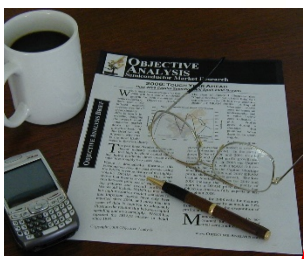
Flash Technology: Annual Update

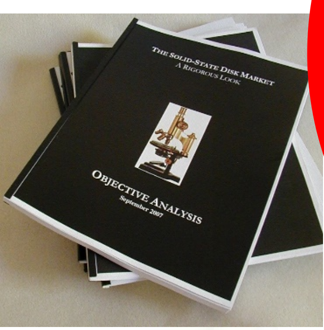
Jim Handy

OBJECTIVE ANALYSIS

OBJECTIVE ANALYSIS

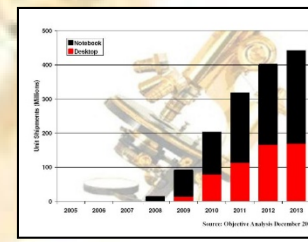
Profound Analysts

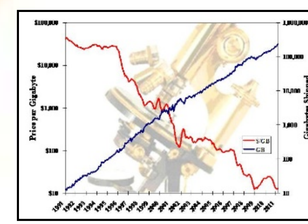


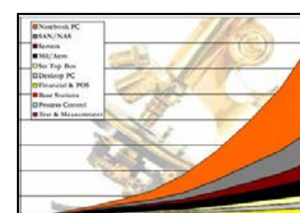


Reports & Services

Custom Consulting







Objective Analysis Semiconductor Forecast Accuracy

Year	Forecast	Actual
2008	Zero growth at best.	-3%
2009	Growth in the mid teens	-9%
2010	Should approach 30%	32%
2011	Muted revenue growth: 5%	0%
2012	Revenues drop as much as -5%	-2.7%
2013	Revenues increase nearly 10%	4.9%
2014	Revenues up 20%+	9.9%
2015	Revenues up ~10%	TBD

Outline

- NAND Market
  - 3D NAND
- SSDs
- NOR Market
- 3D XPoint

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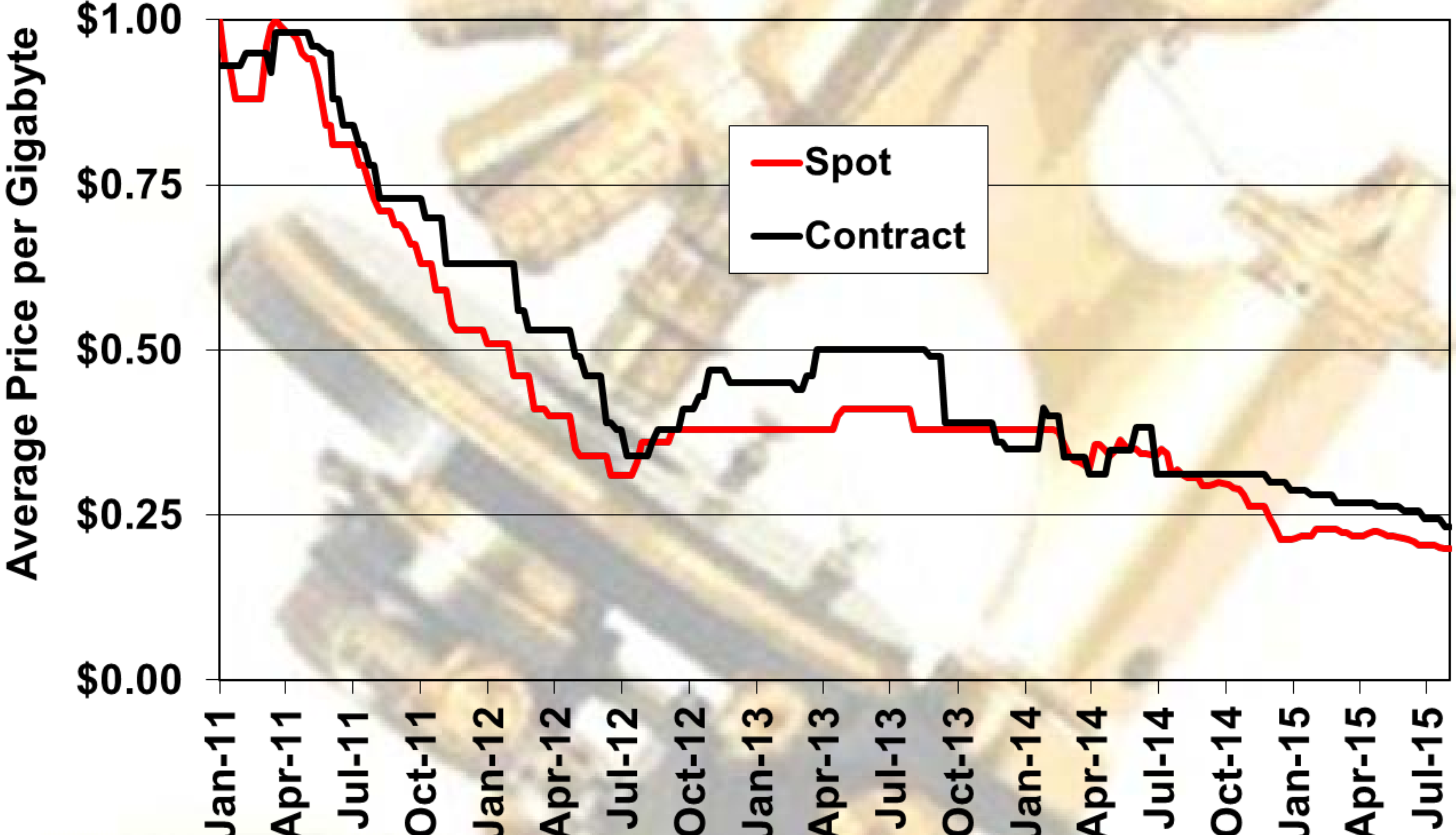
NAND Revenues 2006-2015

NAND Prices In Slow Decline

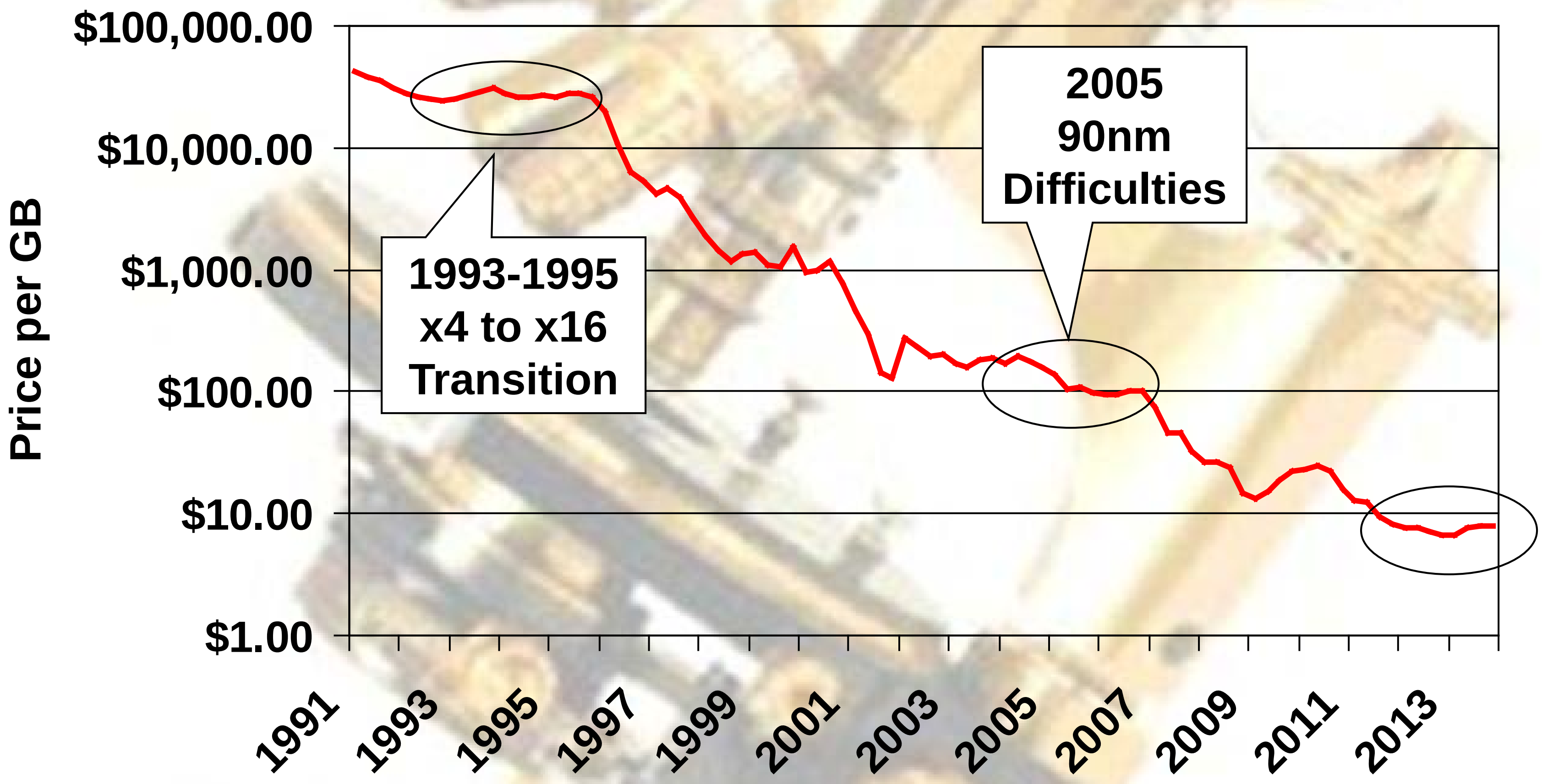


What Drives the Next Downturn?

- Pricing stable into 2017
  - No collapse until 3D is competitive with planar
  - Will drive continuing profitability
  - Should attract new participants
- Historic collapse at the end
  - Organic overcapacity, plus…
  - Externally-funded additions
  - Largest-ever price-cost gap

Tech Challenges Extend Market Cycles

DRAM Examples



Extension is Hard to Predict

- When will 3D be mastered?
  - Samsung is shipping at a loss
  - We have found no evidence of a data sheet
- Other vendors are sampling
  - This indicates some confidence
- Vendors say the big ramp will be in 2017
  - Such projections are usually optimistic
- We say 2017, but may push that out

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Enterprise SSD Outlook

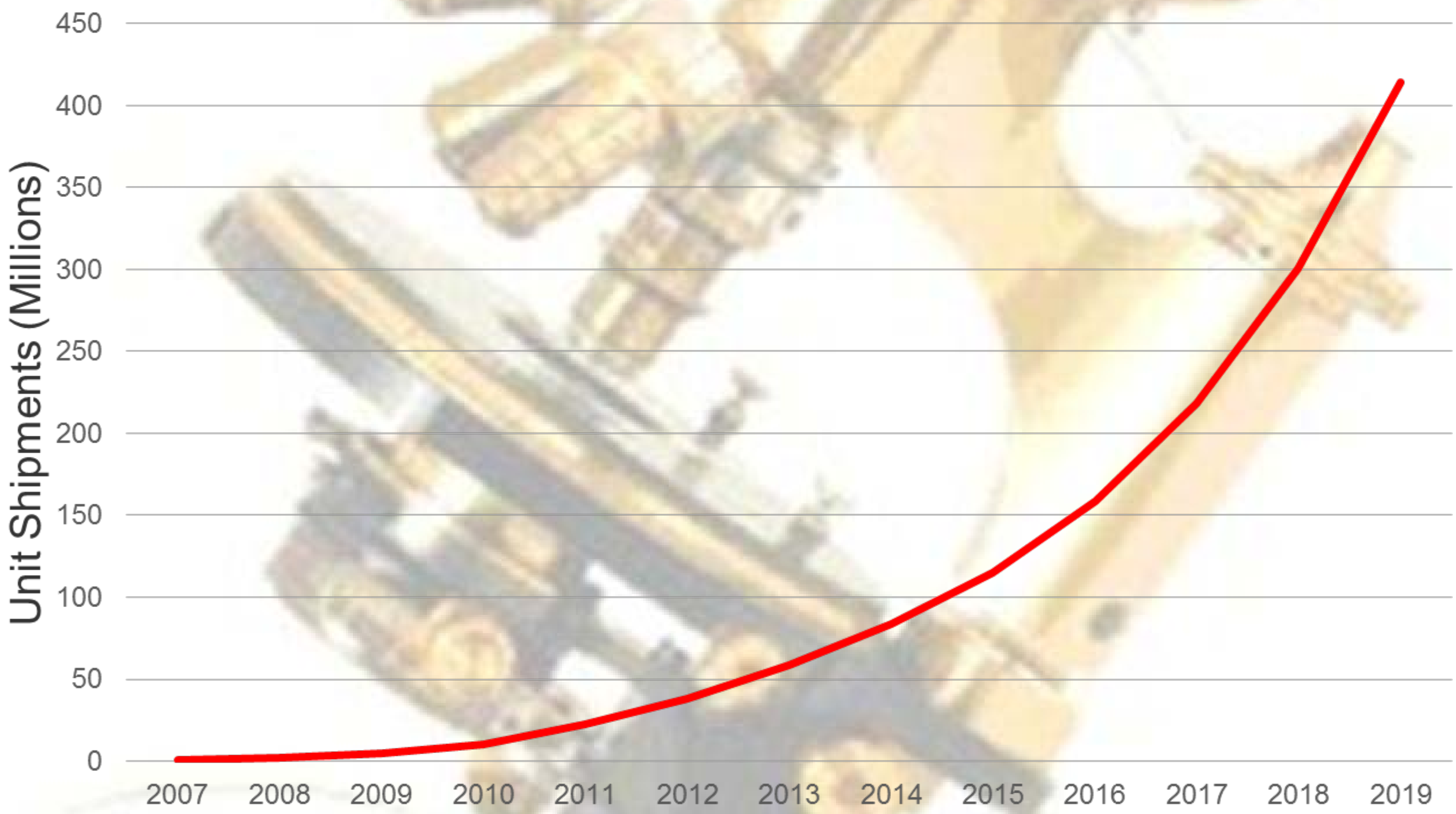
- Penetration still only about 50% of installations
  - Huge upside potential
  - Message is not reaching many corners
- HDD makers are feeling the impact
  - Enterprise HDD market falling
  - Overall HDD market soft

PCIe & SAS SSD Shipments

Client SSD Outlook

- PC market has had many failures
  - SSD-based PCs don’t sell
  - Ultrabook hasn’t driven high SSD sales
  - Apple stands alone in SSD success
    - Apple users have no other option
  - Upgrade market doing very well
- Other markets doing well
  - Difference is the level of understanding

Total SSD Shipments



Demand Softens Temporarily

- PC market still in flux
  - Are tablets reducing PC consumption?
  - Could it be the fault of SSDs?
    - Older PCs are in use longer
  - When will growth resume?
- Enterprise demand still strong
  - Cloud consumption is healthy
  - HDD to SSD conversion impacting HDD makers

SSDs Impacting Coffee Prices?

HDD Legacy Hard to Overcome

- Pre Fusion-io: “Put NAND into an HDD format.”
- Fusion-io: “Put NAND into a RAID format.”
- Violin, TMS: “Put NAND in a big box.”
- Intel: “Give NAND its own bus (ONFi on Braidwood).”
- Diablo: “Put NAND on the DRAM bus.”

Form Factors Finding Their Way

- Client: 2.5” → mSATA → m.2
- Data Center: FC → PCIe → SATA
  - SATA “Fast enough” & cheap
  - High read environment OK with low DWPD
- Enterprise:
  – 3.5” → 2.5”
  – DAS → SAN → DAS
  – FC → PCIe → SATA
  – SAN → Flash Array + JBOD/Cloud

PCIe Moving Into Prominence

- Increased PCIe sockets in client
- NVMe unleashes PCIe's performance
  - Not an "Either/Or"
- Slow recent growth impacts NVMe
  - Ties back to users' lack of understanding of their workloads
- Market's in a strange place
  - Enterprise: SATA's cheap & good enough
  - Client: m.2 PCIe costs the same as SATA

Drive Wear (DWPD/TBW)

User Requests

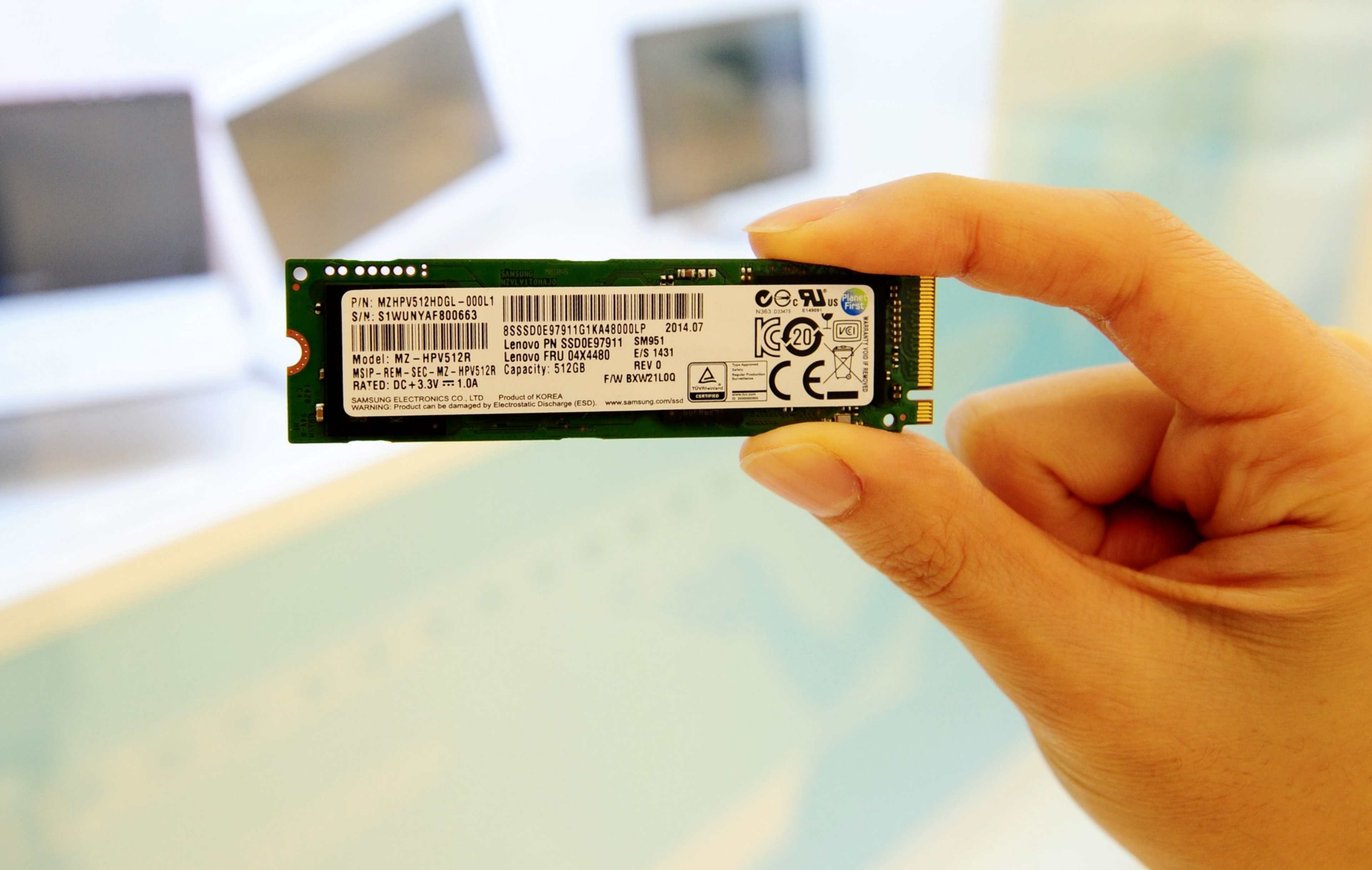
- 2006:Don’t care
- 2008: Real issue
- 2012: Enterprise
- 2013: Even more
- 2015: Less important

Manufacturers Make

- Glorified CF cards
- Low Write Amp.
- 3 DWPD
- 10 DWPD
- Some 1 DWPD

End-User Sophistication is Growing

m.2 PCIe


P/N: MZHPV512HDGL-000L1
S/N: S1WUNYAF800663
Model: MZ-HPV512R
MSIP-REM-SEC-MZ-HPV512R
RATED: DC+3.3V ⎓ 1.0A
8SSSD0E97911G1KA48000LP
2014.07
Lenovo PN SSD0E97911
Lenovo FRU 04X4480
Capacity: 512GB
SM951
E/S 1431
REV 0
F/W BXW21L0Q
SAMSUNG ELECTRONICS CO., LTD
Product of KOREA
WARNING: Product can be damaged by Electrostatic Discharge (ESD).
www.samsung.com/ssd
WARRANTY VOID IF REMOVED

Where does m.2 Fit?

- "It's a replacement for mSATA"
  - This appears to be catching on
- "It's a performance PCIe format"
  - Low chip count works against this
  - Too early to tell if it's a market driver
- "It's a boot drive for servers"
  - First market seems to be here
  - This is a highly-competitive space

2.5" PCIe Conundrum

- Where did this come from?
  - "Flash is storage"
    - "Storage is unreliable and must be hot-swappable"
  - Removing PCIe cards goes against this
- Existing sockets created a market
  - Few new sockets are being developed
  - We expect it to have a relatively short life
  - It's like FC SSDs all over again

PCIe Price Drivers

- Single-chip PCIe controllers are coming
  - PCIe SSD costs/prices will drop
- NAND types
  - Today: SLC and MLC, highly overprovisioned
  - Tomorrow: MLC (non-client) and TLC (client) with less overprovisioning
- NAND pricing changes
  - Prices relatively flat until 2017

The Migration to MLC & Beyond

	Client		
	SLC	MLC	TLC
2005	Stock	Never	Never
2006			
2007			
2008			
2009			
2010			
2011			
2012			
2013			

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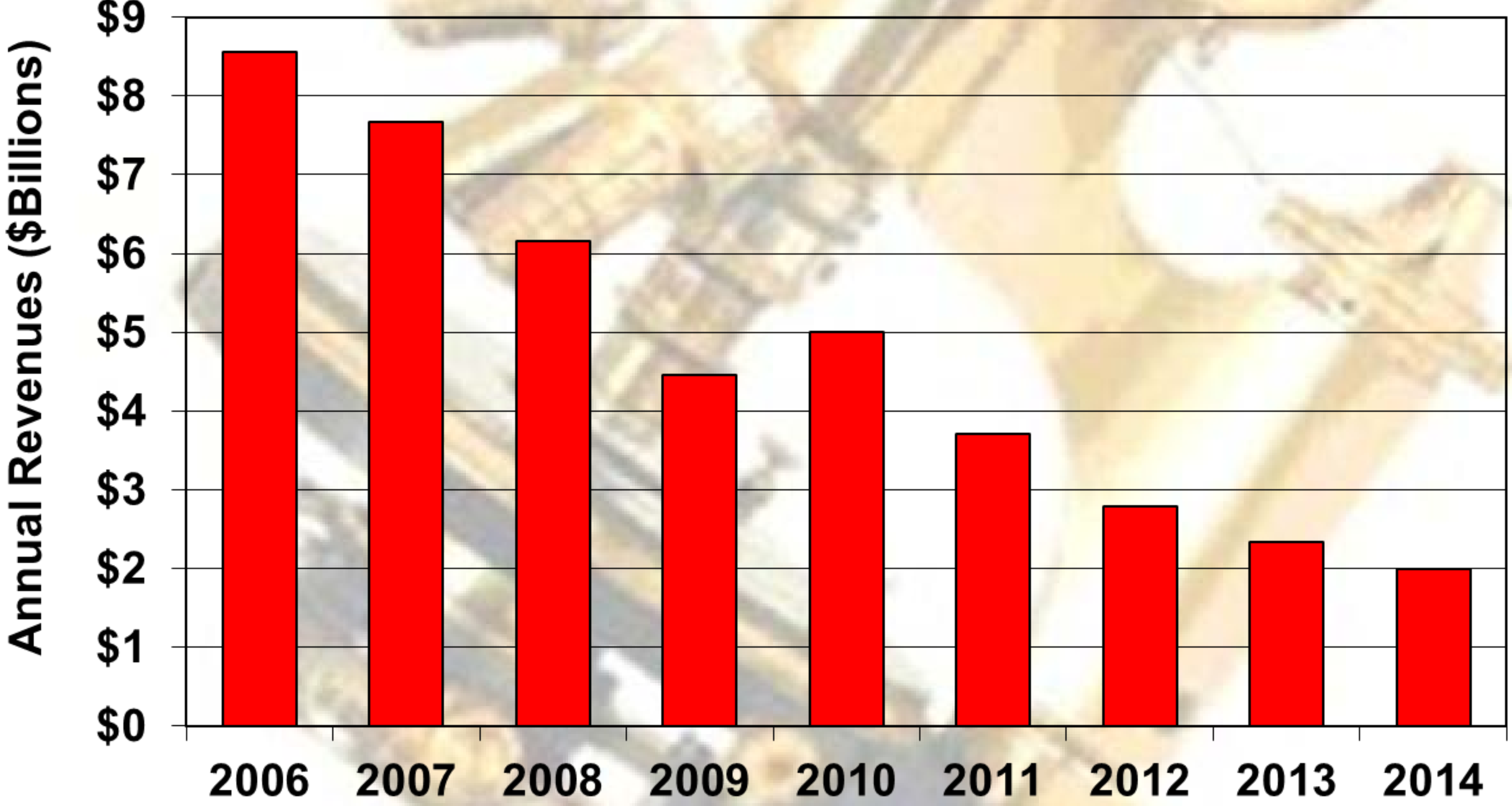
NOR Revenues 2006-2015



NOR Market Leaders

- Spansion
  - Now a part of Cypress
- Numonyx
  - Was Intel & ST
  - Acquired by Micron in 2010
- Samsung
  - Exited a dying market
- Others: Macronix, Microchip/SST, etc.

What Happened To NOR?

- Cell phones were a key market
  - Smart phones have taken over
  - When you have lots of NAND & DRAM, you don't need NOR
- This created an oversupply
  - Prices came down to cost
  - Vendors either exited or consolidated
- No demand growth x price erosion = revenue erosion!

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It's A New Memory Layer

- It fits the memory/storage hierarchy well:
  - Faster than NAND, slower than DRAM
  - Costlier than NAND, cheaper than DRAM
- It's nonvolatile
  - Opens the door to in-memory storage
- This could bring new performance to computing

A New Memory Layer Needs A Lot Of Support

- Will require a new bus
  - DDR doesn't support variable access times
- Will require new O/S support
  - Cache management?
  - Memory management?
- Persistence will require application support
  - SNIA and others working on this
  - Some instruction support now in Intel specs

A Chicken & Egg Problem

- 3D XPoint will be sell in volume once it's priced lower than DRAM
- 3D XPoint prices will fall below DRAM once the volume is high enough

Summary

- NAND poised for continuing growth
  - 3D will cause shortages
  - Big collapse in 2017 or 2018
- SSDs have much room to grow
- NOR flash will remain slow
- 3D XPoint is tomorrow's technology
  - Or, perhaps, the day after tomorrow

Thank You!

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