	
Roadmap	Next gen challenges: PCIe 4, device handling & shop floor automation Protecting investment: Flexibility, Compatibility Lead test innovation, drive COT reduction	

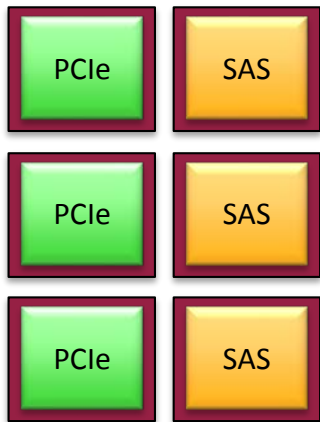**ADVANTEST**®

Product Mix Impact on TCO

Market Demand A

Market Demand B
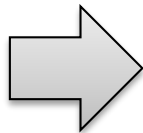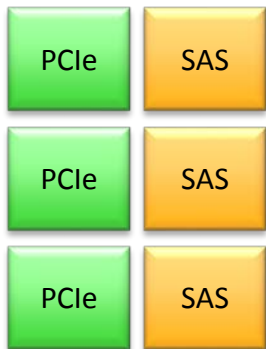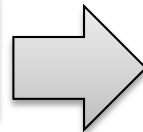
PC Based | **Reconfigurable** | **PC Based** | **Reconfigurable**
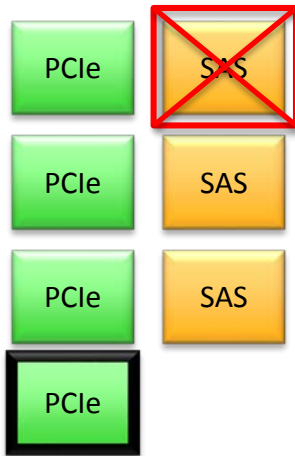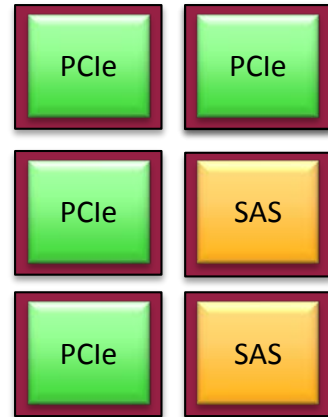
No new testers, FW download in minutes

1x New Tester
1x Idle Tester

Bringing Semi OSAT model to SSD

Semiconductor Test Model

Fabless Company A

develop TP

Fabless Company B

develop TP

Fabless Company C

Local Test Lab

develop TP

High Volume Out-Source Assembly & Test (OSAT)

Copy Exact & Scale Out

New! SSD Test Model

SSD Company A

develop TP

SSD Company B

develop TP

SSD Company C

Local Test Lab

develop TP

High Volume Out-Source Assembly & Test (OSAT)

Copy Exact & Scale Out
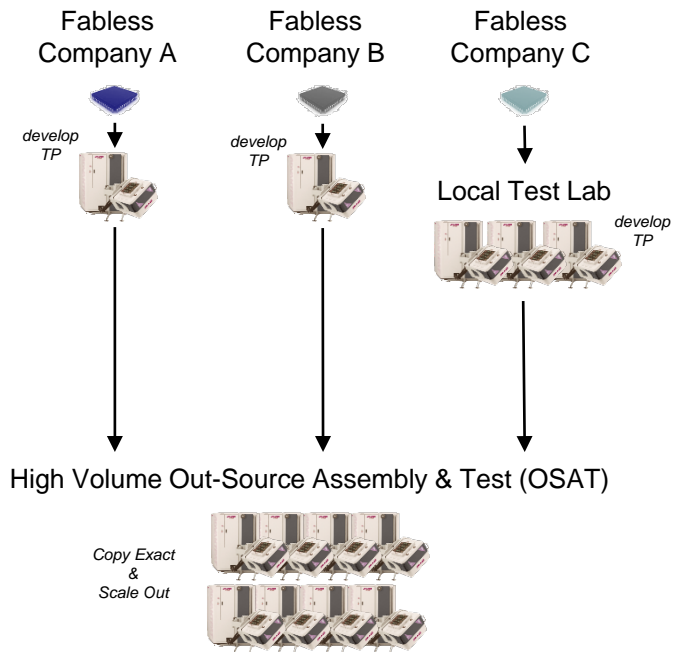
Avoid Capital Cost In Test Strategy

Standardized Testing
90% standard, 10% custom

New Class of Tester
True multi-protocol support in a single tester
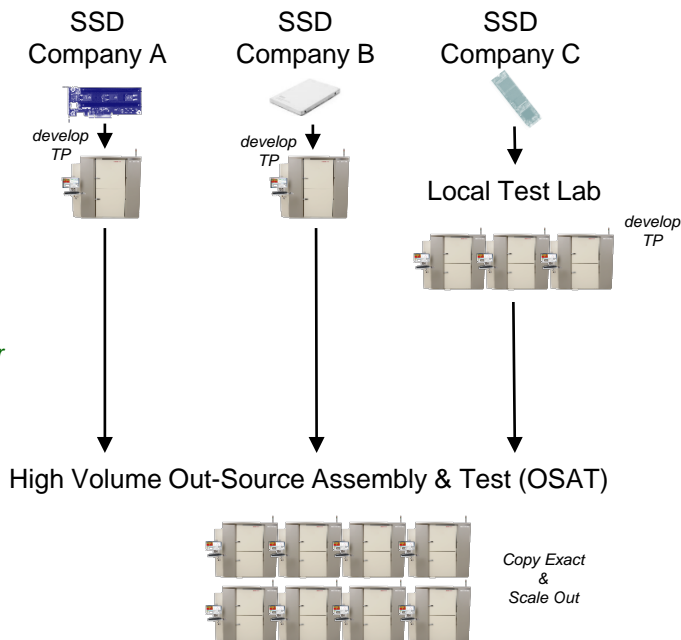*Standard functions + custom CMD hooks*

OSAT buys Testers
Testers usable for different customers
Avoid buy & consign

Upside Flexibility
Scale out 10x, downside Flexibility

Subcon TCO perspective

Test factories need to manage all items going into cost

- Floor space requirements, cost, and future needs
- Power: both power cost and supply/distribution needs
- Direct labor: managing testers, product flow, QA
- Indirect Labor: Managing factory floor, capacity, lead times, demand
- Engineering: Deploying new test solutions, validation, ECOs
- Overhead: IT, Support labs, HR, Management

Maximizing Utilization and optimizing the factory minimizes cost to OEM.

Value of Subcon Model

- Capital spending is minimized/eliminated by OEM
  - Customer pays for testing as it is needed, sees quick return in revenue or product results. No need to be perfect with prediction
- Subcon can flex test capacity to and from other applications minimizing cost
  - Upside capability can be planned for and reviewed, but not billed until use.
  - Costs of underutilization are minimized (ex: 50% loading=2x Cost)
- Pricing/volume models can include total flexibility, % minimum use, or capped capacity to meet OEM requirements for growth and cost
- Subcon manages factory space, staffing, capital purchasing, lead times
- Test hardware suppliers providing leading edge capability that meets latest requirements and testing standards. Proven solutions
- OEM Focuses on product health and business needs

Summary

- Equipment "Price Only" analysis is flawed

- HVM and Large Scale Quality and Reliability Organizations evaluate Total Cost of Ownership (TCO)
  → Equipment and Operational Costs, Throughput, Utilization need to be factored in

- New SSD Out-Source Assembly & Test (OSAT) model enables Test Capacity access and scale out flexibility to OEMs without having to justify Capital Equipment in their test strategies

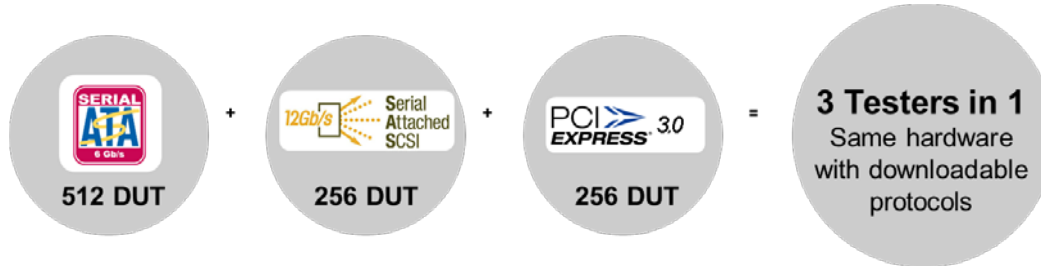Come visit our FMS booth #608 for a MPT3000 demo

New Class of Reconfigurability

Press Release: Advantest Expands MPT3000 System's Capabilities in SSD Testing with Downloadable Firmware to Support Additional Protocols

MPT3000 Platform Becomes the Storage Industry's Most Flexible and Extendible Test Solution for SSDs

TOKYO, Japan – August 3, 2015 – Leading semiconductor test equipment supplier Advantest Corporation (TSE: 6857, NYSE: ATE) has made available to customers downloadable firmware that enables all MPT3000 systems to test Serial Attached SCSI (SAS) 12G and Serial ATA (SATA) 6G solid-state drives (SSDs), making this tester the first true single-system solution for testing SAS, SATA and PCIe protocol SSDs.

SERIAL ATA 6 Gb/s — 512 DUT

+

12Gb/s Serial Attached SCSI — 256 DUT

+

PCI EXPRESS 3.0 — 256 DUT

=

3 Testers in 1
Same hardware with downloadable protocols

Acronyms

- CMD = Command
- COT = Cost Of Test
- DUT = Device Under Test
- DWPD = Drive Writes Per Day
- GB (gigabyte) = 1000 MB (megabyte)
- HVM = High Volume Manufacturing
- JESD219 = JEDEC Enterprise Workload
- MTBF = Mean Time Between Failure
- OEM = Original Equipment Manufacturer
- OSAT = Out-Source Assembly and Test

- PB (petabyte) = 1000 TB
- QA = Quality Assurance
- QUAL = Qualification
- SW = Software
- TB (terabyte) = 1000 GB
- TBW = Tera Bytes Written
- TCO = Total Cost of Ownership
- TP = Test Program
- UPH = Unit Per Hour
- WW = Worldwide