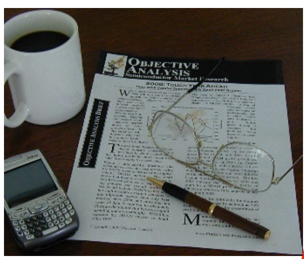
Flash Technology: Annual Update

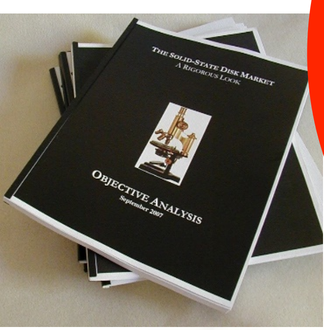
Jim Handy

OBJECTIVE ANALYSIS

OBJECTIVE ANALYSIS

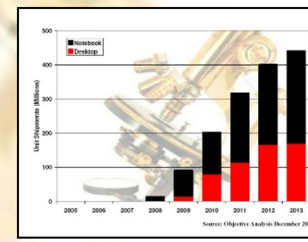
Profound Analysts

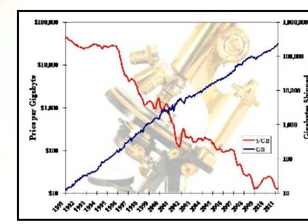


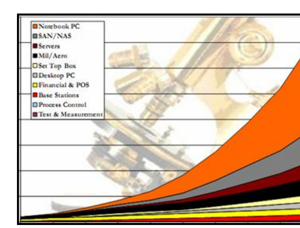


Reports & Services

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%	-0.2%
2016	Revenues up ~10%	TBD

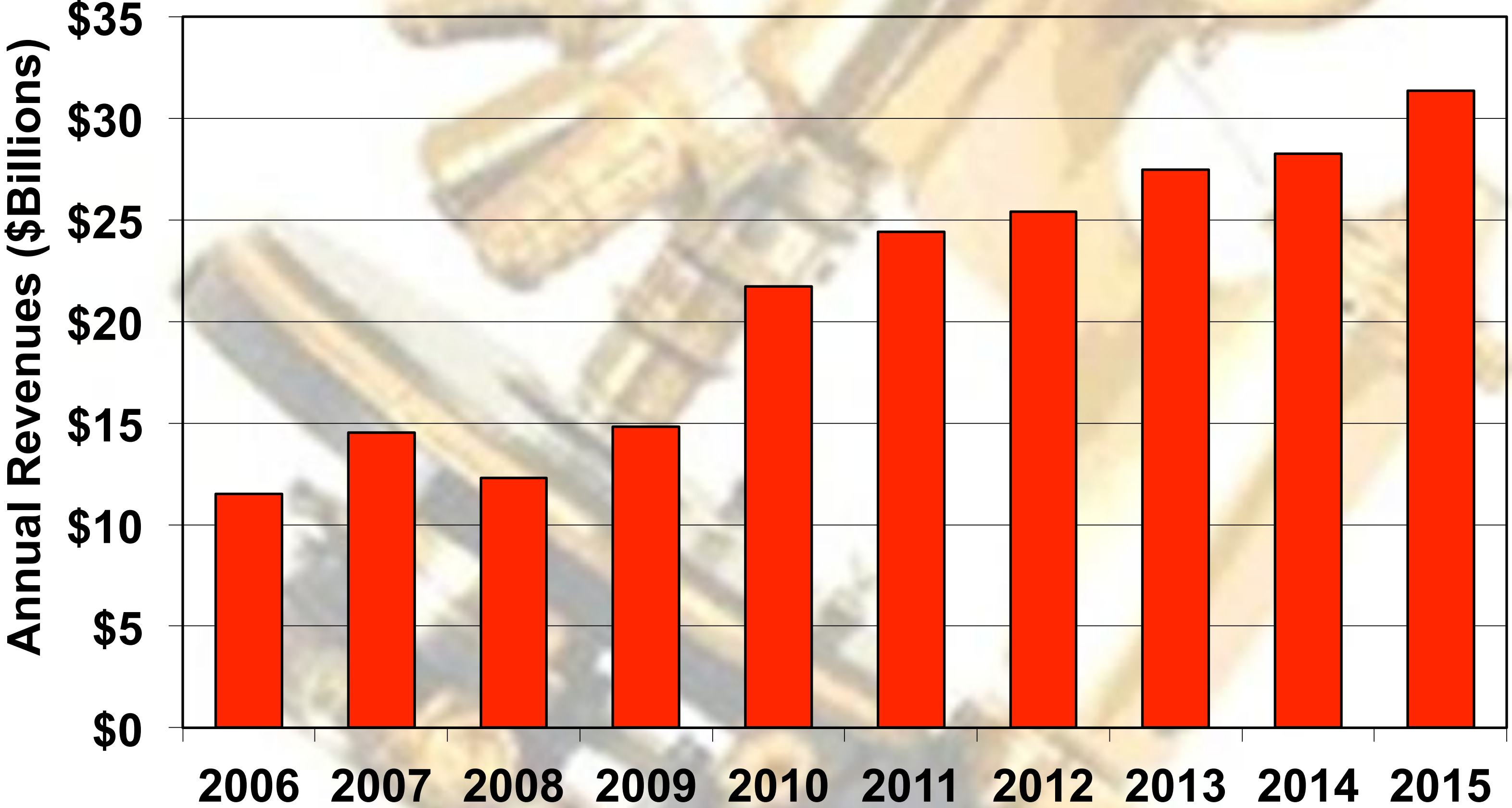
Outline

- NAND Market
  - 3D NAND
- SSDs
  - IOPS needs by application
- NOR Market
- 3D XPoint

Outline

- NAND Market
  - 3D NAND
- SSDs
  - IOPS needs by application
- NOR Market
- 3D XPoint

NAND Revenues 2006-2015

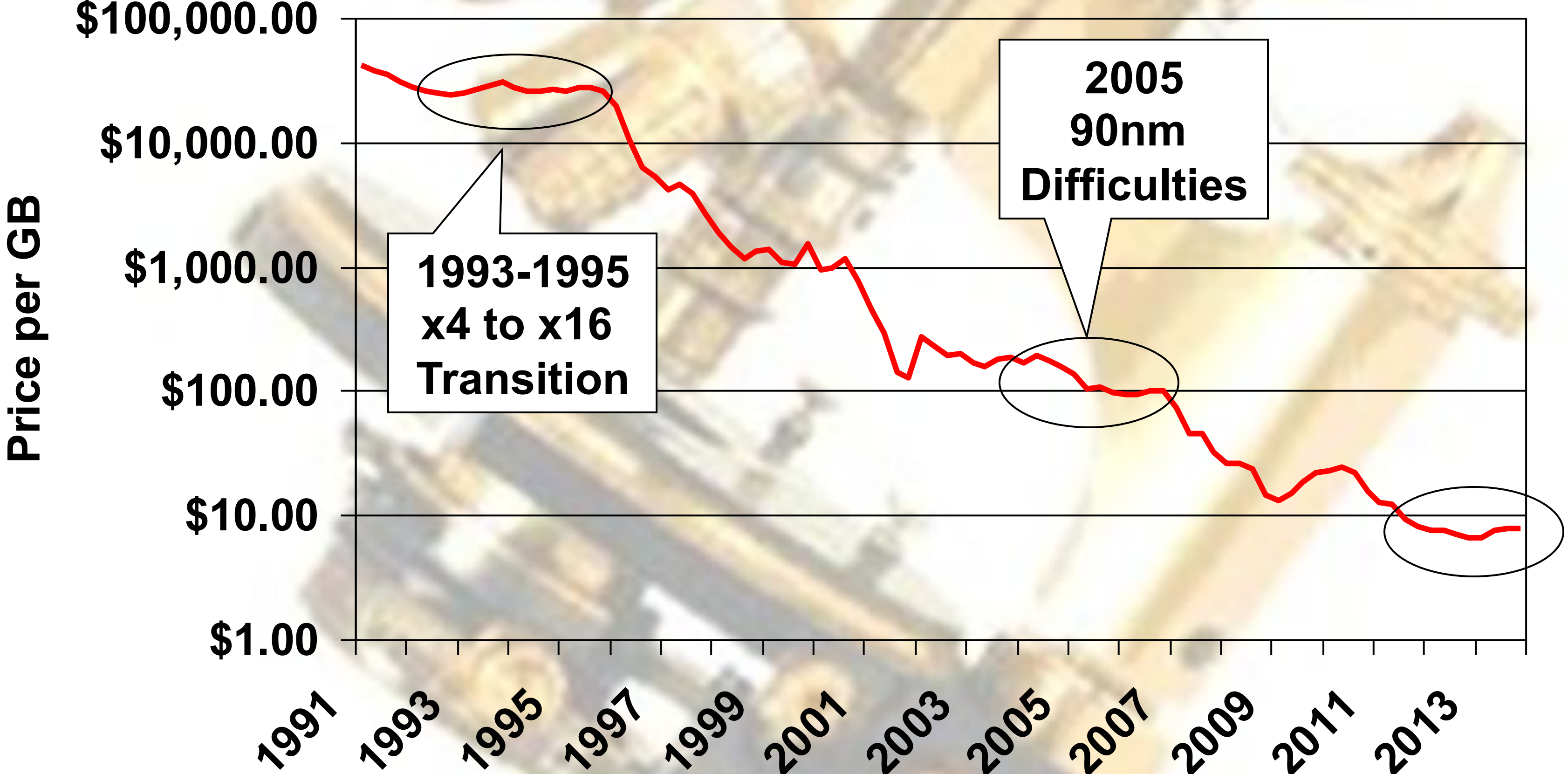


What Drives the Next Downturn?

- Stable prices to mid-2018
  - Collapse once 3D becomes cost-competitive
  - Stable prices drive profits
  - China not a factor until downturn
- 2018 price collapse
  - CapEx-Driven overcapacity
    - Augmented by China investments
  - Largest-ever price-cost gap

Smaller Challenges Have Extended Prior Market Cycles

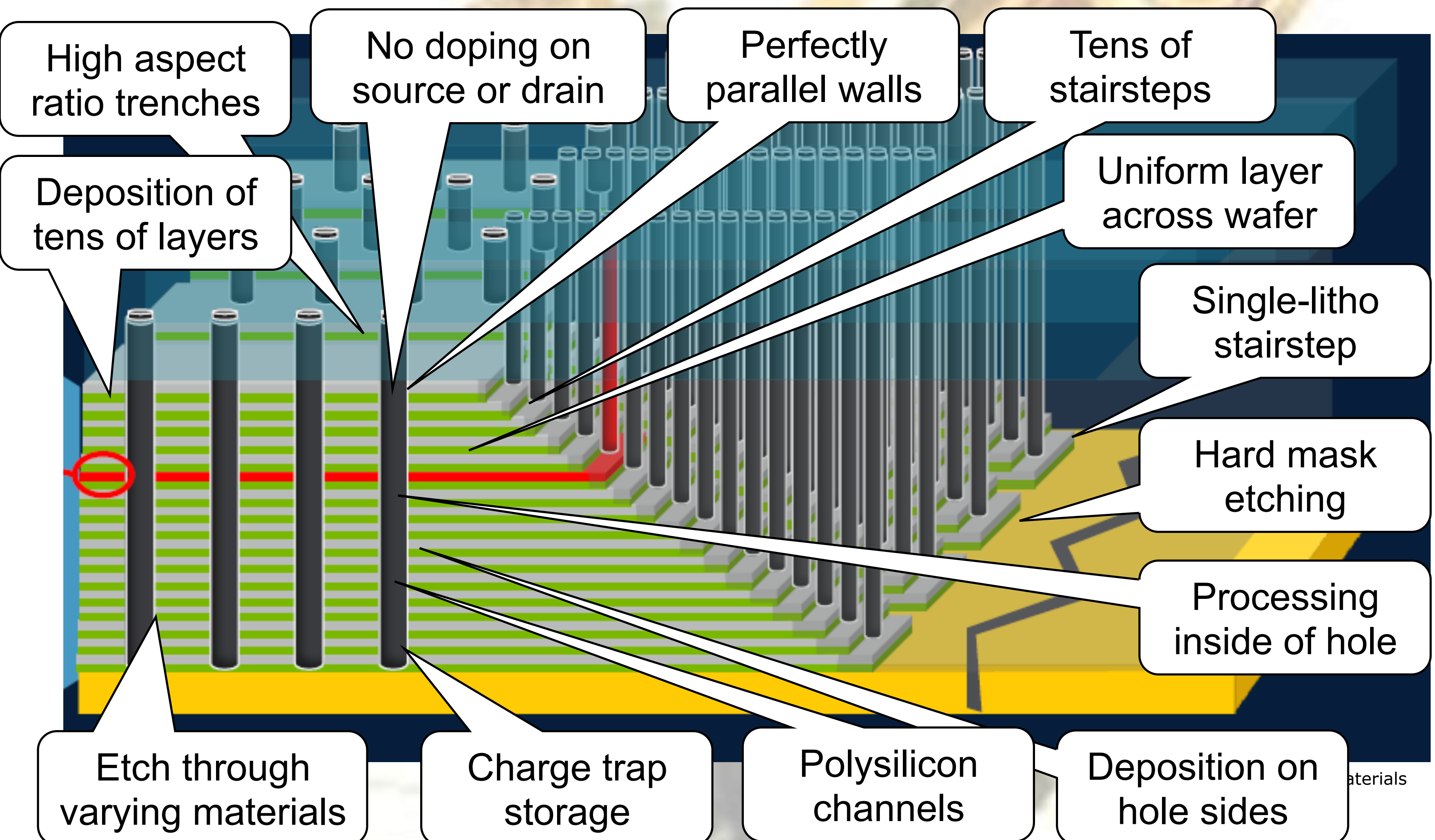
DRAM Examples



Extension is Hard to Predict

- When will 3D be mastered?
  - Samsung and Micron are shipping
    - This does not imply that 3D costs less than planar
- Other vendors are sampling
  - This indicates some confidence
- Vendors say the big ramp will be in 2017
  - Such projections are usually optimistic
- Our guess: Mid-2018

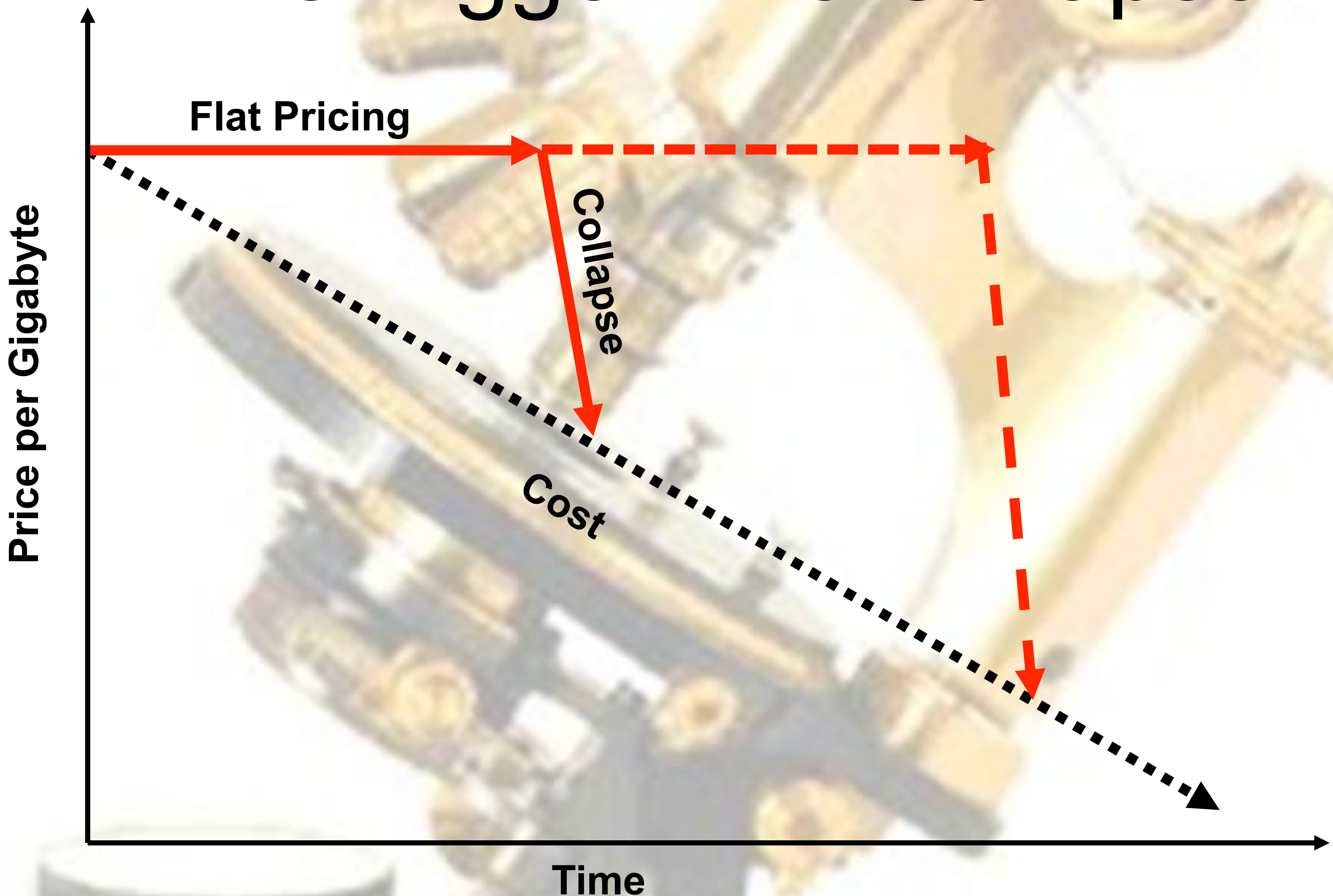
What's So Hard About 3D NAND?



An Analogy

Ϟӄ щэξϖ
ӿÞϑ!!!

The Longer Shortage, The Bigger The Collapse!



Outline

- NAND Market
  - 3D NAND
- SSDs
  - IOPS needs by application
- NOR Market
- 3D XPoint

Enterprise SSD Outlook

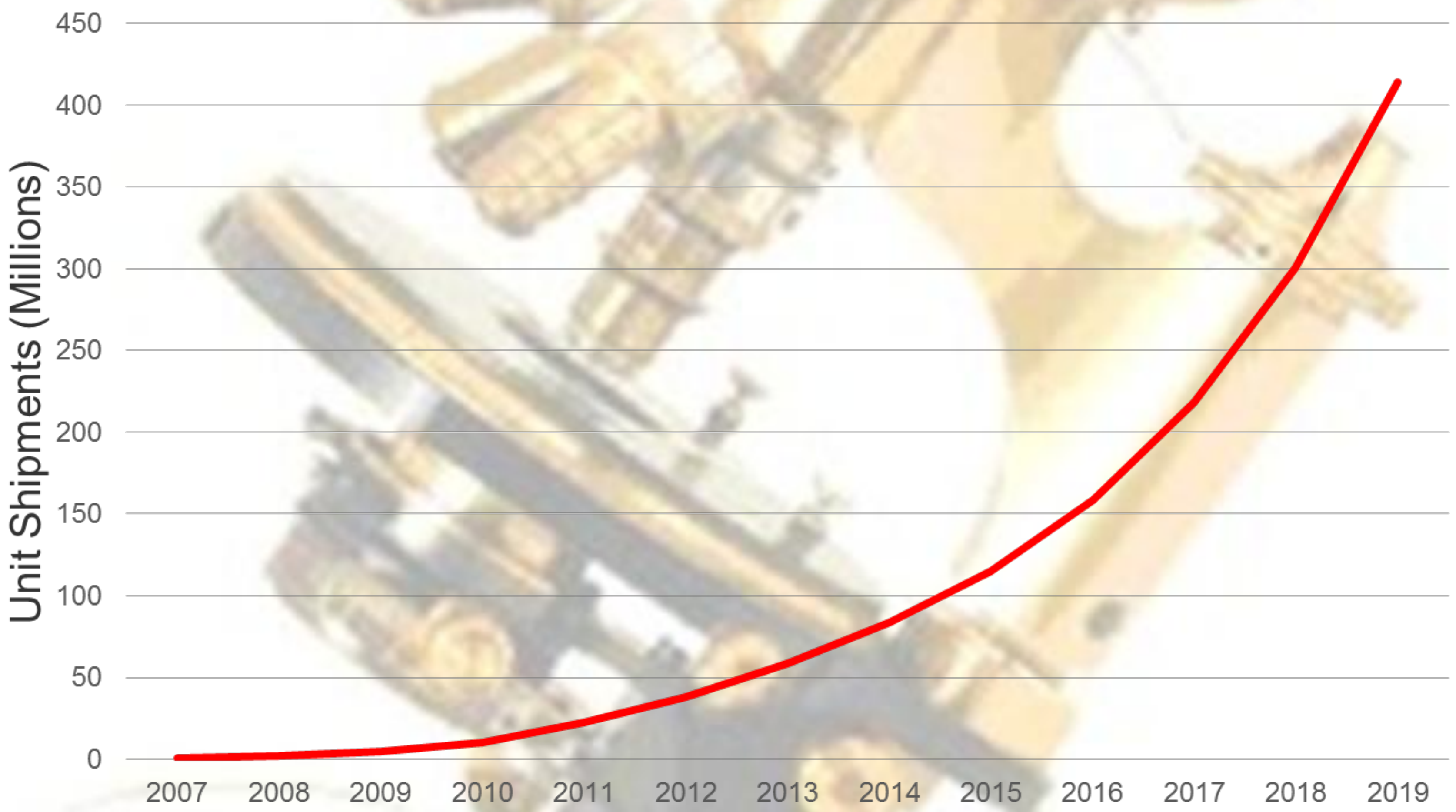
- Server penetration is still only about 50%
  - Continuing huge upside potential
- HDD makers are feeling the impact
  - Enterprise HDD market falling
    - SSDs provide “One-to-Many” replacement
  - Overall HDD market soft
    - PC consumption low for other reasons

PCIe & SAS SSD Shipments

Client SSD Outlook

- PC SSDs not meeting expectations
  - Consumers don't understand cost/benefit
  - Apple accounts for majority of SSD-based new PC sales
    - Their faithful users have no other option
  - Upgrade market continues with strength
- Other markets doing well
  - Difference is the level of understanding

Total SSD Shipments



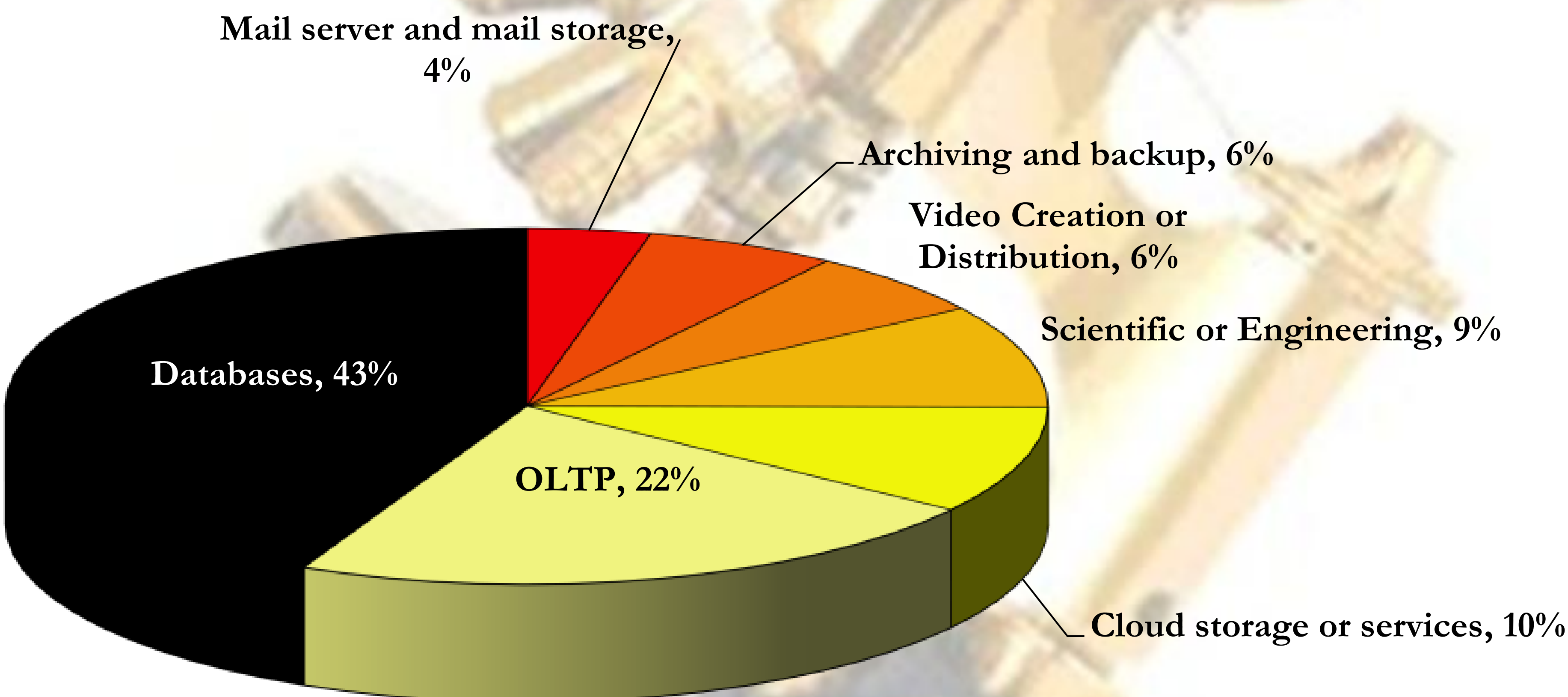
Current Market Softness

- PC market not doing well
  - Main culprit appears to be exchange rates
    - Price of oil also causing trouble
    - Developing nations were growth targets
  - Older PCs are in use longer
    - SSDs help extend their lives
- Enterprise demand still strong
  - Cloud consumption is healthy
  - Enterprise HDDs losing sales to SSDs

Dealing with HDD Interface Legacy

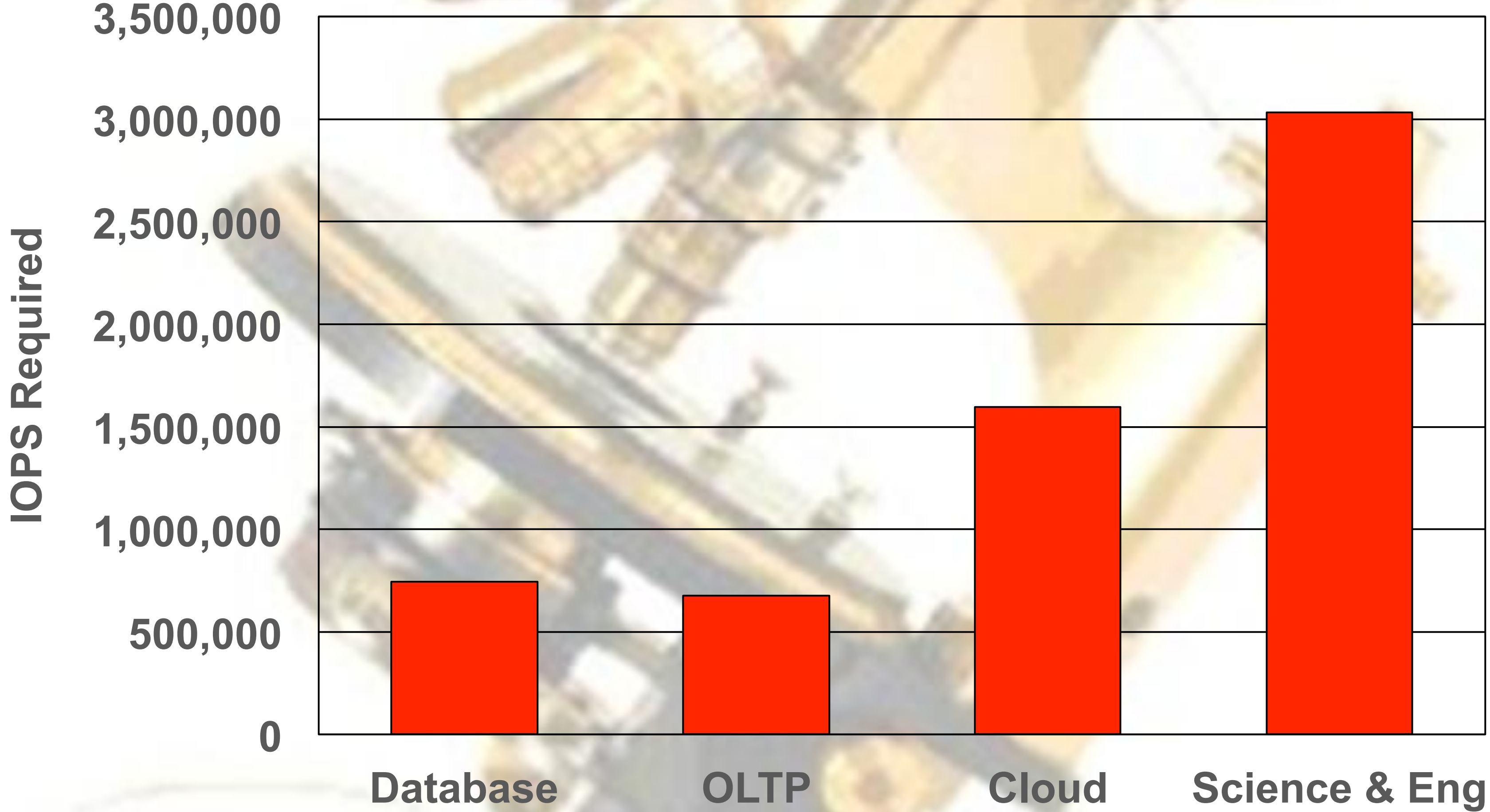
- Old thinking: “It’s storage, make it look like an IDE hard drive.”
- Gradual changes: “Hey! That’s slowing it down! Let’s:
  – Put it on SATA
  – Make SATA faster
  – Put it on PCIe
  – Bring it to the memory bus

IOPS Survey



From: ***How Many IOPS Do You Really Need?*** **Objective Analysis & Coughlin Assoc.**

Average IOPS by Application



From: ***How Many IOPS Do You Really Need?*** **Objective Analysis & Coughlin Assoc.**

Changing Needs

Client

2.5” → mSATA → m.2

Data Center

Fibre Channel → PCIe → SATA

Enterprise

3.5” DAS → SAN → 2.5” DAS/SDS

PCIe Poised to Take Over

- PCIe sockets prevalent in client
  - NVMe unleashes PCIe's performance
- Will become the volume leader
  - PCIe/NVMe costs will drop below SATA
- An interesting dynamic
  - Enterprise: Use SATA because it's cheap
  - Client: Make m.2 PCIe cheaper than SATA

U.2 (2.5" PCIe)

- "Storage is unreliable!"
  - "Flash is storage"
  - You can't hot-swap PCIe cards
  - U.2 is the solution. Swappable PCIe
- Expect a short life cycle
  - Market is existing sockets
    - Few new sockets being developed
    - Fibre Channel SSDs did the same thing

The Migration to MLC & Beyond

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

Outline

- NAND Market
  - 3D NAND
- SSDs
  - IOPS needs by application
- NOR Market
- 3D XPoint

NOR Revenues 2006-2015

NOR Market Leaders

- Cypress/Spansion
- Micron (Numonyx)
- Macronix
- Microchip/SST
- Some smaller players

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!

Outline

- NAND Market
  - 3D NAND
- SSDs
  - IOPS needs by application
- NOR Market
- 3D XPoint

3D XPoint Was <u>Last</u> Year's News!

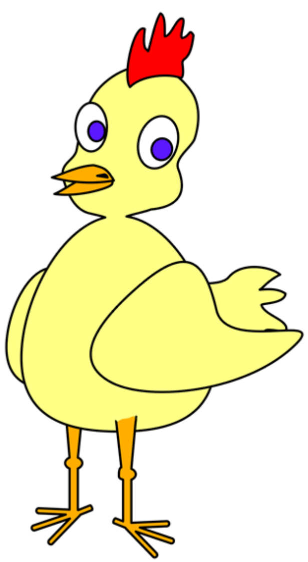
- Not out yet
  - But we'll hear a lot about it this week & next!
- Good fit for the memory/storage hierarchy:
  - Faster than NAND, slower than DRAM
  - Costlier than NAND, cheaper than DRAM
- Opens door to in-memory storage – "SCM"
- Applications are being developed for it

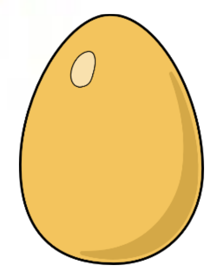
This Will Require a Huge Effort!

- DDR can support variable access times
  - Fancy arrangement of flags and software
- Will receive O/S support
  - Cache & memory management
- Persistence will require application support
  - SNIA NVM Programming Standard
  - Linux "pmem" initiative: www.pmem.io
  - Instruction support is 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 growth continues
  – The 3D transition will create shortages
  – Watch for price collapse in 2018
- SSD growth strong & steady
  – IOPS requirements becoming more focused
- NOR flash in a gradual decline
- 3D XPoint will come… eventually!

Thank You!

Jim Handy
(408) 356-2549
Jim.Handy(at)Objective-Analysis.com

OBJECTIVE ANALYSIS