



# NAND Flash: The Ubiquitous Storage Medium

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# Presentation Agenda

- ❑ Some Industry Perspective...
- ❑ NAND Market Trends
- ❑ Key NAND Growth Drivers
- ❑ Innovative Product Showcase
- ❑ Concluding Remarks

# First, the Bad News...



**\$120-140 Oil**

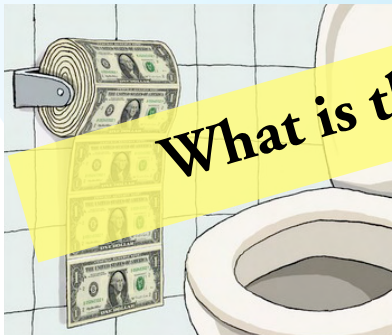


**Housing Crisis**



???

**Inflation**



**US Economic Malaise**



**What is the Outlook for NAND Given These Conditions?**

**Global Warming**



# Putting it into Perspective: “The New World Order” ...for Semiconductors



**China's Middle-Class will Increase 7X to 700M by 2020**



**India's Middle-Class will Increase 10X to 600M by 2020**



**Wal\*Mart's International Sales Grew 17.5% This Year  
International Revenue Now 24%, vs 8.9% 10 Years Ago**

**Technology  
Adoption  
Rates Vary  
Greatly**



**WW  
Avg**



**Internet:**

**71%**

**20%**

**PC's:**

**80 per 100**

**13 per 100**

**Cell Phone:**

**~100 per 100**

**13 per 100**

Semiconductors is a truly global business with tremendous growth opportunity  
Moore's Law will continue to inspire **innovation**...

# Storage Requirements Increasing Dramatically



Multi-Media Files  
Full Length Movies  
(Over 10GByte)



Video Clip  
5mins DVD Quality  
(100MByte)



Picture  
3Mega Pixels  
(1MByte)



e-Mail  
(10KByte)

100X

100X

100X

# New ID Presents Storage Challenges

Devices Getting Smaller, Portable, Multi-Functional  
Storage Progression: Tape → CD → NAND



Video Camera



Cassette Player



Wired Phone



Video Camera



CD Player



Cell Phone



Video Camera



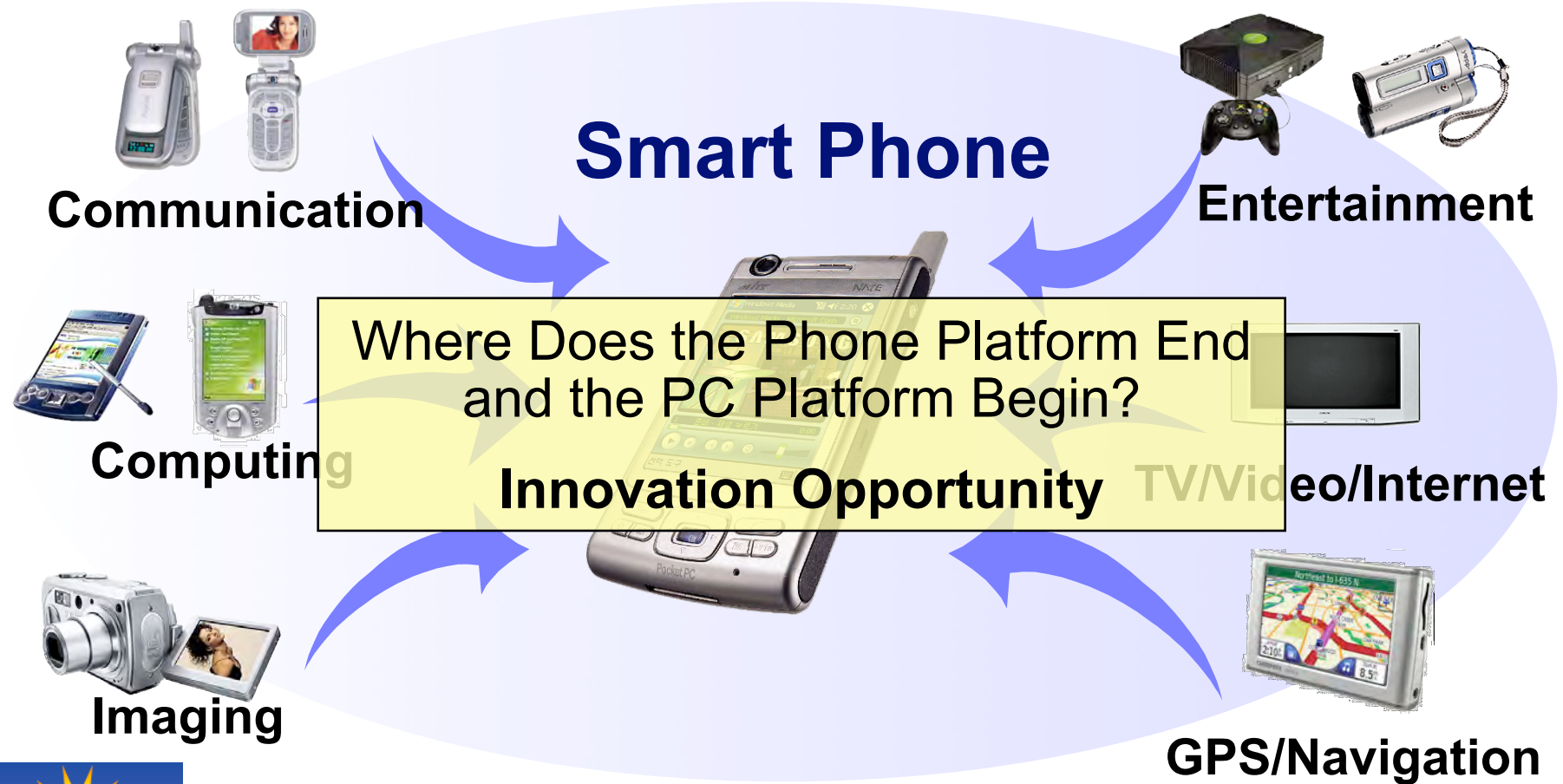
MP3 Player



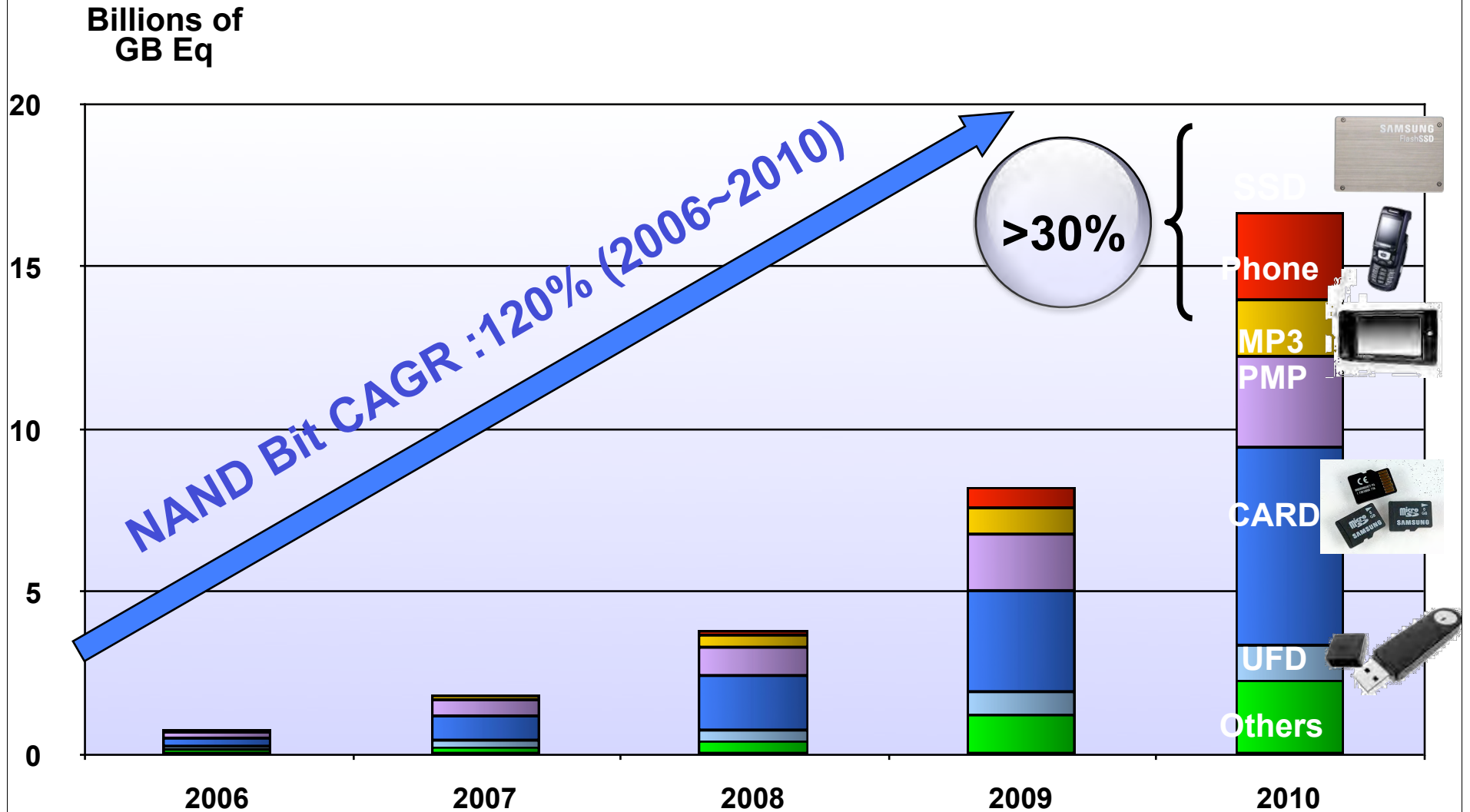
Multimedia Phone

# Multi-Functional Devices Proliferating

Increased Storage Needs: Embedded NAND & Flash Cards

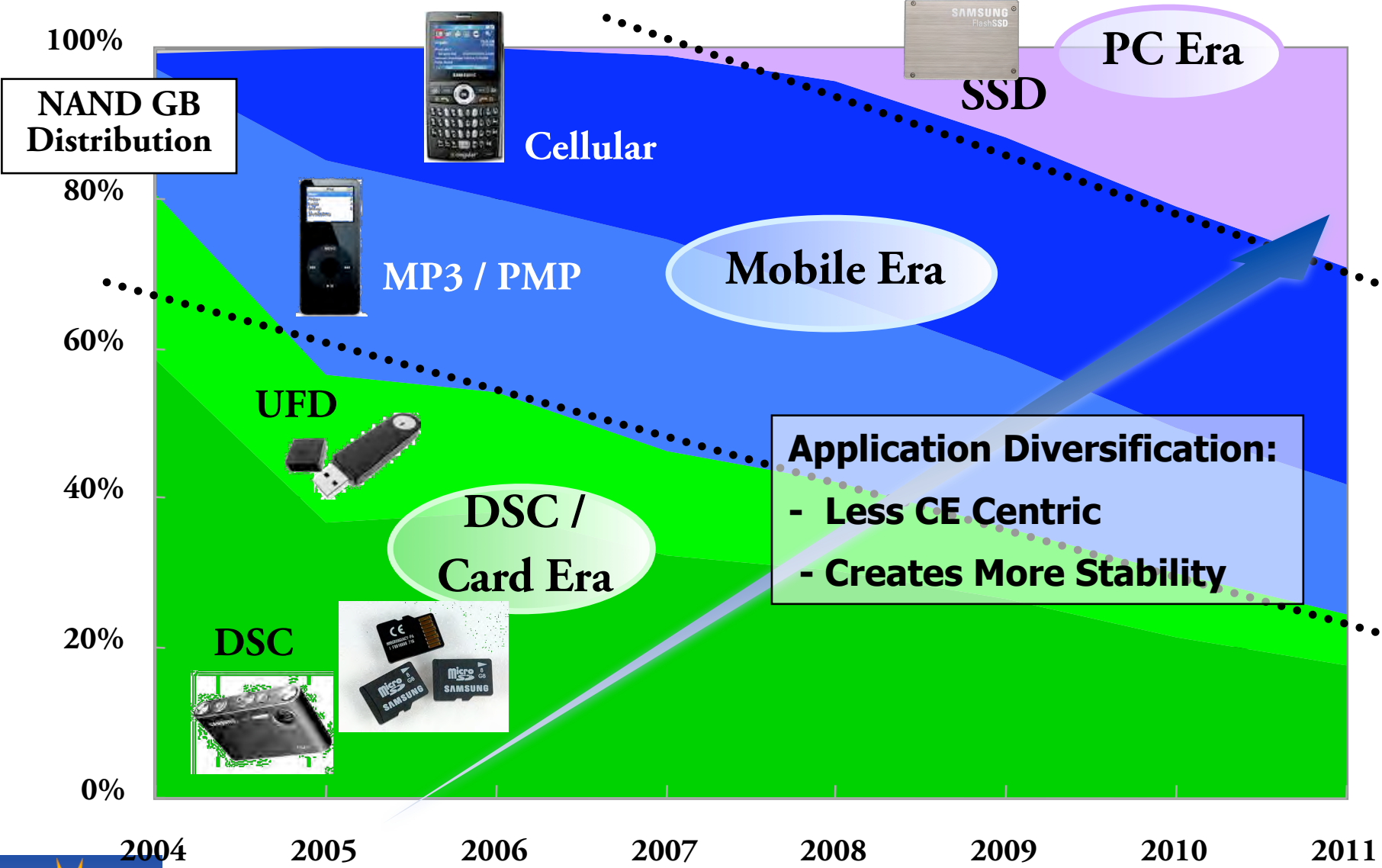


# NAND Applications Proliferating





# NAND Transcending CE Arena...



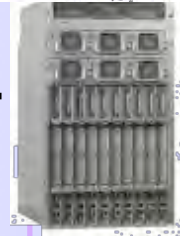
# NAND Categories Emerging by Application

Endurance

PC / Enterprise

**SLC / Server SLC**

100K Endurance →  
500K Endurance



Consumer Products

**2-Bit MLC**

~10K Endurance



Notebook +  
Read-Centric  
Enterprise

**3-Bit+ MLC**

~1K Endurance



Content  
Distribution

Speed

SAMSUNG

# NAND Growth Drivers

MP3/PMP



Phone



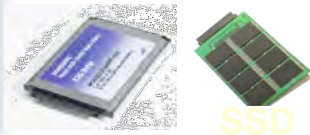
Card



UFD



SSD



Consumer



Video Driving Growth

Digital Convergence

Riding Cell Phone Wave

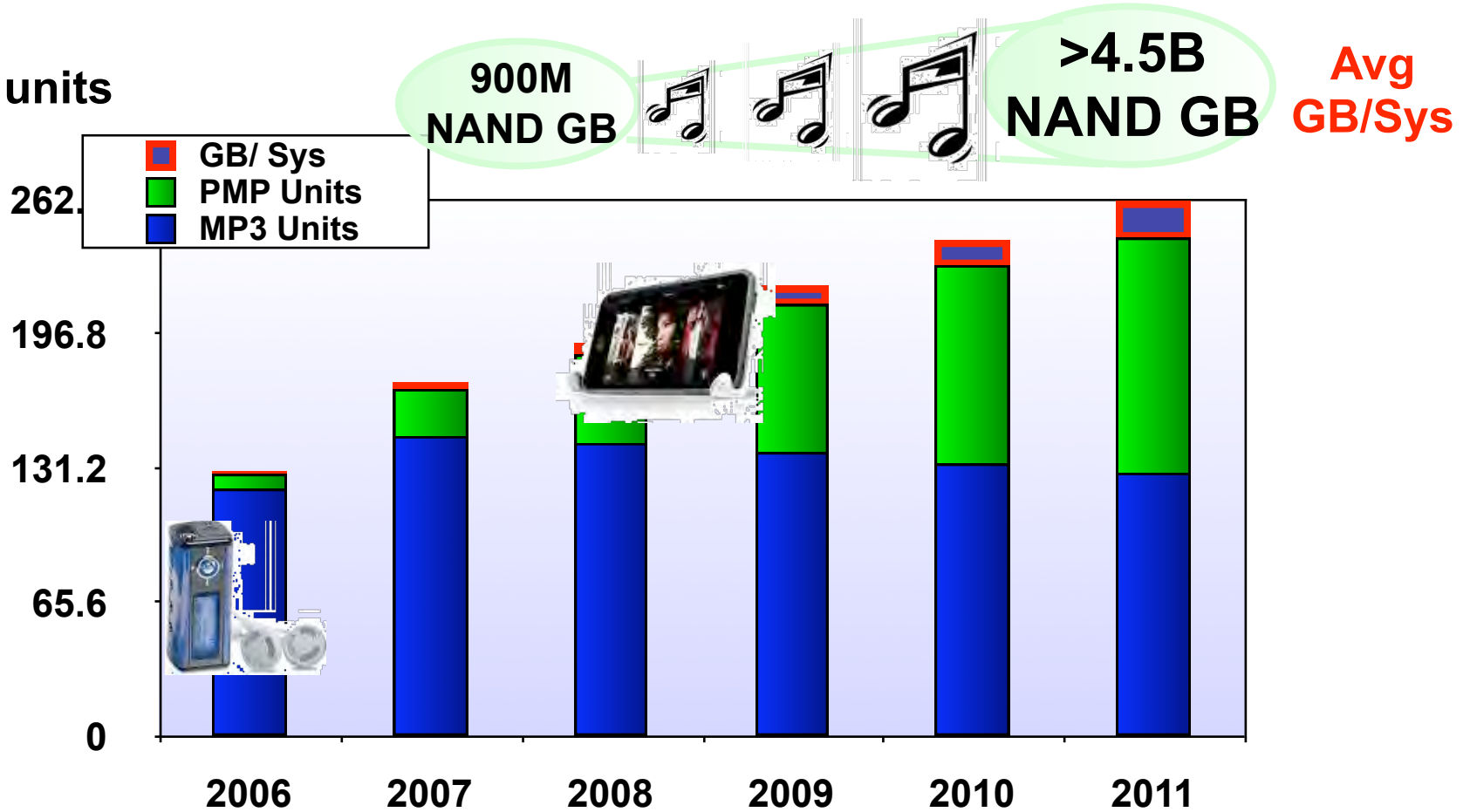
Now Ubiquitous

The Next Killer App...

Ground Zero for Innovation

# MP3 / PMP: Video Driving GB Content

M units



\*Source: SEC



How to Define a PMP?

Wikipedia: Audio, Images and **Video**

Also, screen size can be a designator



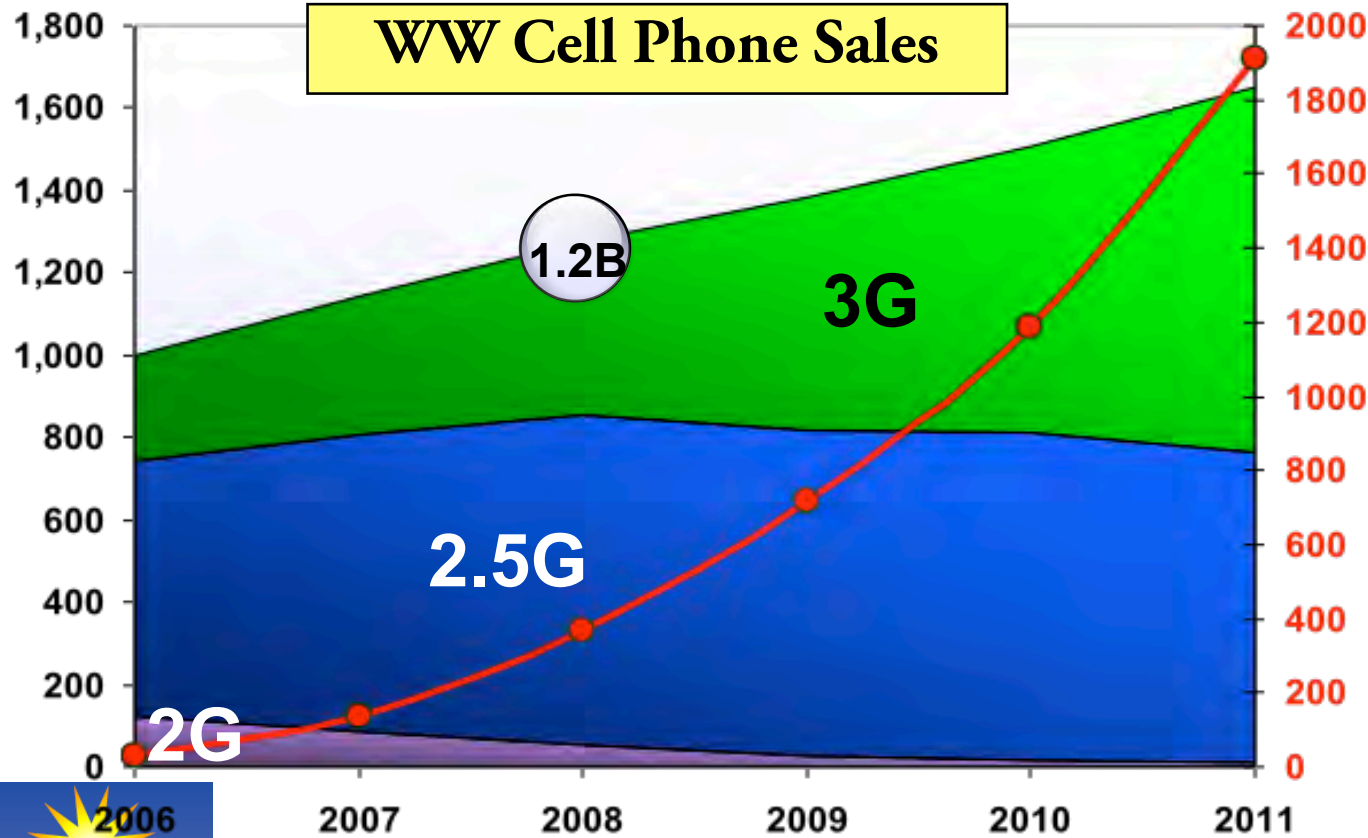
# Cellular + NAND: Demand Ringing off the Hook

- 2008: Mobile phones are the major market driver for flash cards
- 50 Photos + 1 Map + 200 Songs + 10 Games + 3 movie clips: ~ 2GB



M Units

Avg MB



# Flash Card Market Growth

Card Units, M

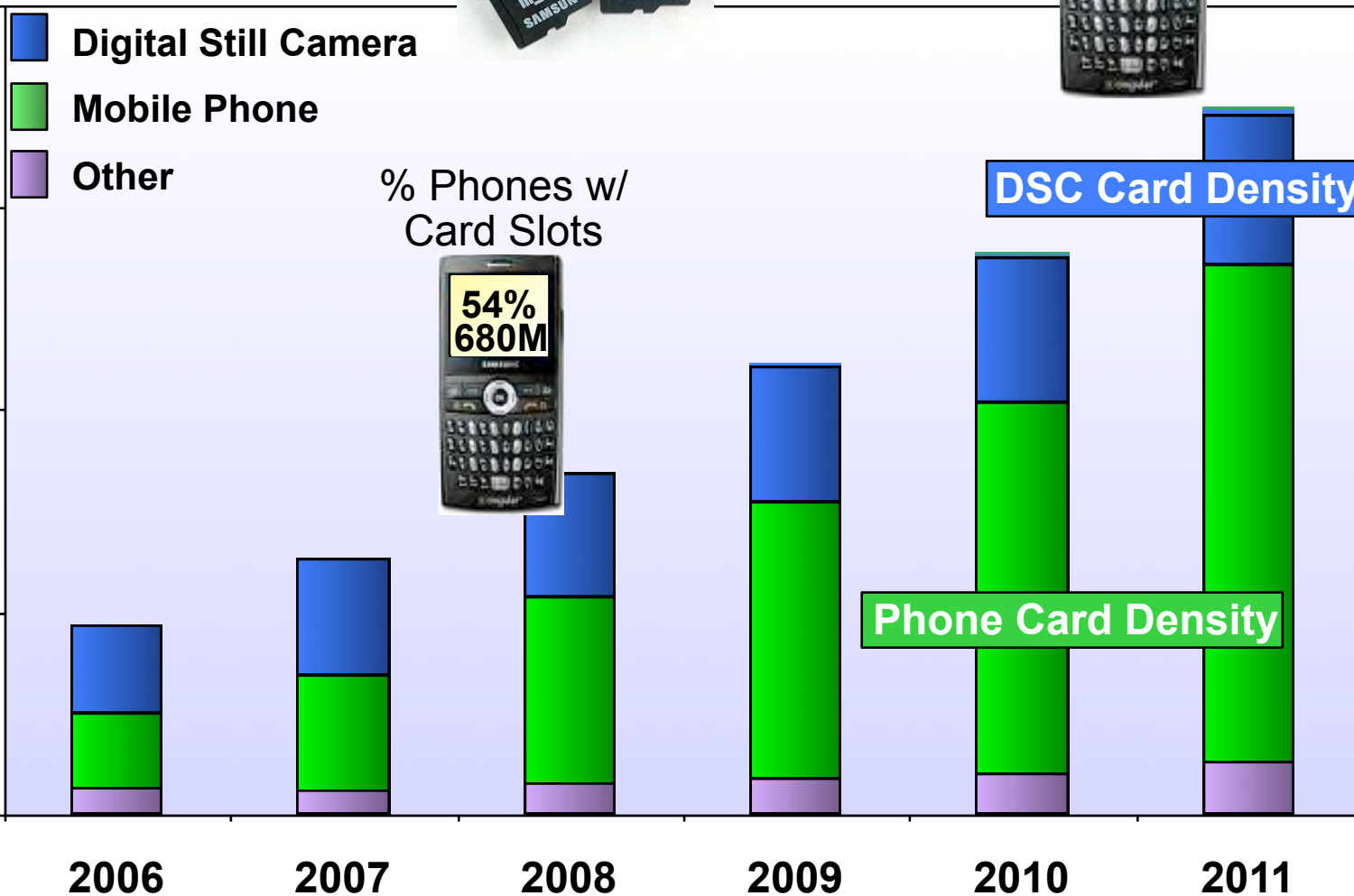
2000

1500

1000

500

0



Avg Card GB

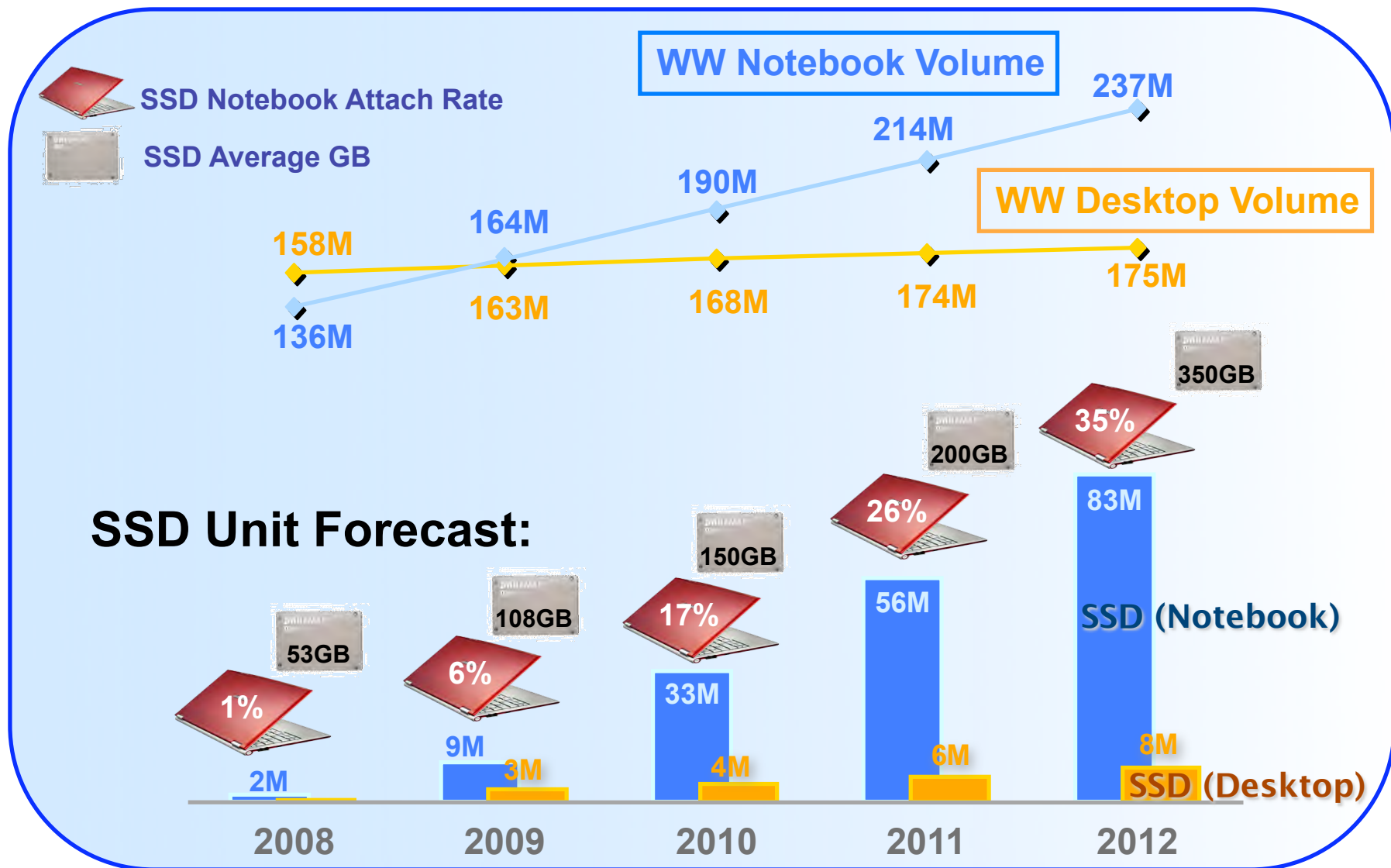
% Phones w/  
Card Slots



DSC Card Density

Phone Card Density

# SSD Volume, Attach Rate Forecast



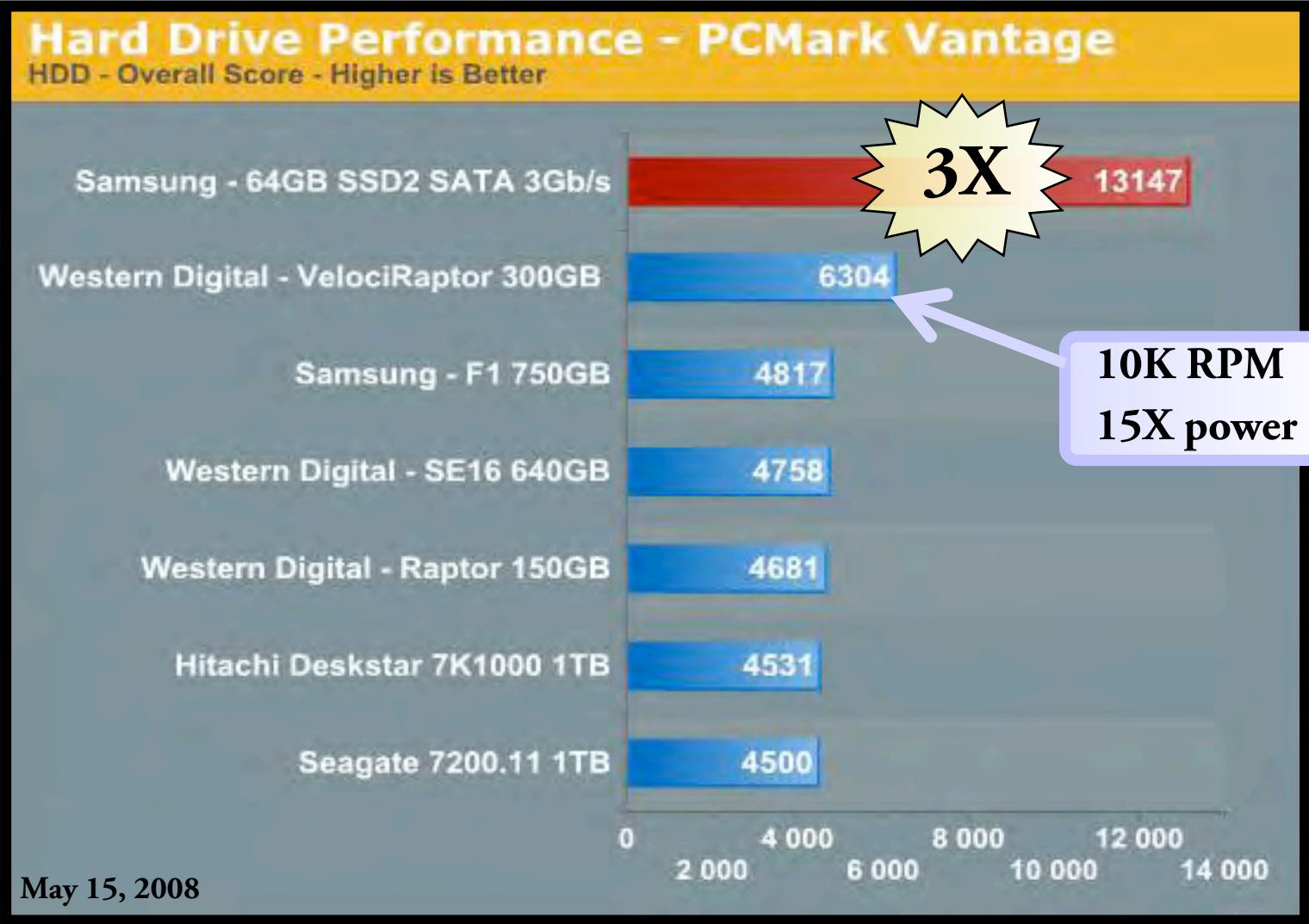
# SSD Value Proposition Recap

- ❑ Performance
- ❑ Density
- ❑ Endurance
- ❑ Reliability, Acoustics, Heat, Power



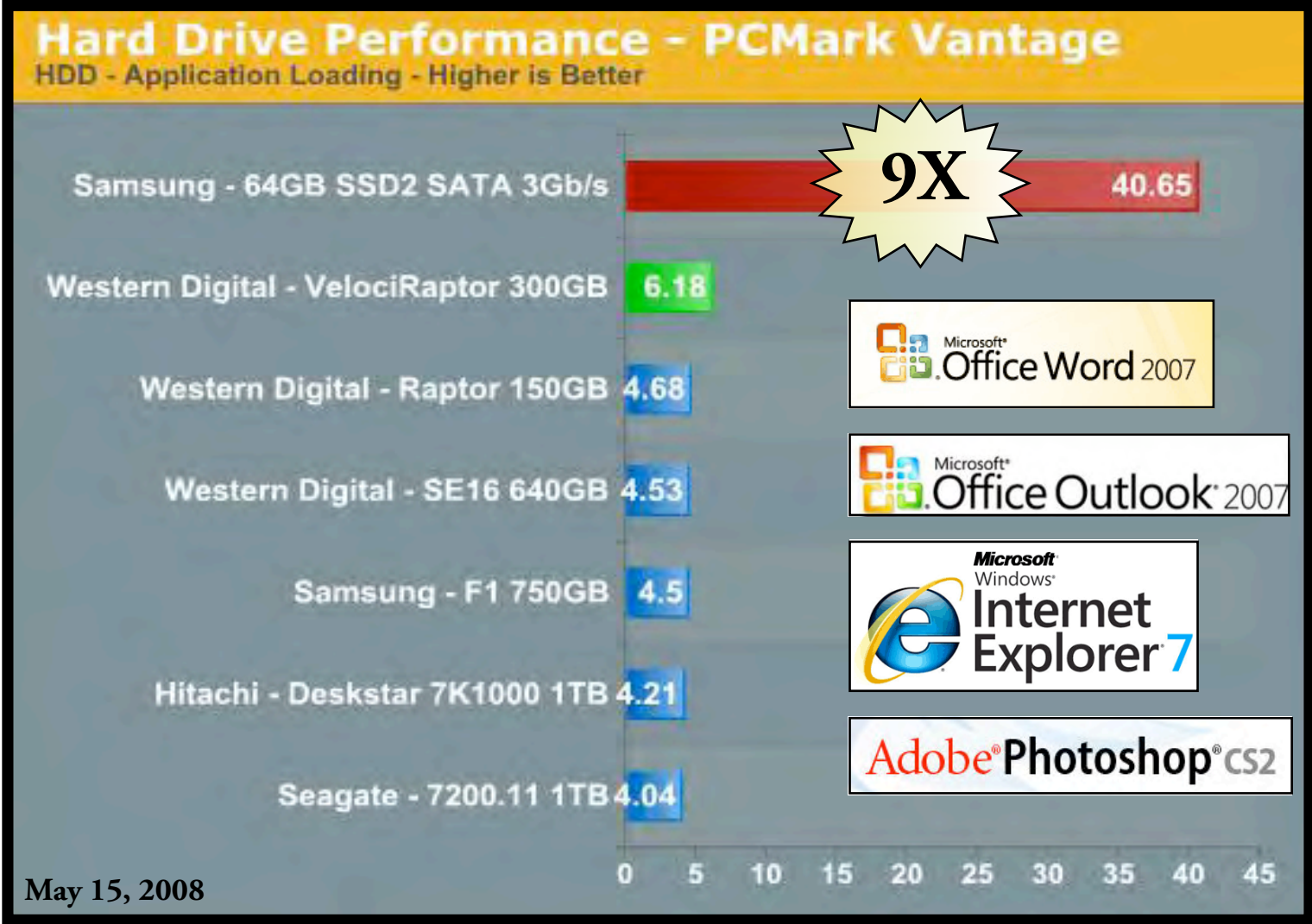


# SSD SATA-II vs HDD: Overall Performance Scores



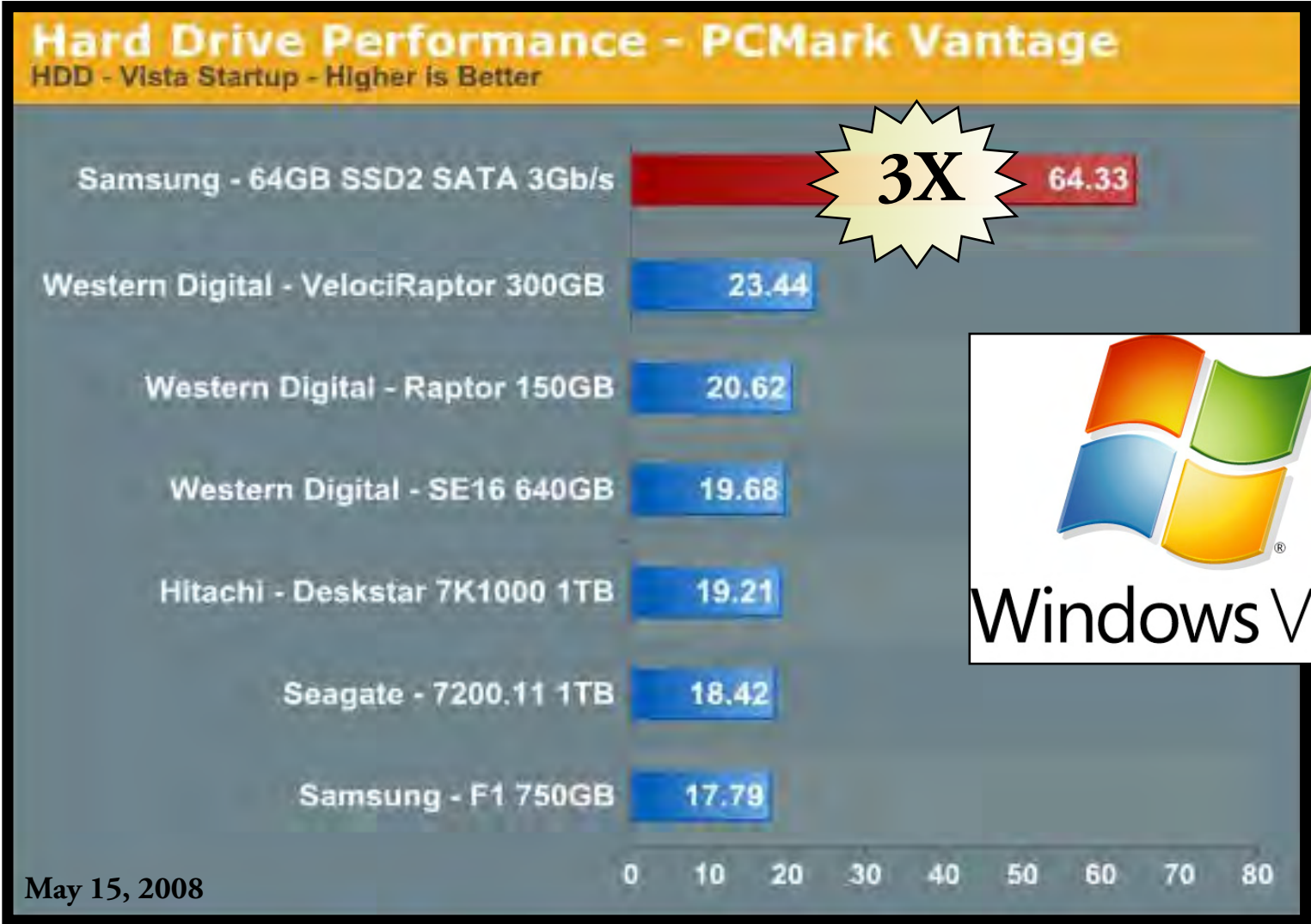


# SSD SATA-II vs HDD: Application Loading



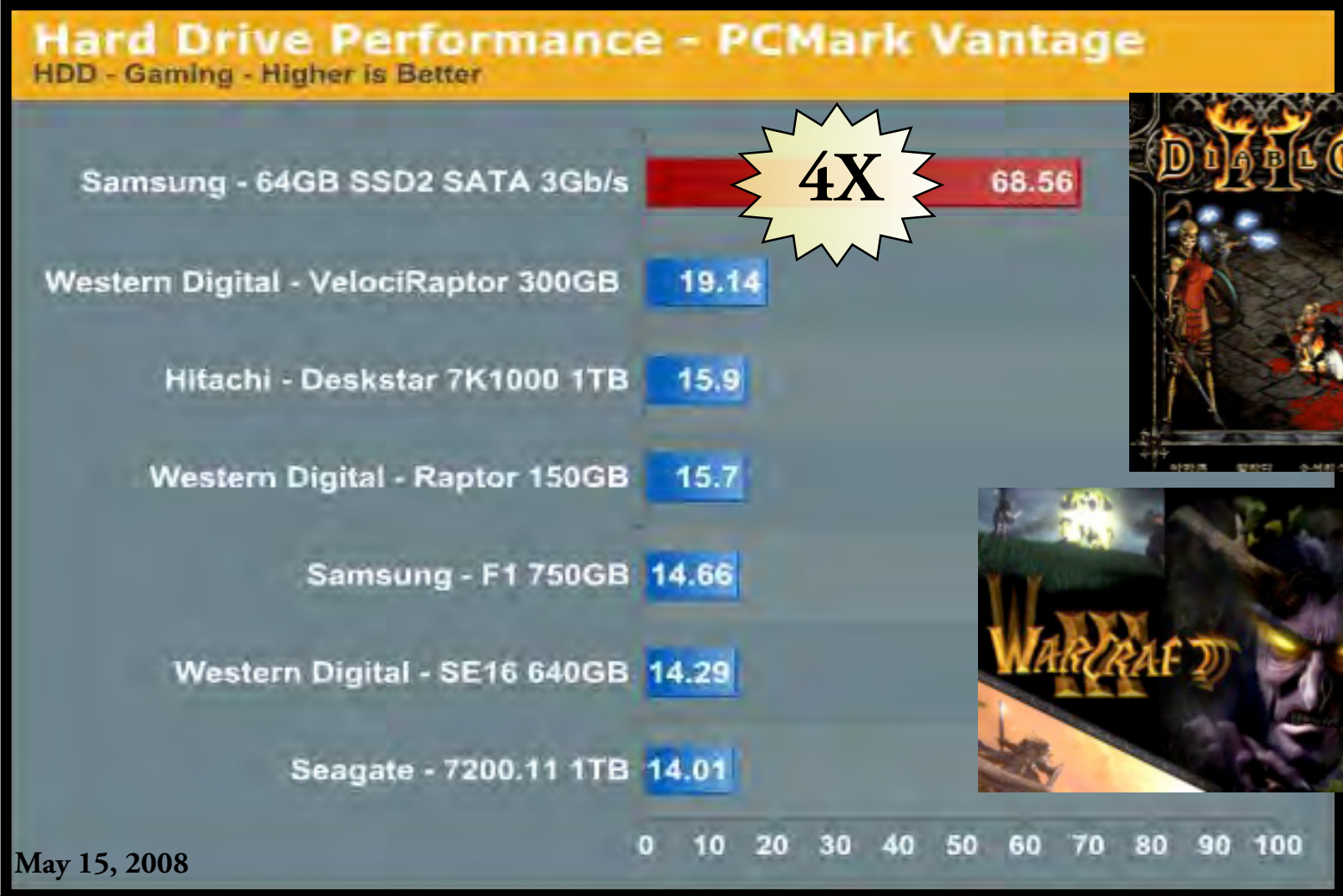


# SSD SATA-II vs HDD: Vista Startup

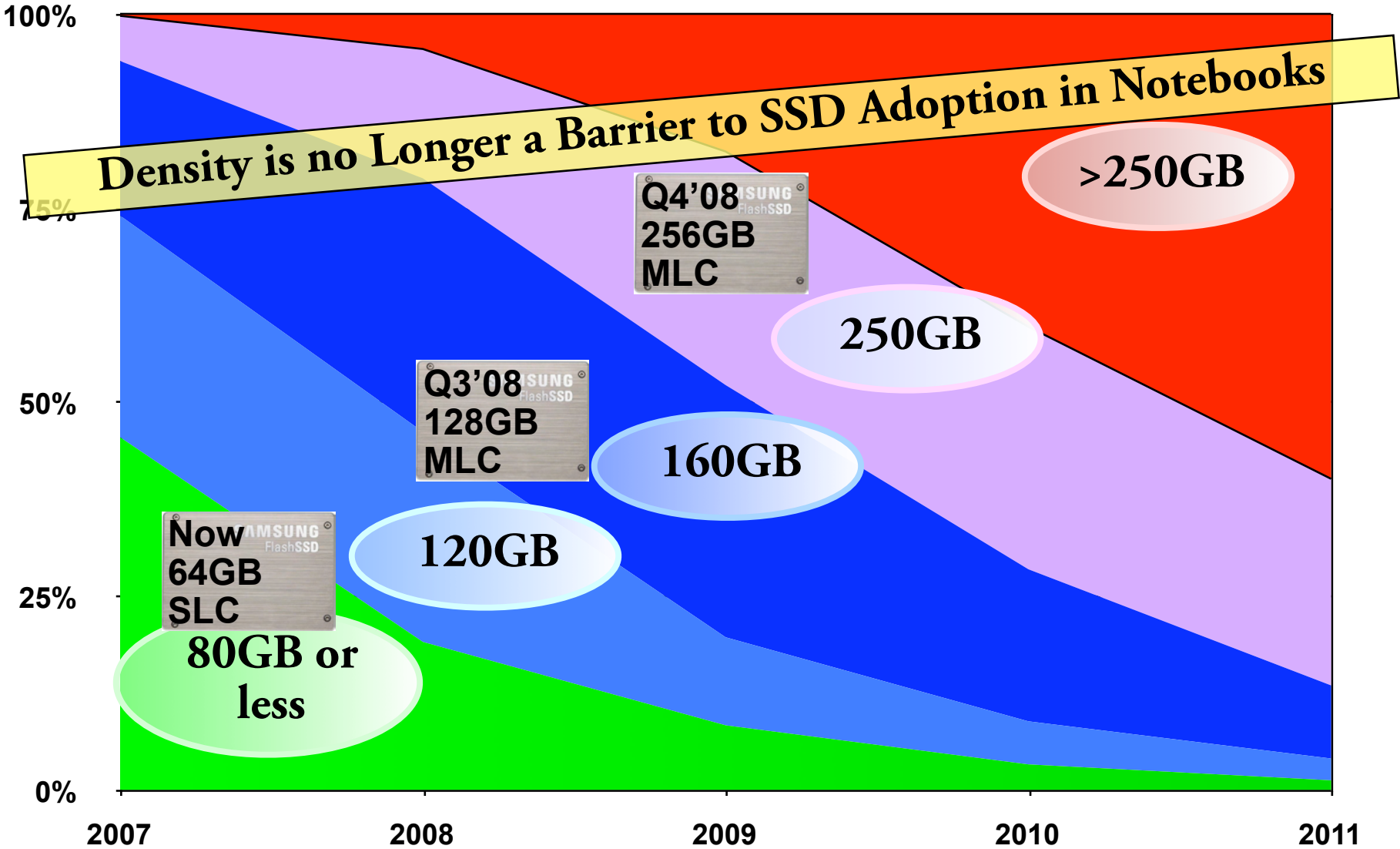




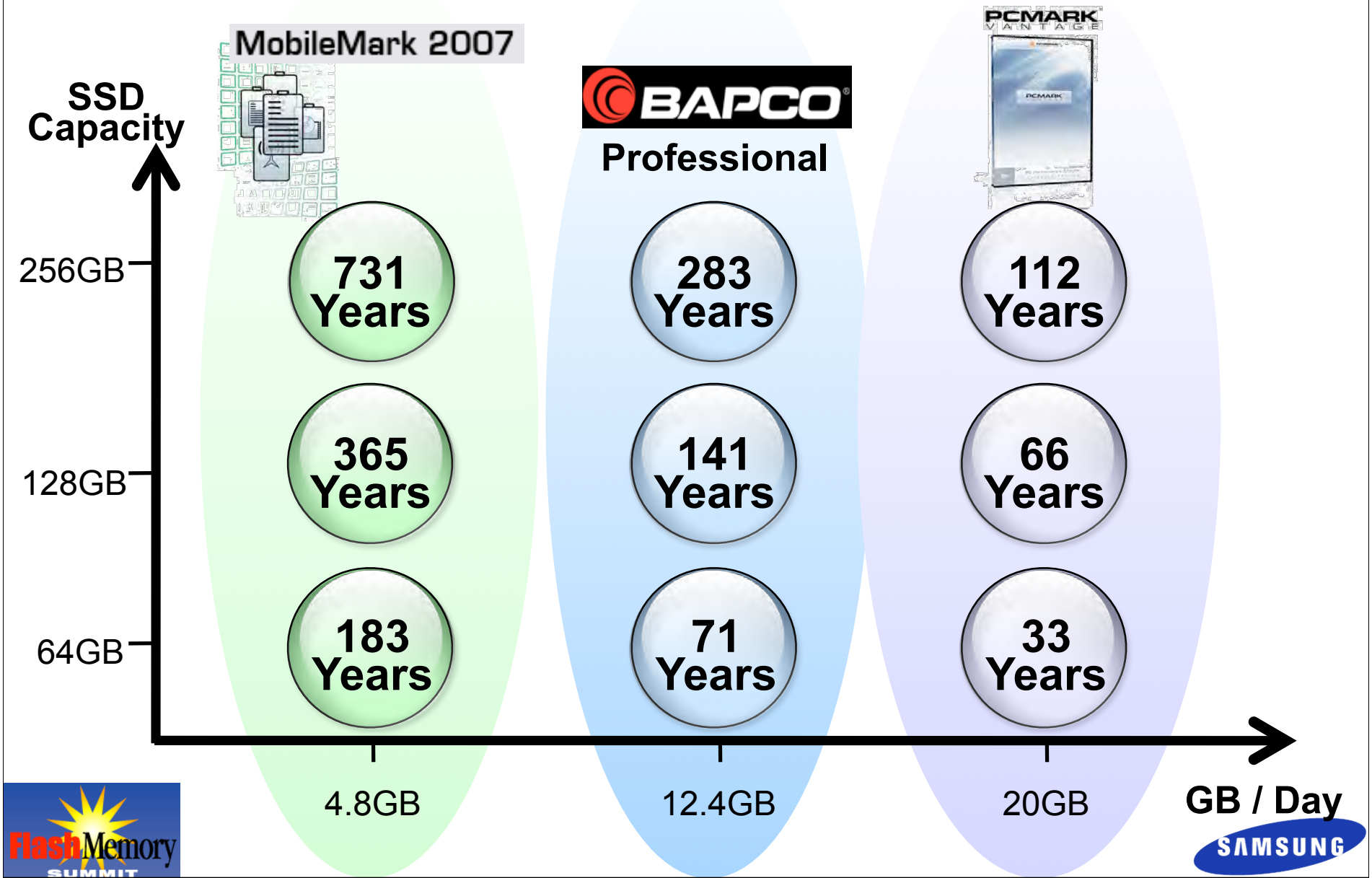
# SSD SATA-II vs HDD: Gaming



# Notebook 2.5" HDD Capacity



# MLC SSD Estimated Notebook Lifetime



# SSD Value Proposition Recap

- ✓ Performance: Superior
- ✓ Density: 256GB covers >90%
- ✓ Endurance: More than Enough + Predictable
- ✓ Reliability, Acoustics, Heat, Power

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## □ Pricing

- ❖ Notebook: System-Level Optimization
- ❖ Enterprise: \$/IOPS and IOPS/Watt



# Hybrid Car Analogy: Camry vs Prius

Hybrid “Configure  
To Order”



Prius: Hybrid-Only



Metric	Camry: Hybrid CTO	Prius: Hybrid Only
Car Facts	#1 Selling Car Brand in US	#1 Registered Car in Santa Clara County
Hybrid Design Optimization	None: Conventional Gas + Electric Add-on	Holistic Approach: Thin Tires, Aerodynamic, Lighter Weight
Fuel Economy	Improved: 26 → 33 MPG	Best in Class: 46 MPG
MSRP	\$20K → \$25.7K (+ \$5.7K)	\$21.5K Entry Level
<u>Pricing Decision</u>	<u>Mileage Needed to Break Even</u>	<u>Total System Value</u>
Customer	“Fence sitter”	Eco-friendly, Trend-Setter
Product Perception	Engine Option Only	Leading-edge Innovation, Green

# Notebook Analogy: CTO vs. SSD-Only

## Configure to Order



## SSD Only



Metric	CTO / Menu	SSD-Only
SSD Configuration	Usually "Opt In"	SSD-Only at System Level
CPU Optimization	None	Speed Downgrade → Save \$\$\$, Save Power, Less Heat
Battery Optimization	None	Smaller and Lighter → Save \$\$\$, Less Heat
<u>Pricing Logic</u>	<b>Upgrade Price, ROI</b>	<b>Total System Price</b>
Marketing Approach	Shotgun (Non-Specific)	Rifle (Road Warrior, Security)
Product Perception	Storage Option Only	Leading-edge Innovation

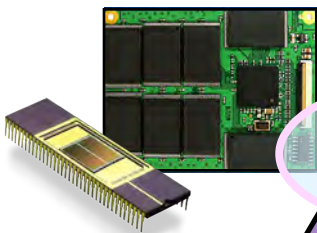


# The SSD-enabled Lenovo X300



- ❑ First “Mainstream” SSD Only Notebook
- ❑ 64GB Solid State Drive
  - ❖ No HDD Option or “Opt Out”
- ❑ Represents an Irreversible Industry Trend...

# Notebook SSD Evolution



Custom  
ID

Disruptive  
Technology  
in Action

## Full SSD Integration

Flash on Motherboard  
AND DIMM

Q1 2008



SSD  
Only

## Lenovo X300

- Optimized System Design

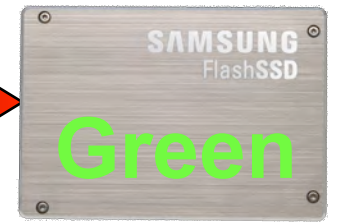
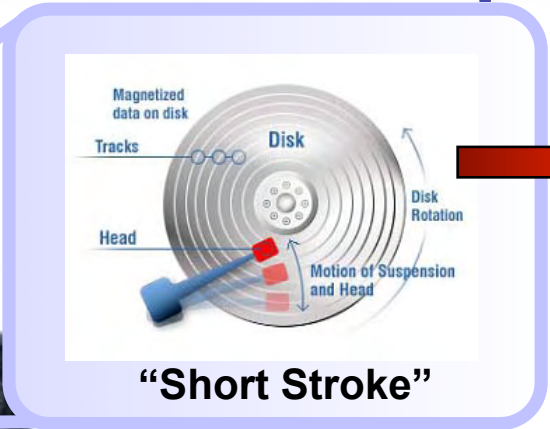
CTO Model

## U.S. Market

- 40+ SKUs
- All Major OEMs



# Server SSD Performance Comparison



	15K HDD 3.5”	15K HDD 2.5”	SSD 2.5”
<b>Capacity</b>	146GB	73GB	64GB
<b>Read</b>	93 MB/s	108 MB/s	100 MB/s
<b>IOPS</b>	650	570	8000
<b>Price Est.</b>	~ \$280	~ \$470	~ \$600
<b>Avg. Watts</b>	15 W	8.3 W	<u>0.41 W</u>
<b>\$ / GB</b>	\$1.9	\$6.2	\$9.3
<b>\$ / IOPS</b>	\$0.43	\$0.82	\$0.07
<b>IOPS / W</b>	43	70	19512

**6X**

**11X**

**450X**

**280X**

\*SSD: IOPS: random read @ 512B, Data (SEC Marketing)

\*HDD: Price and Data from storagereview.com; IOPS: average read speed



# Innovative Product Showcase

# pulse™

S M A R T P E N

**1GB and 2GB  
NAND Based**

**RECORD AND LINK AUDIO**  
to what you write.

**LISTEN TO YOUR RECORDINGS**  
by tapping on what you wrote.

**SEARCH AND SHARE YOUR NOTES**  
from your computer.

**NEVER MISS A WORD™**



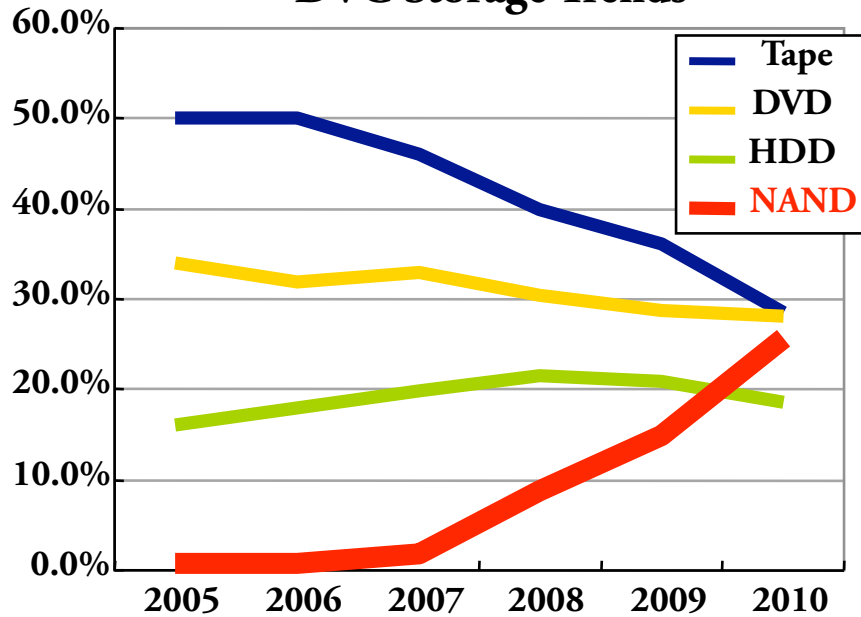
 livescribe.

[www.livescribe.com](http://www.livescribe.com)

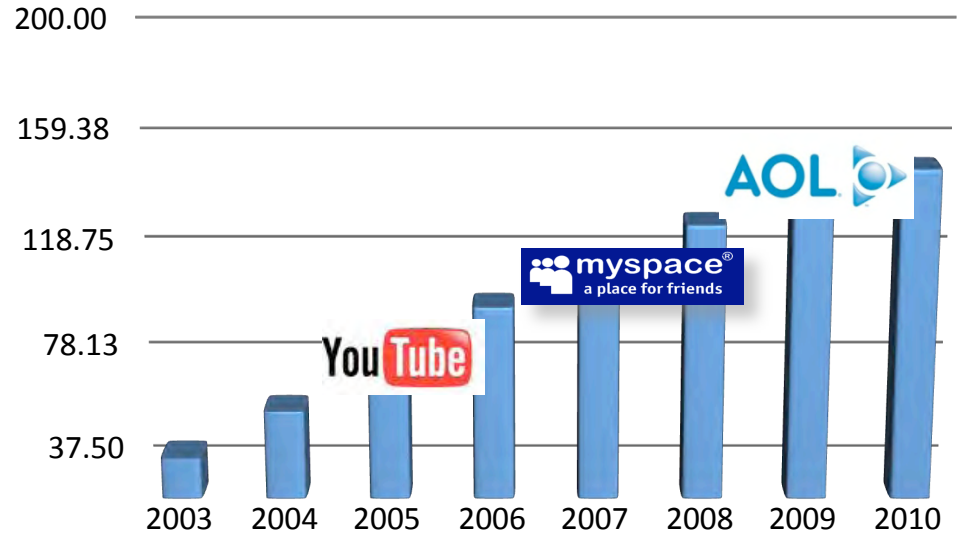


# Enabling “Content Creators” at \$179

DVC Storage Trends



US Online Video Viewers (M)



Pure Digital- Flip Video

#1 Selling Camcorder in the US

60 Minutes of VGA Video: **\$179**

2GB Embedded NAND



Source: ComScore; eMarketer, NPD June '08





# Eye-Fi

Wi-Fi Enabled 2GB SD Card

Wireless Uploads to the Web and your Computer



Hotspot Access at 10,000 Wayport Restaurant, Hotels & Airports

Automatic Geo-tagging

Take Pictures



Wirelessly Upload



Automatically Save



Easily Share



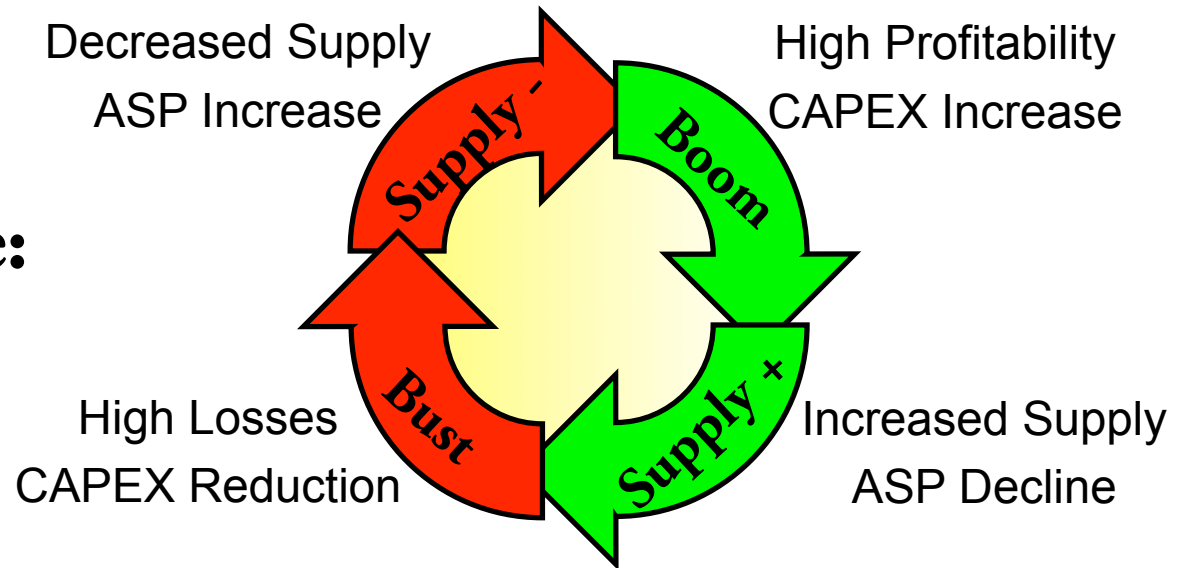


# So Where is the Market Headed?



# Concluding Thoughts

## Traditional Memory Cycle:



## Future Prospects:

**Moore's Law Continues to Inspire Innovation.**

**Innovation Will Drive Growth...**



**Thank You!**

