Flash Memory Forecast

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Web-Feet Research

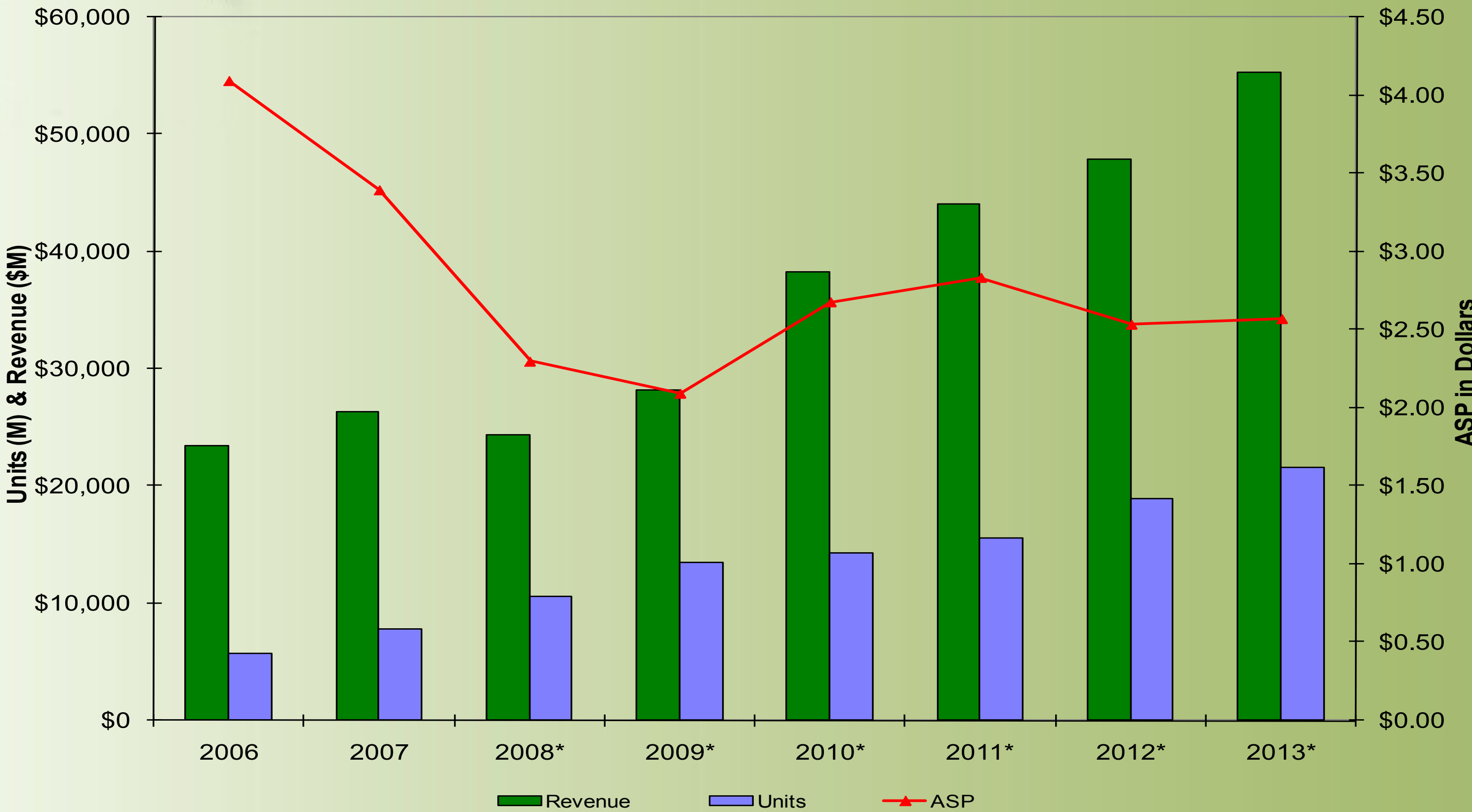
Alan Niebel

- Founder and CEO of Web-Feet Research, February 2000
- Has thirteen years Non Volatile Memory market research experience
- Over twenty five years experience in computers and semiconductor industry

Web-Feet Research, Inc.

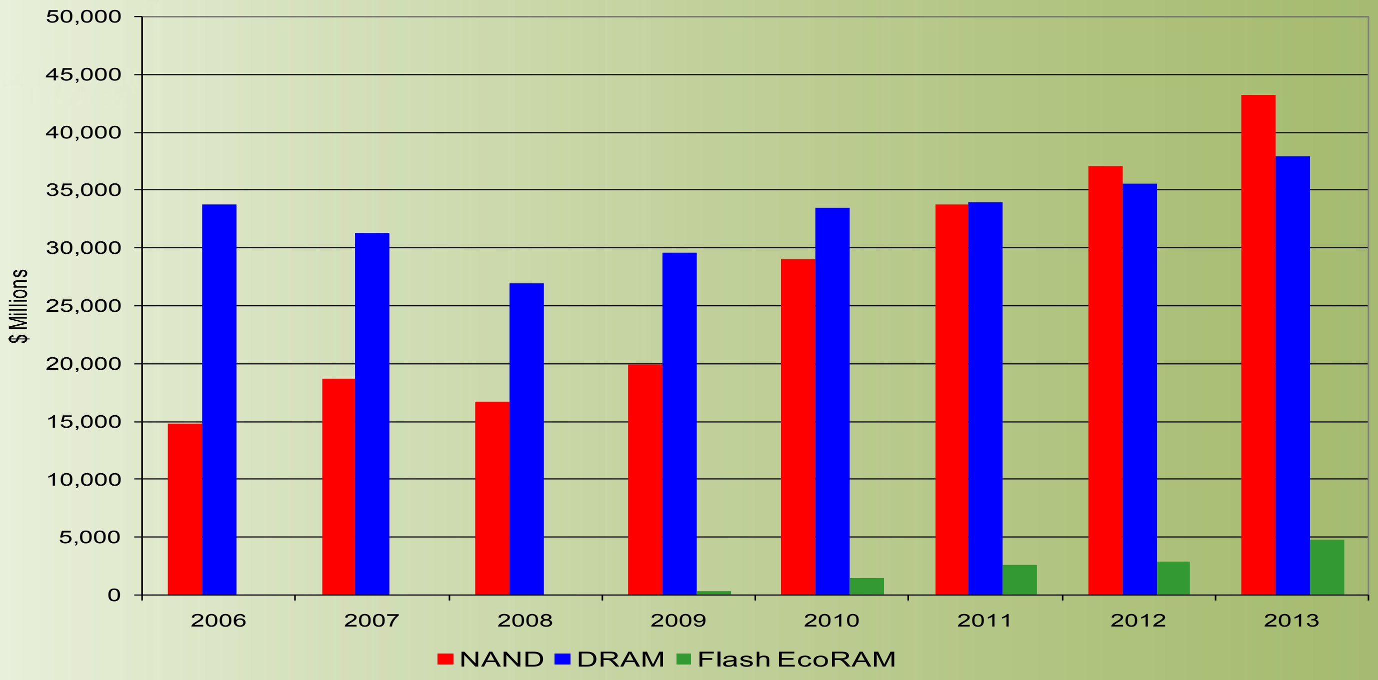
- Focuses exclusively on Memory and Storage Markets
- Market Research for Flash and Non Volatile Memory Markets: Forecasts, Applications, Technology, Market Shares, Business Models
  - *Flash Memory Components: NOR, NAND, NROM*
  - *Flash Cards*
  - *Embedded Flash Drives*
  - *Flash Cache*
  - *Solid State Drives*
  - *Small Form Factor Hard Disk Drives*
  - *Alternative NV Memories*
- Provides full complement of technology and management consulting

Flash Revenue, Units and ASP Forecast



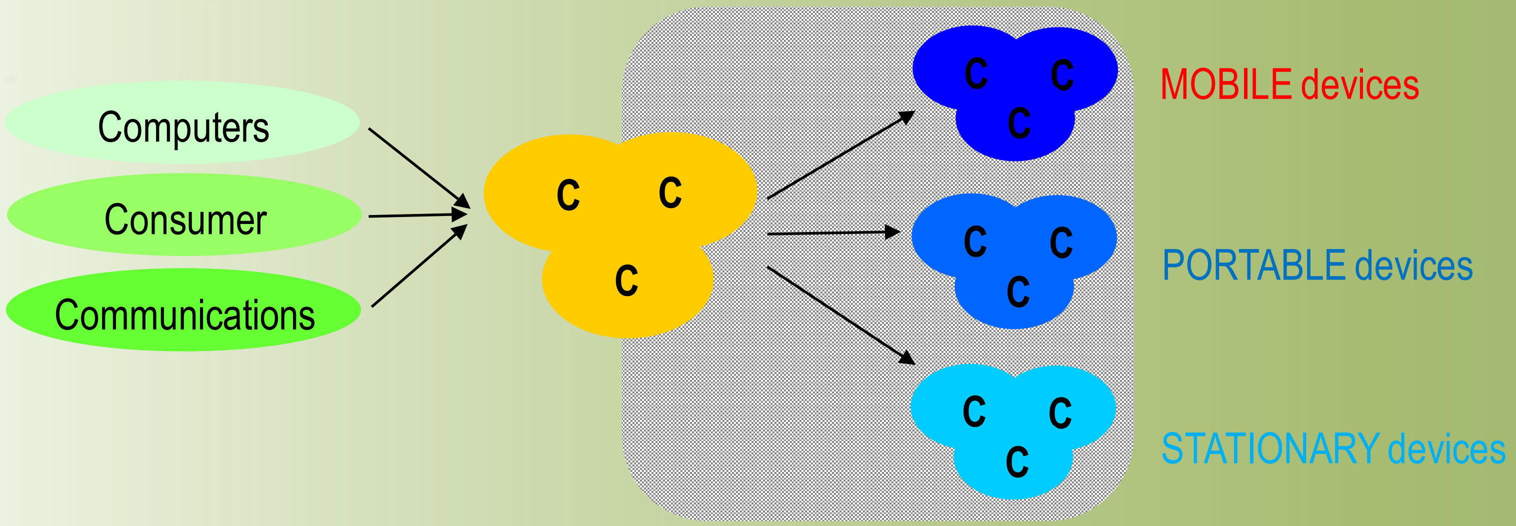
- Revenue demand growing thru 2007, decline in 2008, return to growth thru 2013
- Aggregate ASPs decline in 2005 thru 2008, excess NAND force down prices
- Product mix shifts to higher ratio of high density and high priced parts, raises aggregate ASPs to 2011

Outlook – DRAM vs NAND



- Drivers
  - DRAM: PC refresh Vista, mobile phone
  - NAND: Cards, Media players, USB, Cache, SSD, Mobile phone, TV/Movies
  - Flash EcoRAM: Read Optimized Servers
- NAND Revenue cross over in 2011 due to rise in Flash computing: SSD, Cache
- NAND technology leads industry – capacity, $/bit, process innovation

Market Changes – Device Functionality Evolution

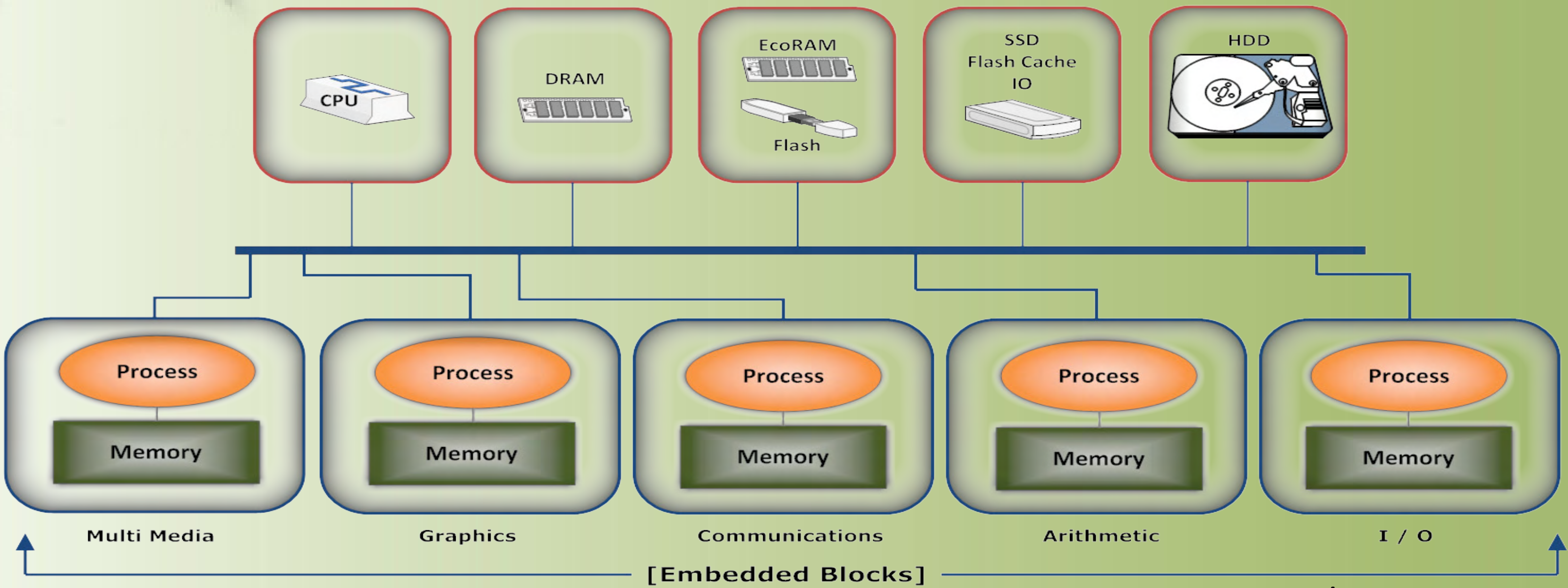


- Transition
  - From: MARKET FUNCTION-based segmentation
  - To: USE-MODEL-based segmentation
  - To: USE-FUNCTION-based converged segmentation

- MOBILITY
  - Drives the INFLECTION POINT for NV memories

- STATIONARY / PORTABILITY
  - Evolutionary, highly predictable
  - Changes in Computing memory subsystems, generates new inflection point

COMPUTING – System Architecture



- Optimal "internet computing" server configuration will combine new memory/storage layers
- Impact on system storage
  - Rethink infrastructure of storage system – move NAND media closer to RAM and processor
  - Rearchitect storage firmware – remove mirroring of data and built-in wait states
  - Innovate Hardware and Software to communicate unimpeded from Flash to RAM to processor
- System memory/storage redesign hierarchy
  - Storage – HDD (capacity), SSD (I/O performance, cache, low power), Flash NAND cache
  - Read Memory - EcoRAM (XIP, 4x DRAM capacity, 1/8 power, minutes reboot)
  - Main Memory – DRAM (write optimized, hi performance, hours reboot)

SSD Definition

Traditional definition of SSDs

- Use semiconductor components to store data
- Have standard HDD form factors
- Utilize standard HDD interfaces
- Considered an HDD replacement.

Updated definition of SSDs expands beyond legacy definition of SSDs

- Inclusive of traditional SSD definition
- Includes form factors appropriate for respective application: Form factor agnostic
- All will utilize open industry standard interfaces and protocols for point-to-point data paths
  - *Interfaces are; Fibre Channel (FC), Serial Attached SCSI (SAS), Ultra 320 Parallel SCSI (U320), Serial ATA (SATA), Parallel ATA (PATA), Consumer Electronics ATA (CE-ATA), Universal Serial Bus (USB) and PCI Express (PCIe).*
- All will be used in the capacity of mass storage or cache.
- Will complement HDD storage in some applications and will be native storage in newer applications

Growth Drivers (2008-2012) – Major Trends

- Real-time demands for business and applications
- Extreme Mobility
  - 24/7, On-the-go lifestyle
- New market segmentation, further deepening new markets
  - Old markets morph into new ones
- Personal value creation mechanisms
  - Focused information ("personal data")
  - Cost savings and empowerment – tailored to individual
- Internet computing
  - Use model opens new markets
  - Virtual reality
  - Social networking
- Branding
- NAND/NROM investment : able to meet demand requirements for 2012 ?
  - Growth rate forecast : 8.0% (08-12CAGR)

Conclusions

- Flash memory market growth
  - Growth pattern
    - Revenue growth fastest in Semiconductor market but subject to DRAM cycles
    - Sustainable Mbit demand/supply at 88% CAGR 08-12
    - Normalized prices drop -37.5% CAGR 08-12, maturing market in 2012+
  - Slow down expected in 2008 -2009 but residual effects outside U.S. unknown
  - New market segmentation - NAND technology enables Internet computing

- Mobility Market
  - Increased demand from multiple markets: Smart/feature phone, PMP, DVC Hybrid
  - Transition into "sustainable growth" phase: DSC, Voice phone, Cards
  - Innovative products:
    - Motion sensing Gaming Player or PED (Personal Entertainment Device) – Wii or we play?
    - iPhone – leads mobile access to internet, new Embedded Flash Drive storage form factor
    - Mobile Television – Will users adopt?

- Portable Market
  - Flash cache and SSD carry NAND growth 2009 beyond – transition to acceptance
  - LCPC with SSD, GPS, Gaming, and Digital Radio emerging markets

- Stationary Market
  - Flash computing key industry driver: SSD, Flash cache/RAM