Enhancing the Visual Experience on the Mobile Computing and Communications Platforms

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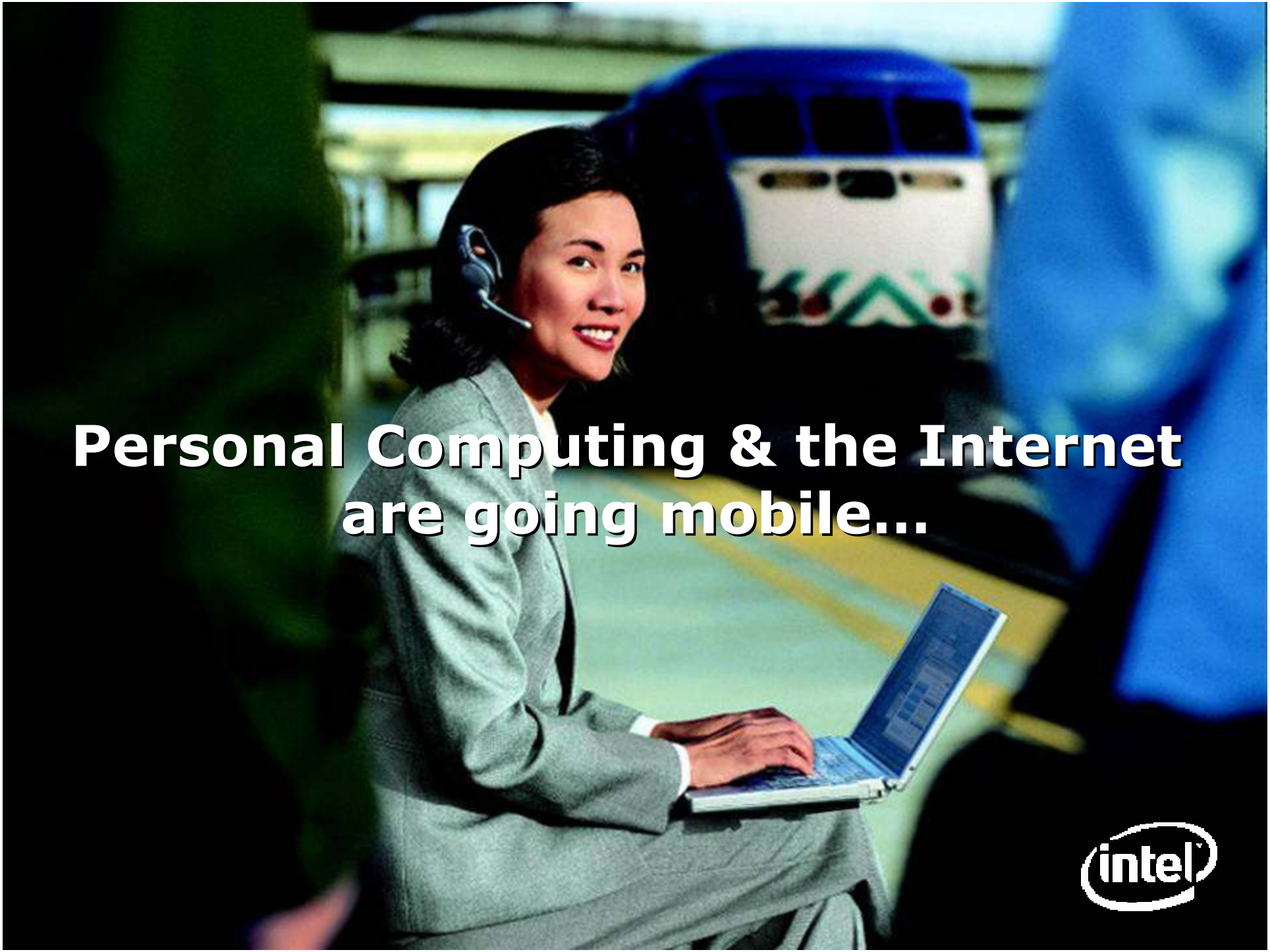
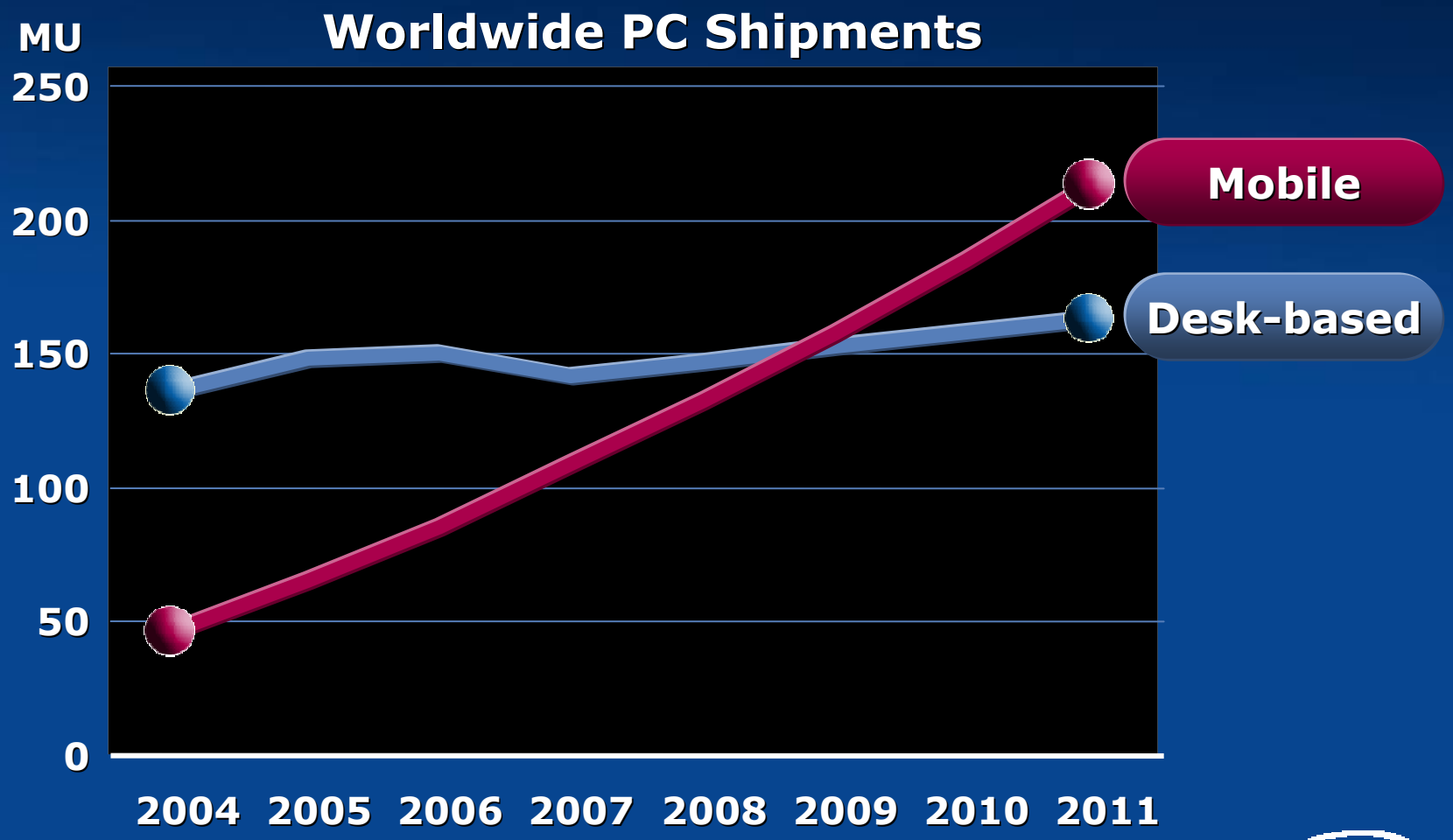
Outline

- Mobile computing: recent trends
- Consumer focus: key requirements
- Video & display technologies for mobile platforms: advances, challenges and opportunities


Personal Computing & the Internet
are going mobile…
intel

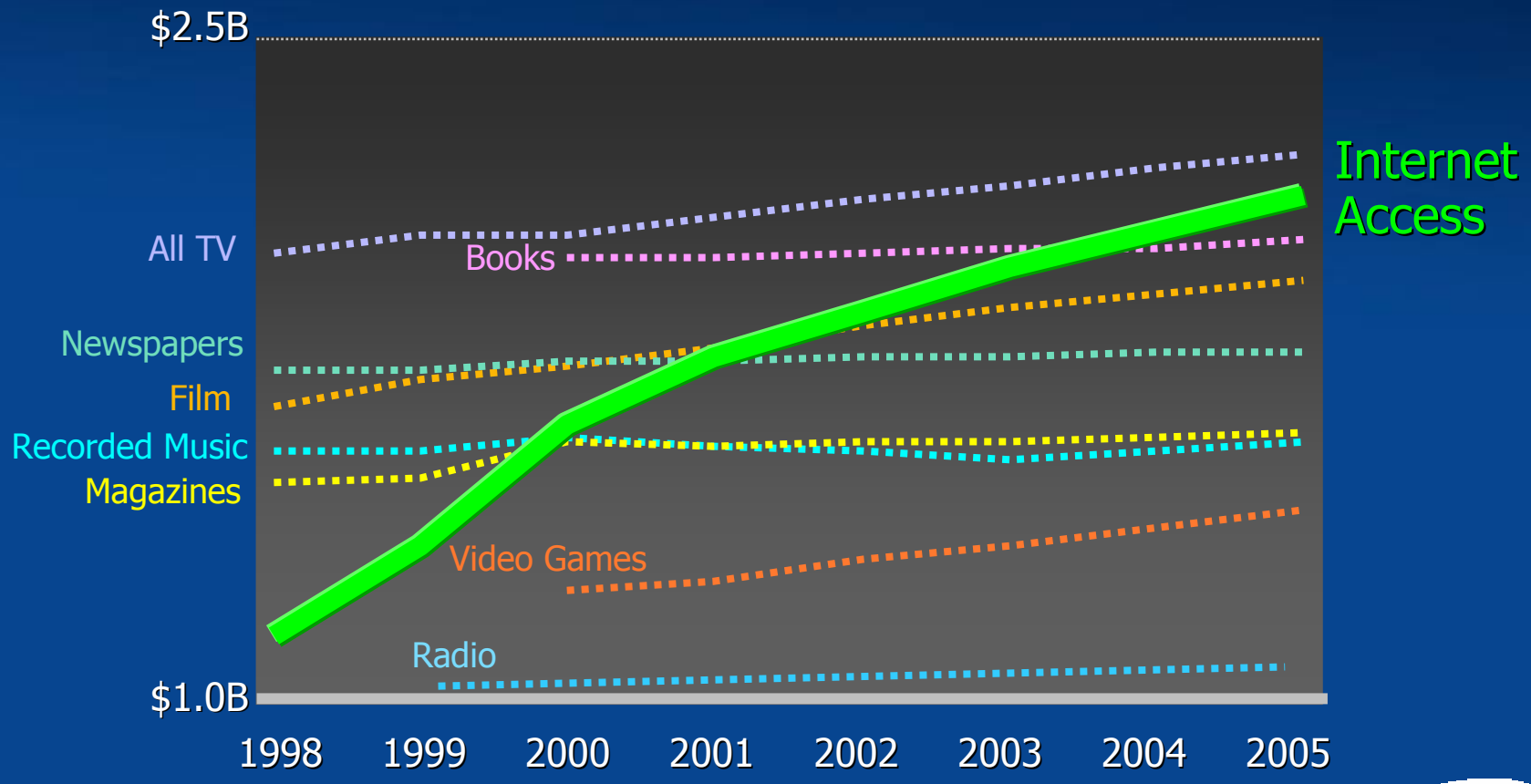
Personal Computing is Going Mobile!



Source: Intel Estimates

Internet to Pass All Other Media

Consumer Spending by Media

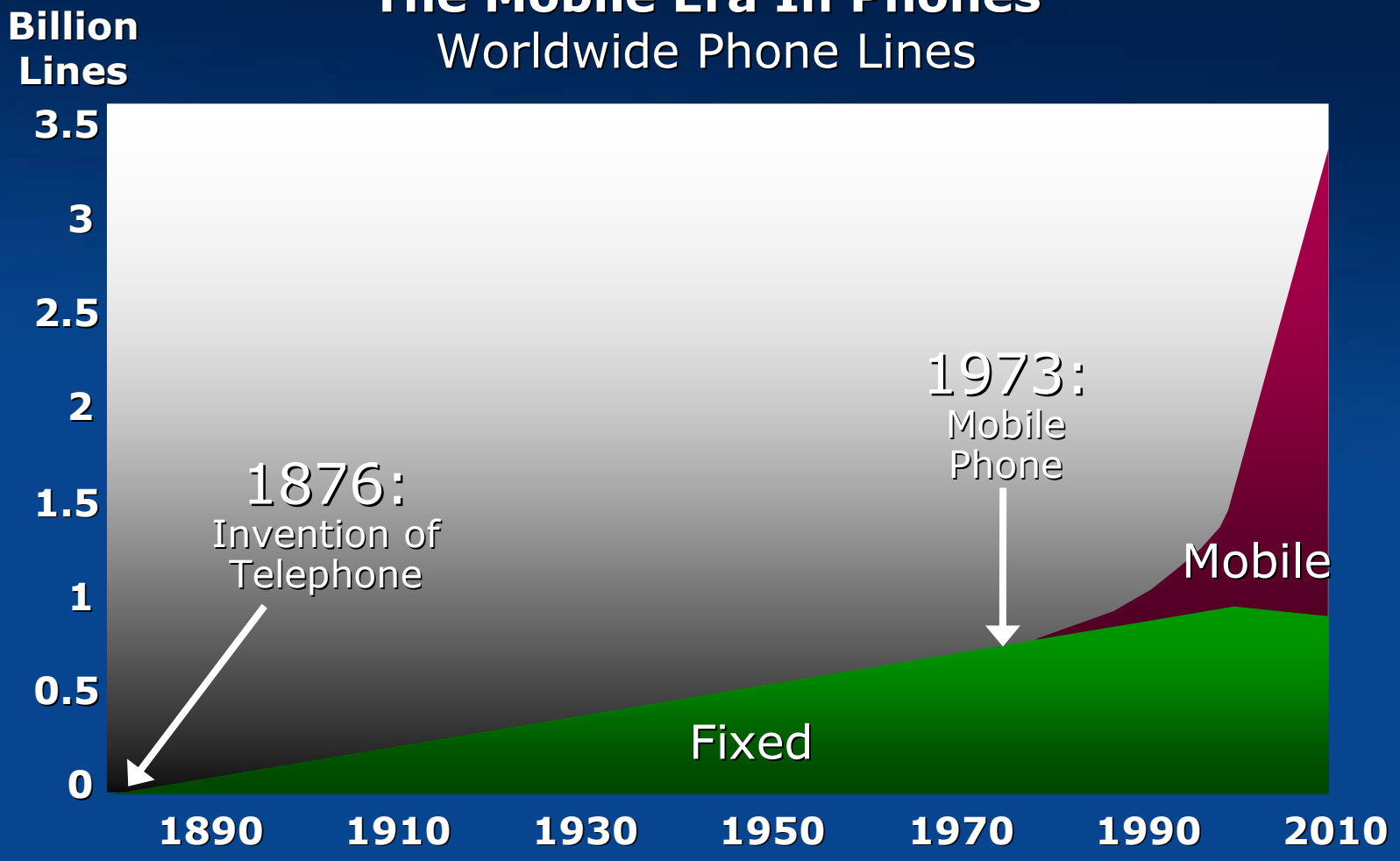


Source: Pricewaterhouse Coopers

Mobility and Growth

The Mobile Era In Phones

Worldwide Phone Lines



Mobility Will Have As Profound Effect On The Internet and Computer As It Did On The Phone!

Source: CTIA, RHK

Intel is Building on a Tradition of Notebook Platforms

Napa
2006

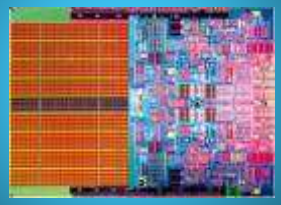
Intel® Core™ Duo Processor

Santa Rosa
2007

Montevina
2008

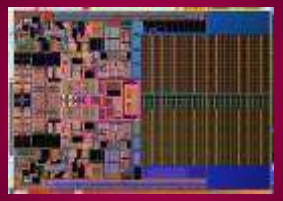
Refresh

Intel® Wireless WiFi Link 4965AGN



Intel® Core™ 2 Duo Processor

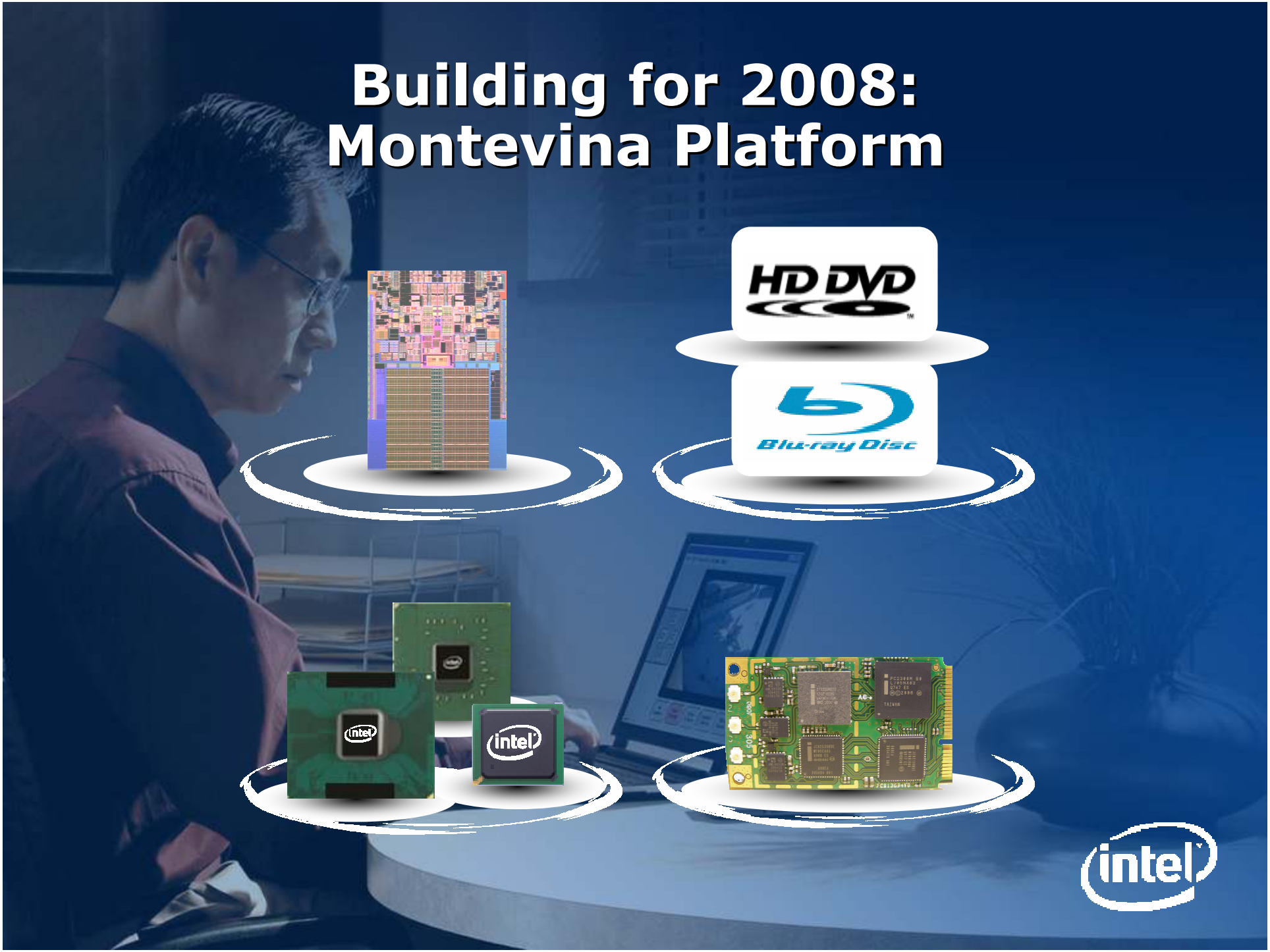
Refresh



Penryn
(with Intel 45nm Hi-k metal gate silicon technology)

Santa Rosa Platform Launched May 2007

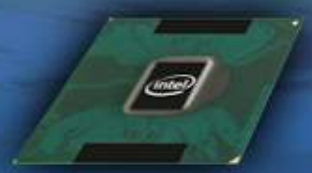
Building for 2008: Montevina Platform



Intel Technology Spans the Mobile Computing Spectrum

MID, UMPC

Notebooks



CPU

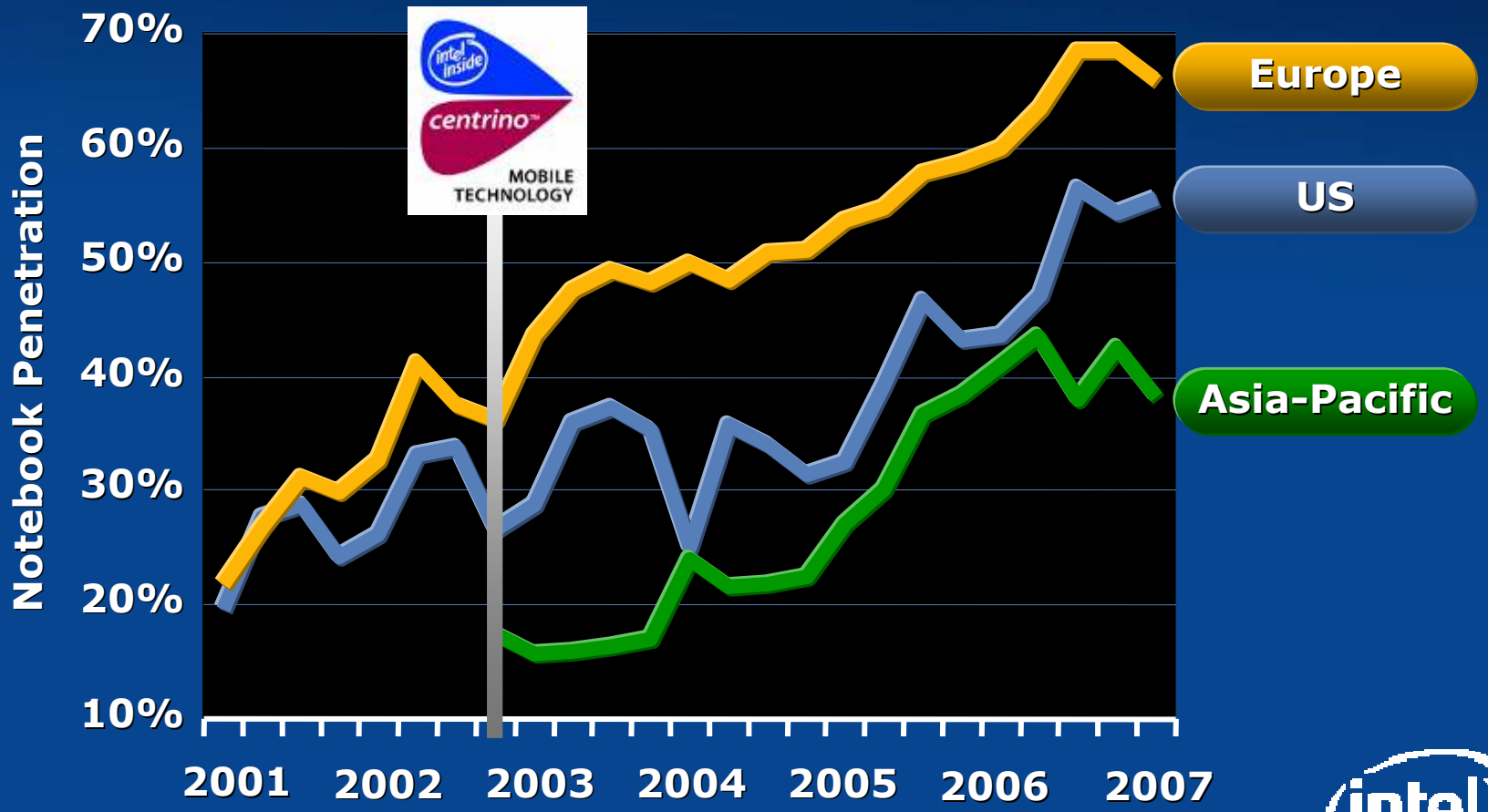
Graphics & Chipset

Wi-Fi / WiMax

intel

Consumers Driving Mobility; Even in Emerging Markets

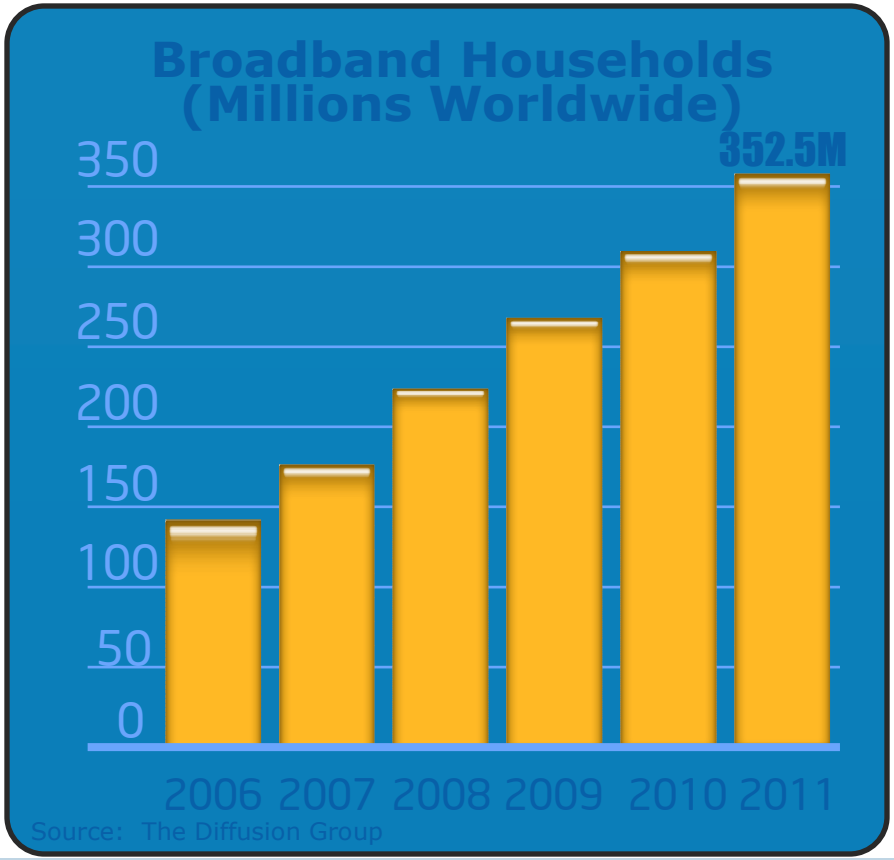
Notebook as % of Consumer PC Market Segment



Source: Intel estimates

Key Consumer Trends

- Web video growing in importance in Mainstream Consumer experience
  - The average consumer watches 151 minutes of video over the Internet a month[1]
  - User-generated content sites (YouTube, etc), TV networks, and movie studios are providing compelling content



Growth in Worldwide Broadband Penetration is Enabling the Video Revolution

1 comScore, March 7, 2007: http://www.comscore.com/press/release.asp?press=1264

Video complexity is on the rise…
"The Fast and the Furious: Tokyo Drift"

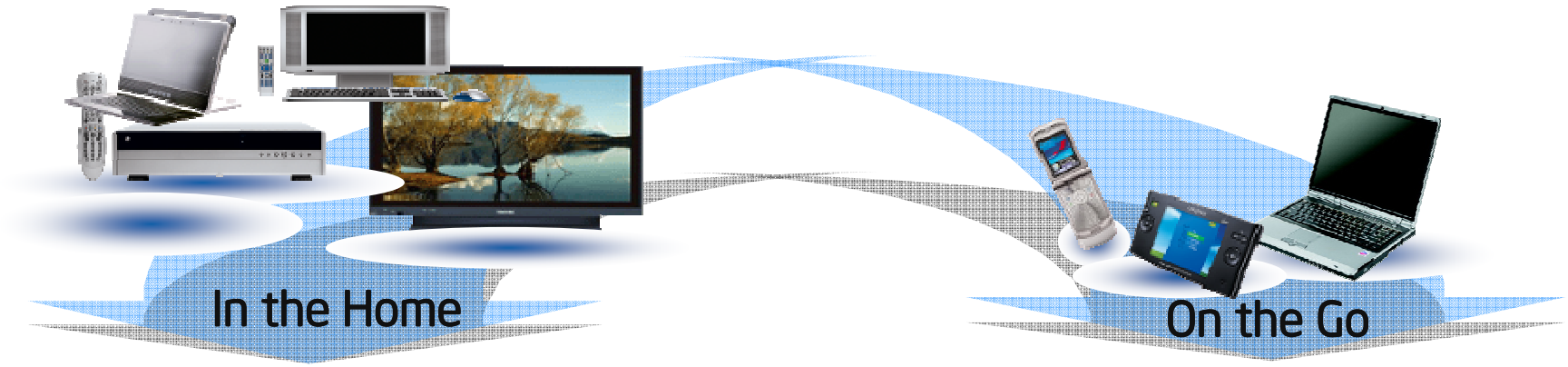
- Courtesy to Andre Espinoza, Universal Studios Home Entertainment, for providing the HD DVD movie image
- HD DVD Logo is a Trademark of DVD Format/Logo Licensing Corporation.

Pervasive Media Usage: Intel Vision

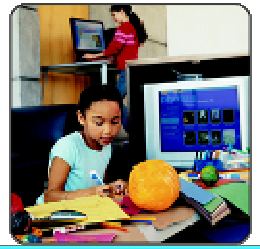
Consumers Enjoying Entertainment

(Movies, Music, Photos, Games)

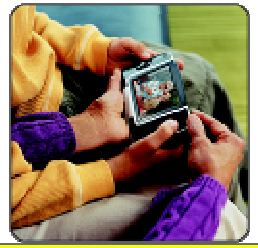
Anytime… on Any Device



Enjoy Media & Games

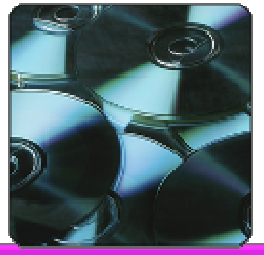


Stream Content to Connected Devices



Synch Content to Media Players

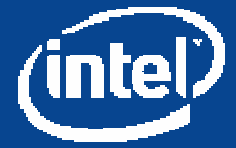
Take Media with You



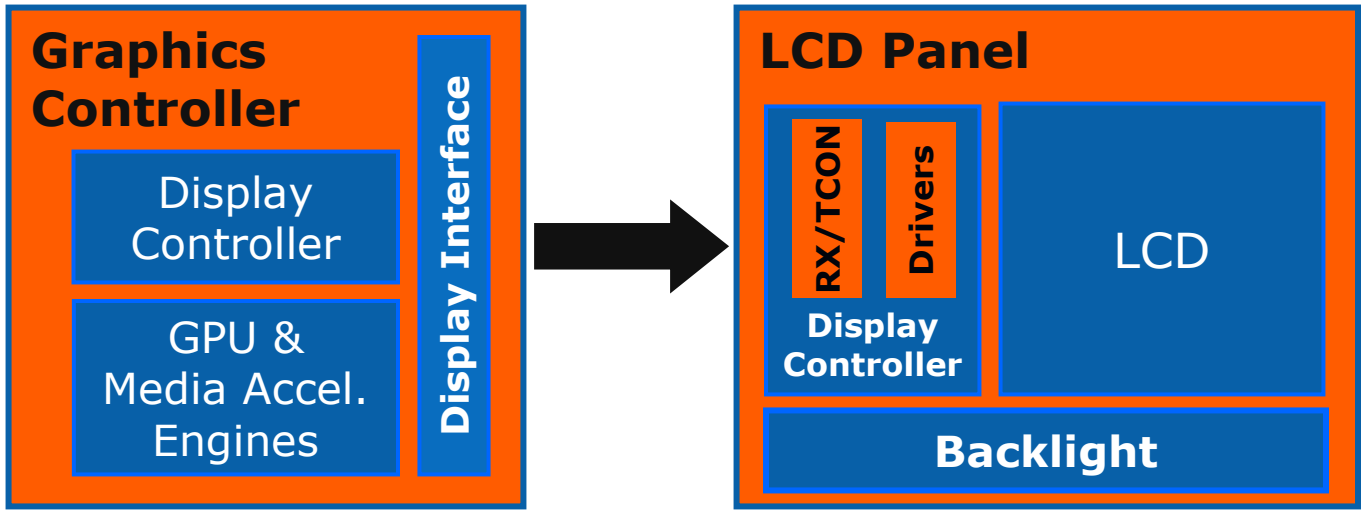
Burn-N-Go

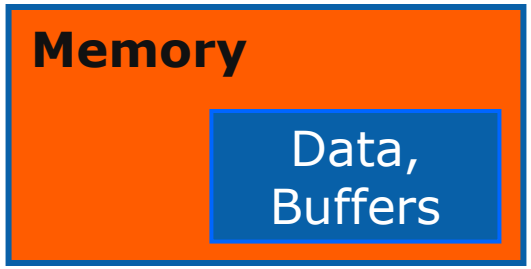
Key Requirements for the Video & Display Subsystem

- Low-power to enable long battery life
- "CE-like" visual experience
  - High-quality video decode and post-processing architecture and algorithms
  - Display with high brightness, high contrast & color gamut, fast response time & blur-free motion performance
- Display with form-factor and attributes for mobile usages
  - Thin & light
  - Viewable in both dark and bright ambient
  - Wide viewing angle
- New consumer usages (e.g. low-power high-quality faster-than-real-time encoding/transcoding, etc.)



Notebook Video & Display Subsystem:
Platform View





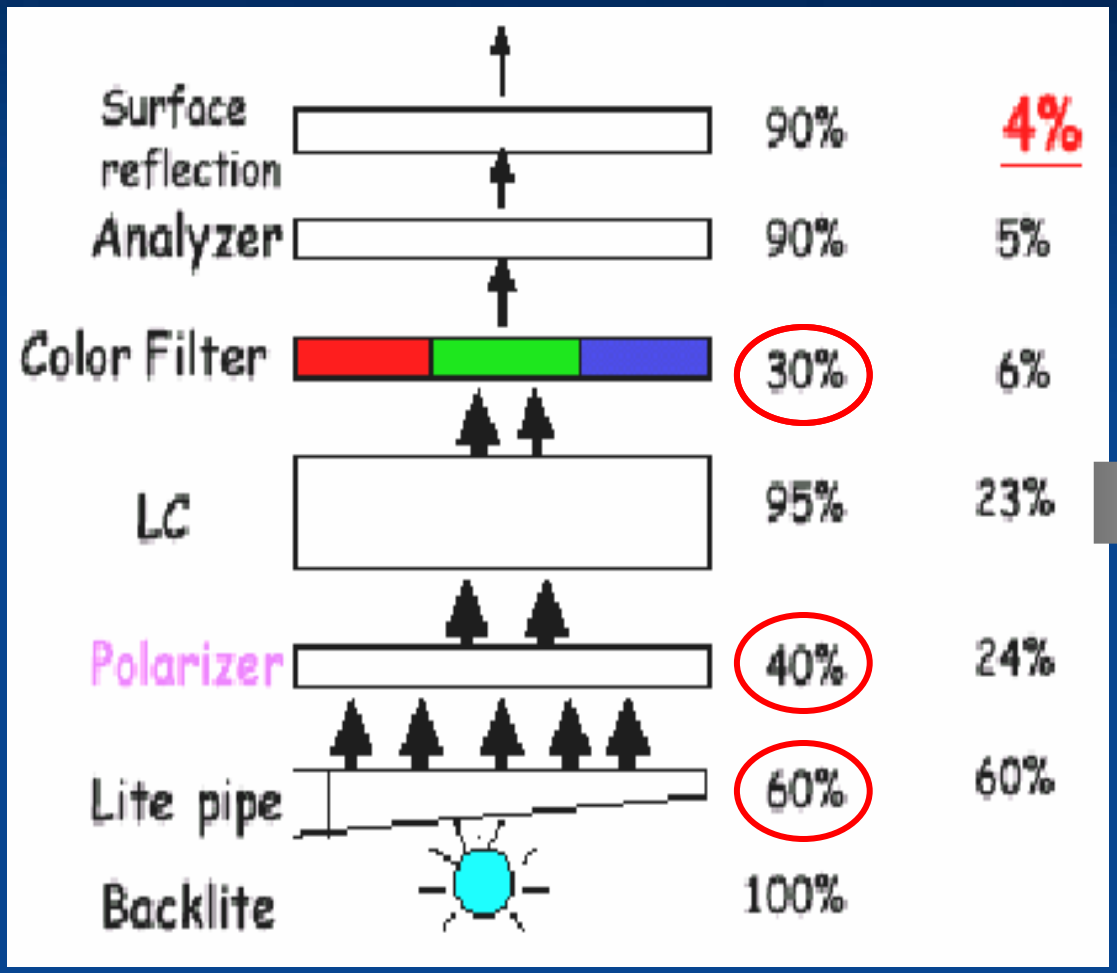
- Major elements
  - Video & Display processor in Graphics Controller
  - LCD module: LCD panel, drive electronics, backlight
  - Display interface

Opportunity for system-level optimization…

LCD as the Mobile Computer Display

First, The Good: LCD Made "Mobility" Possible

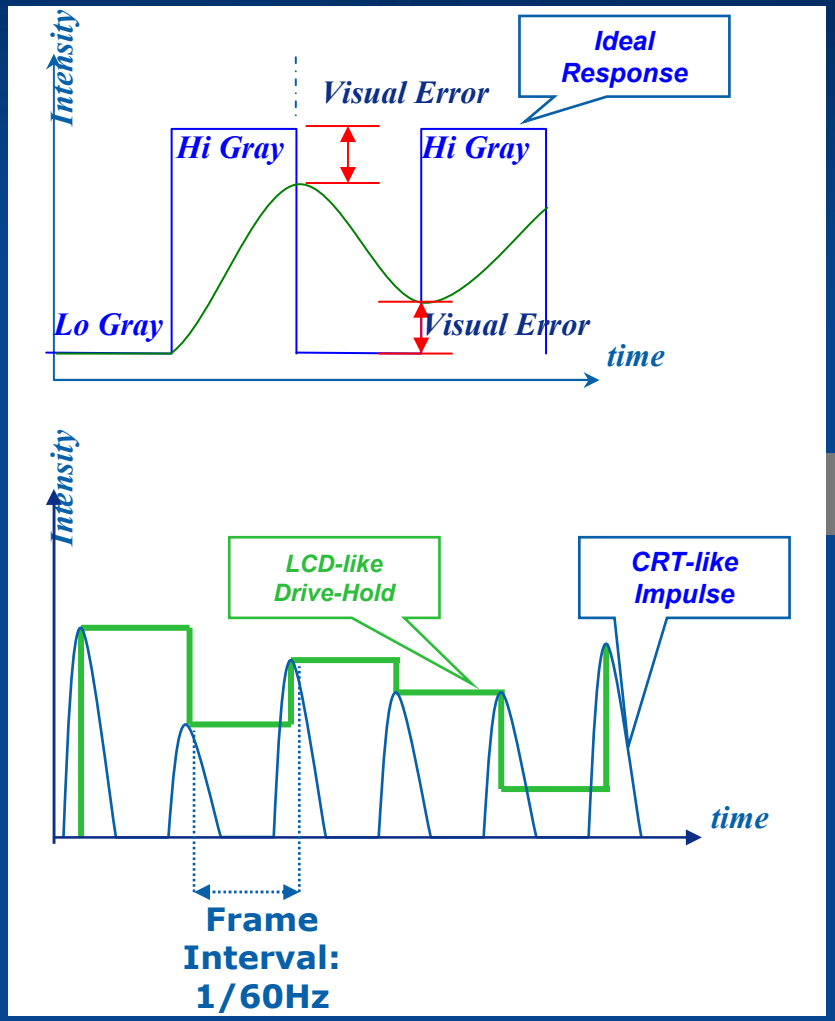
Issues with LCD:
1. LCD optical stack has very poor efficiency



Consumes almost half of platform average power at full brightness

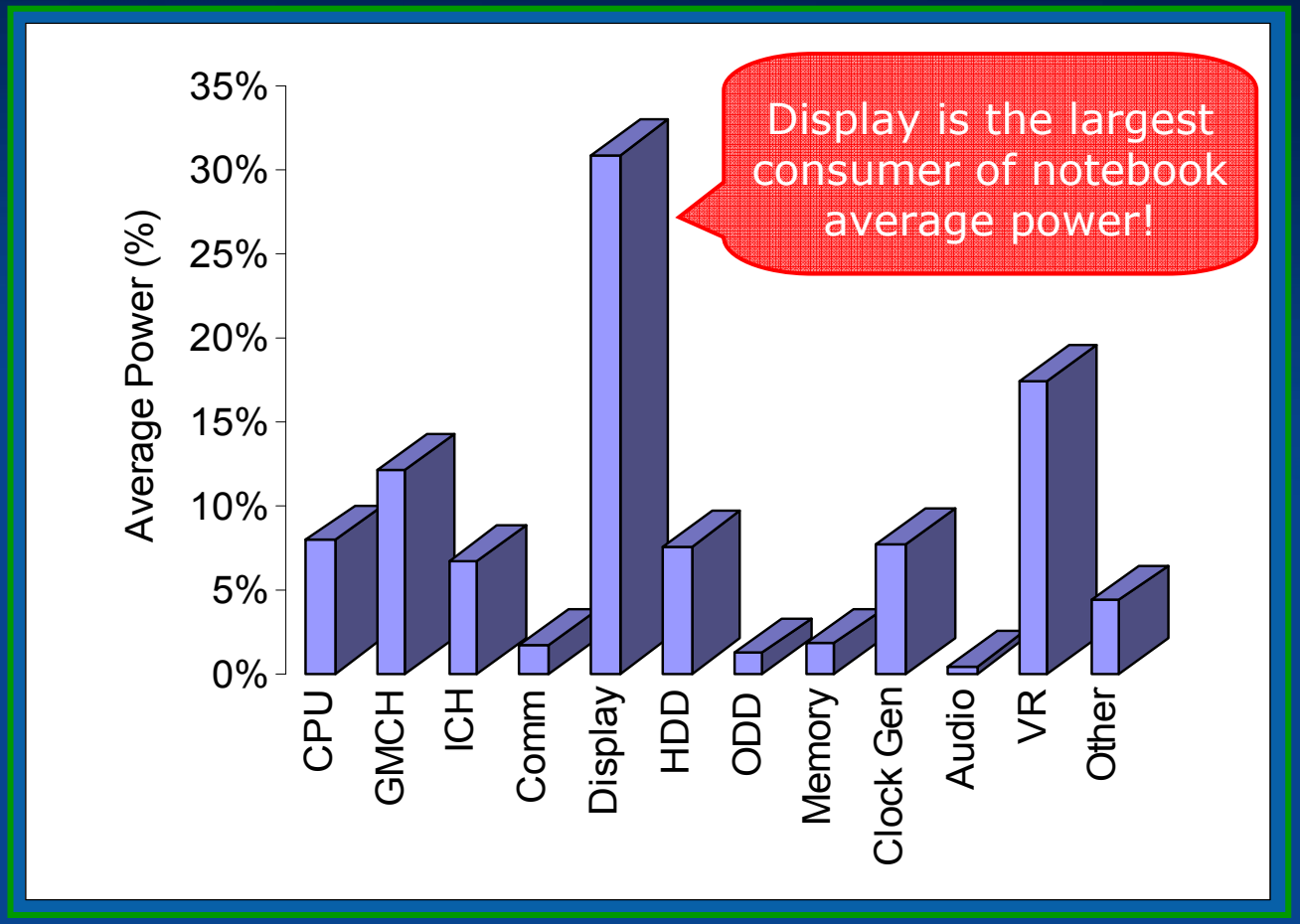
intel

2. LCD exhibits severe motion blur due to
a. Slow LC response time
b. Sample-and-Hold characteristics



Blurred Video

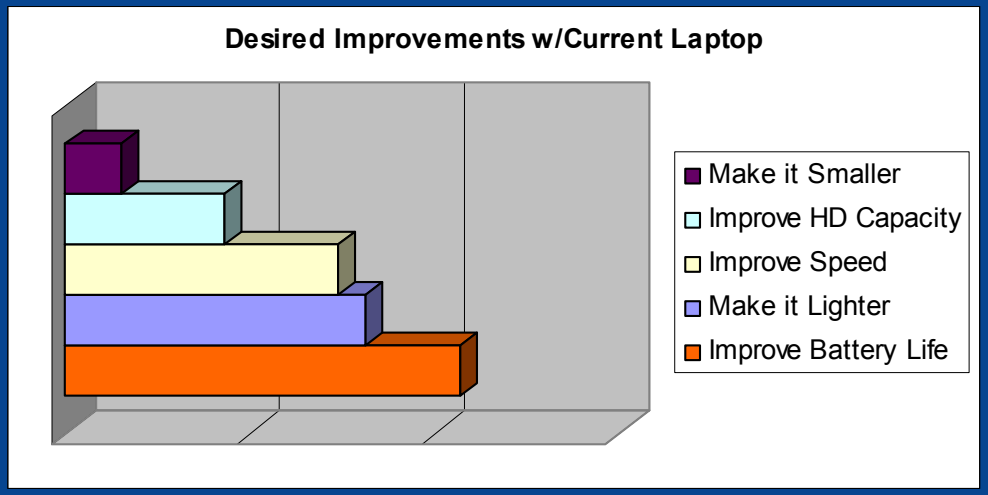
Mobility's Nemesis: Battery Life



BAPCo* MobileMark* 2005 Workload Average Power
System: Thin & Light segment Notebook, 2.26 GHz Intel® Centrino® processor technology, Intel® 915GM chipset, 14.1" XGA display, 60 GB Hard Disk, 512 MB DDRII-533 memory, CD/DVD Drive, Microsoft* Windows* XP SP2 Operating System
Note: The subsystem percentages noted in the chart are representative figures; they may vary from platform to platform.

Strong Market Demand for Battery Life#

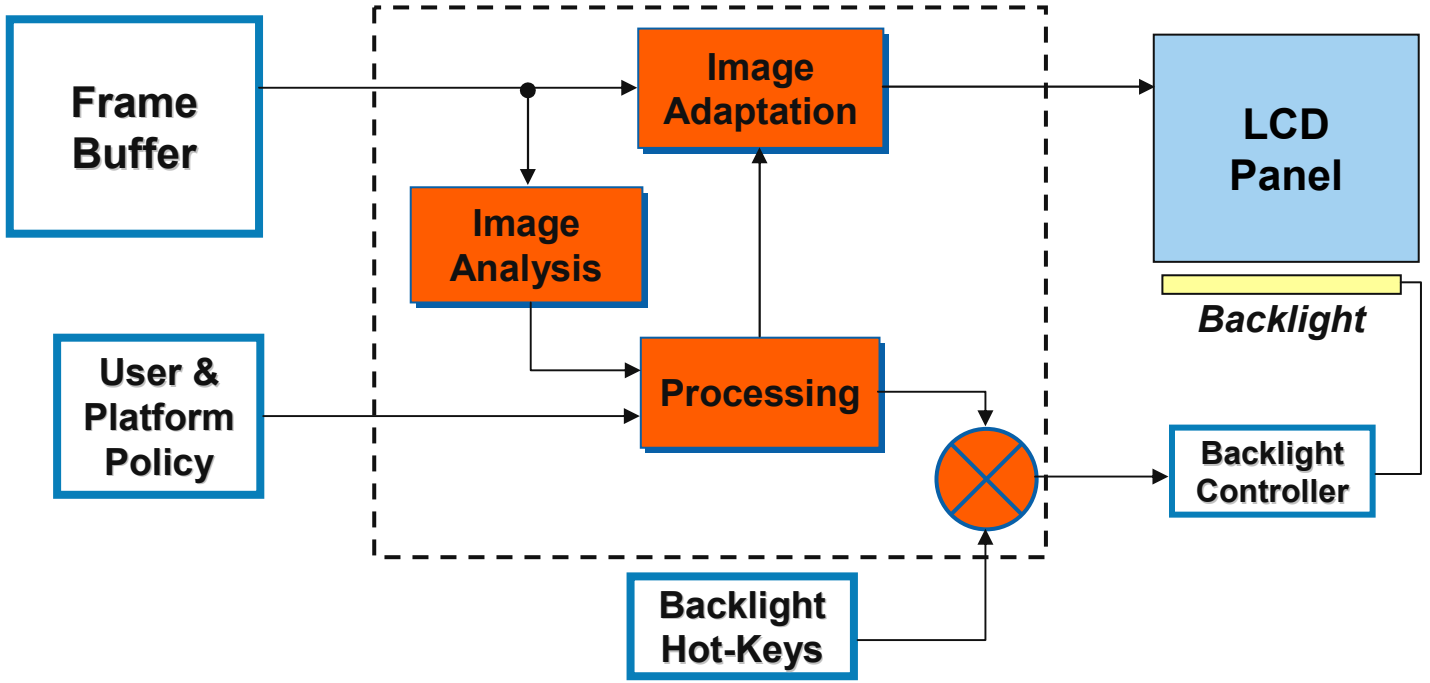
- User research study to better understand laptop purchase process, usage and satisfaction
- New buyers: Top three factors in laptop purchases
  - #1: High Performance or Speed
  - #2: Long battery life
  - #3: Wireless Capability
- Existing users: Desired improvements with current laptop
  - Battery life ranked #1



Long battery life: a high priority end-user requirement

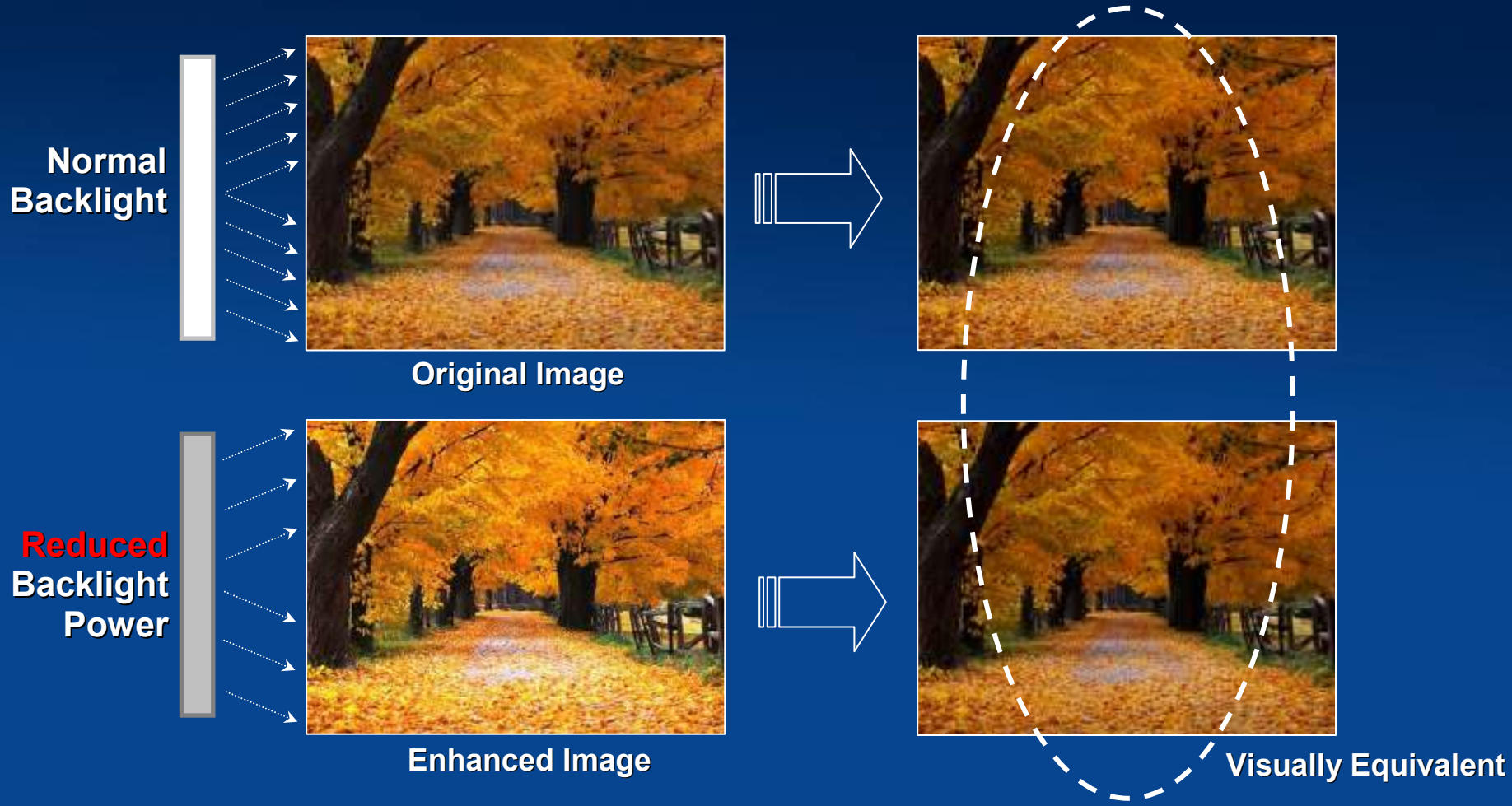
#Intel research Dec 2005, US, Japan, Europe, China

System-Level Display Optimization for Mobile Platforms



	Traditional Approach	Intel® Centrino® Platforms
LCD Backlighting	Static settings independent of content and ambient lighting	Dynamic backlight level and image adjustment
LCD Driving	Refresh rate change associated with glitch on display	Dynamic and seamless refresh rate management

Intel® Display Power Saving Technology (DPST)

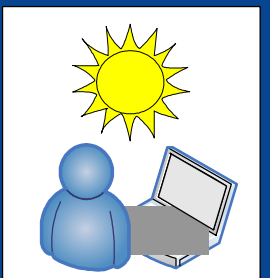


- DPST digitally enhances the graphics and video images prior to transmission to display, simultaneously adjusts the backlight
- ~25% backlight power saved: >1W at full panel brightness
- Most major OEMs have adopted DPST on laptops

Intel® Automatic Display Brightness

- Ambient Light Sensor detects ambient light conditions
- Automatic Display Brightness feature uses this information to adjust backlight brightness as appropriate for current environment
  - In a dark environment, decreases backlight brightness to account for increased sensitivity of human eye as pupil dilates
  - In a bright environment, increases backlight to adjust for decreased human eye sensitivity

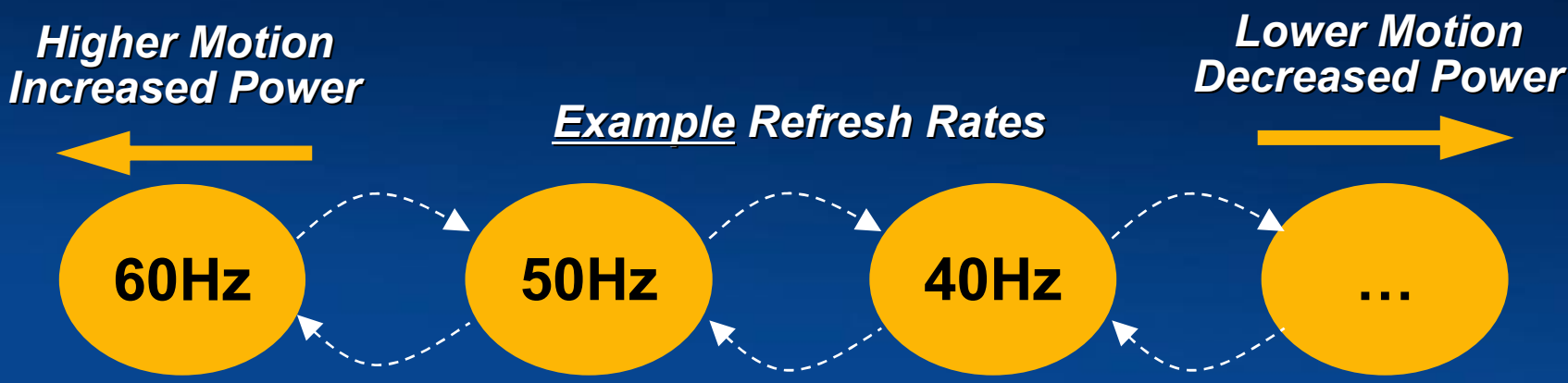
Dimmer display in dimly-lit environments



Brighter display in brightly-lit environments

Usability benefit, and in some environments, power savings benefits

Intel® Display Refresh Rate Switching



Power conservation by dynamically switching between multiple display refresh rates depending on content and power policy

Reduced power consumption in panel electronics, display controller, display link, and memory

Dynamic Display Power Optimization* using Multi-Field Drive Technology

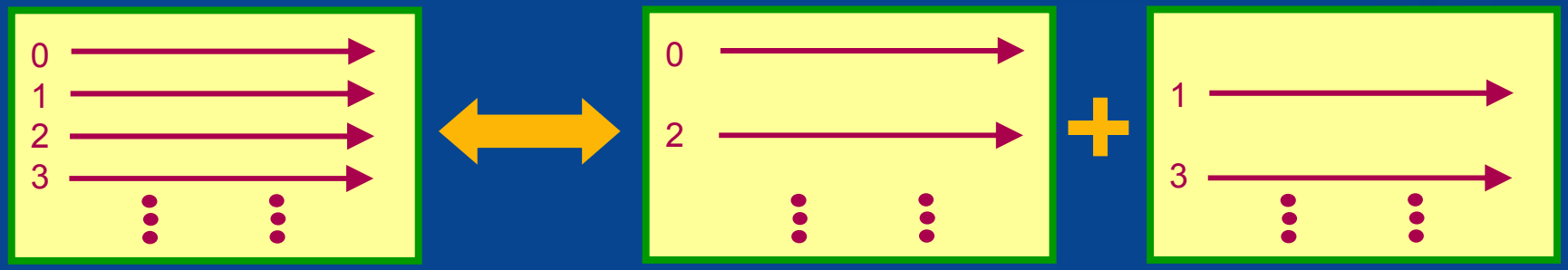
High motion content

60Hz Progressive

Static / low-motion content

60Hz Interlace

Dynamic seamless switching based on motion detection



Progressive: n^{th} "frame"
60 "frames" per second

Interlace: n^{th} "field"

$(n+1)^{th}$ "field"

60 "fields" per second

Reduced power consumption in panel electronics, display controller, display link, and memory

* Jointly developed by Intel and Toshiba Matsushita Display Technology Co., Ltd.

LED is Emerging as LCD Backlight

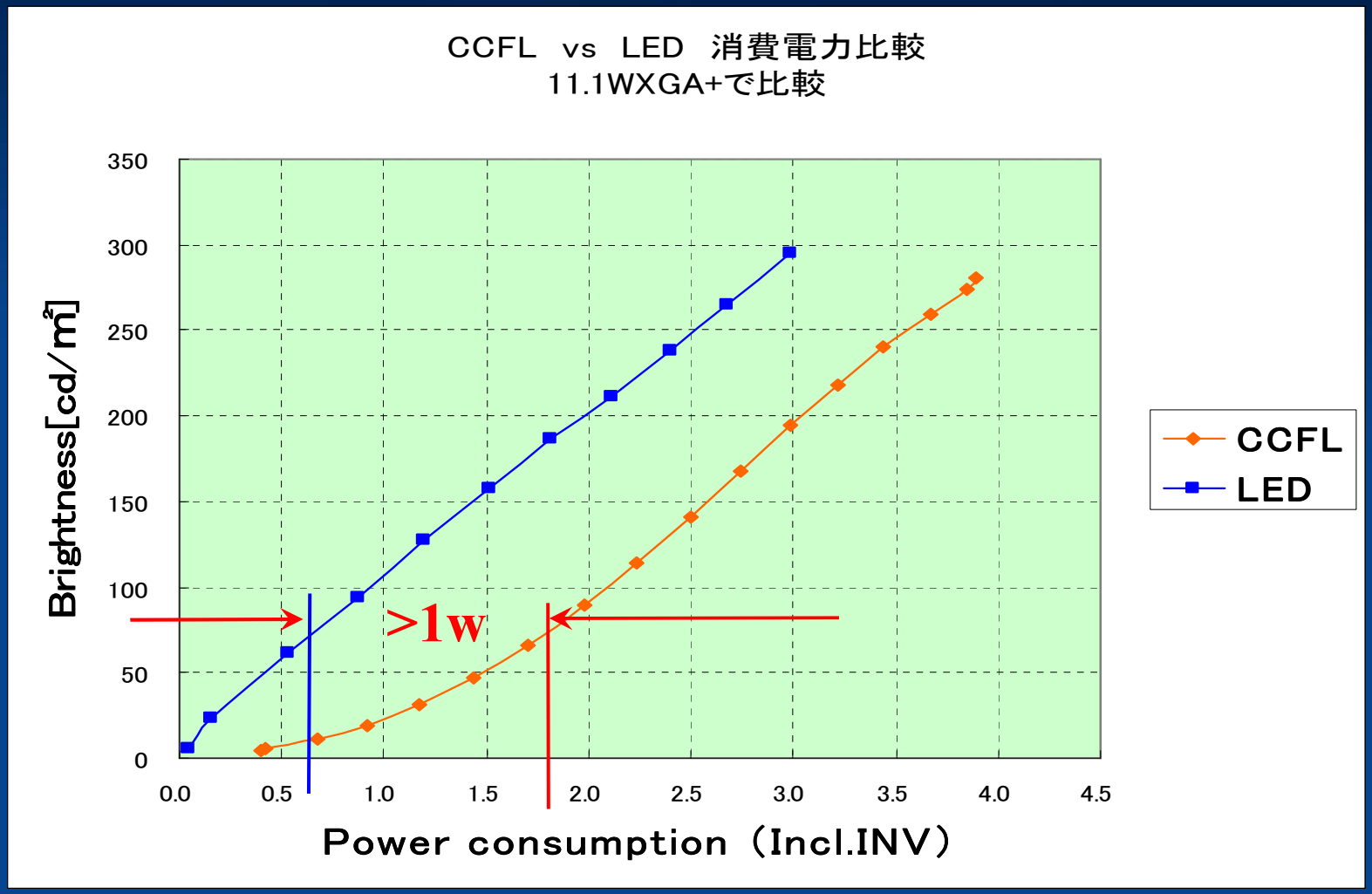
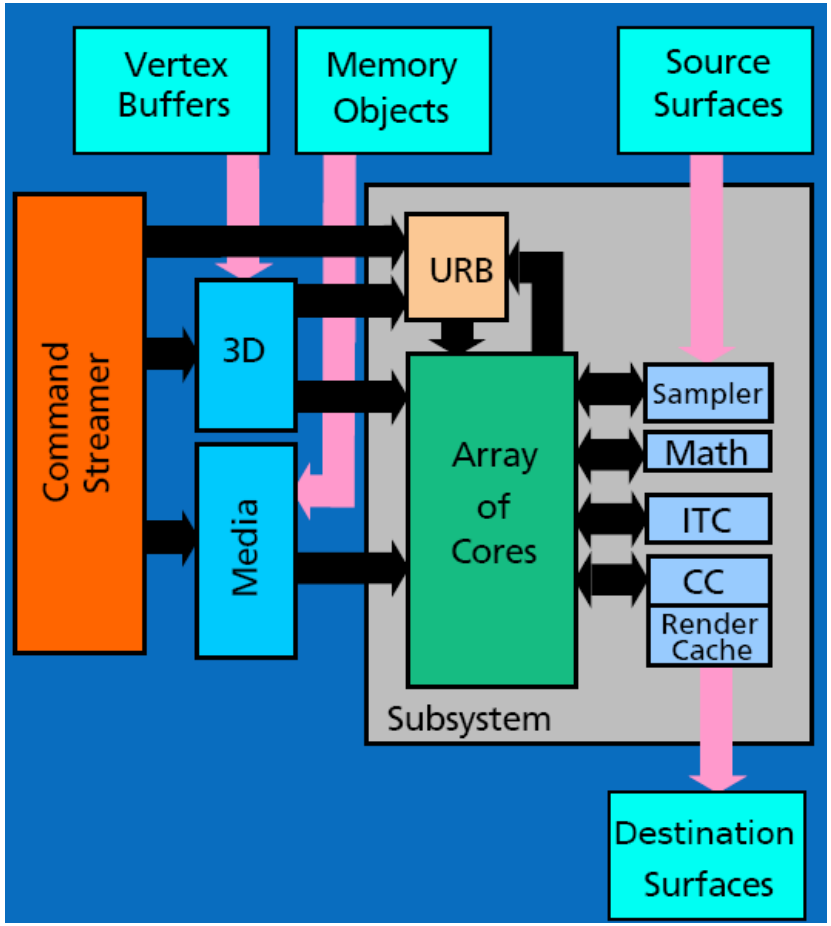


Chart and data from Toshiba Matsushita Display Technology Company Ltd.

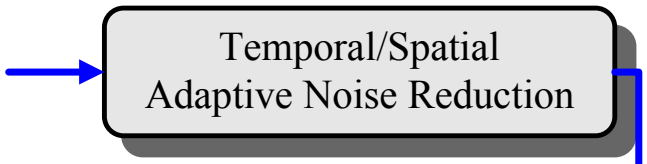
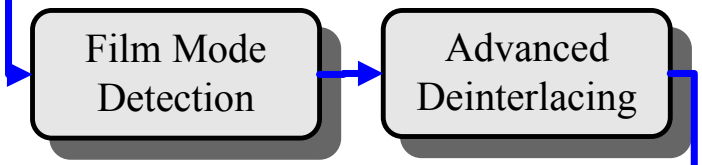
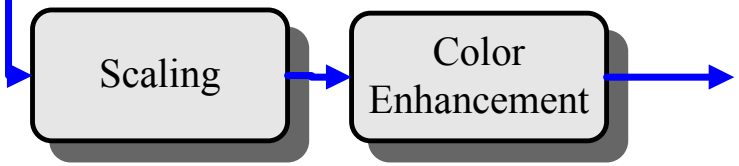
Intel® Graphics Media Accelerator

- Array of Cores
  - Multi core
  - Multi-thread per core
  - Advanced SIMD ISA
- Fixed Functions
  - Sampler: texture engine
  - Math: transcendental
  - ITC: Inter thread communication
  - CC: Color Calculator
  - 3D: 3D fixed function pipe
  - Media: Media fixed function pipe



Advanced graphics media architecture balancing programmable and fixed function acceleration

Processing Pipeline in Intel® Clear Video Technology

Video Processing Pipeline	Description
	• Remove video sensor, analog and digital noise
	• Convert Interlaced video to Progressive Scan video. • Includes 24 to 30 frame rate conversion and Film mode detection.
	• Sharpness and detail enhancement
	• Change size to match display size/type • Enhance picture contrast and color

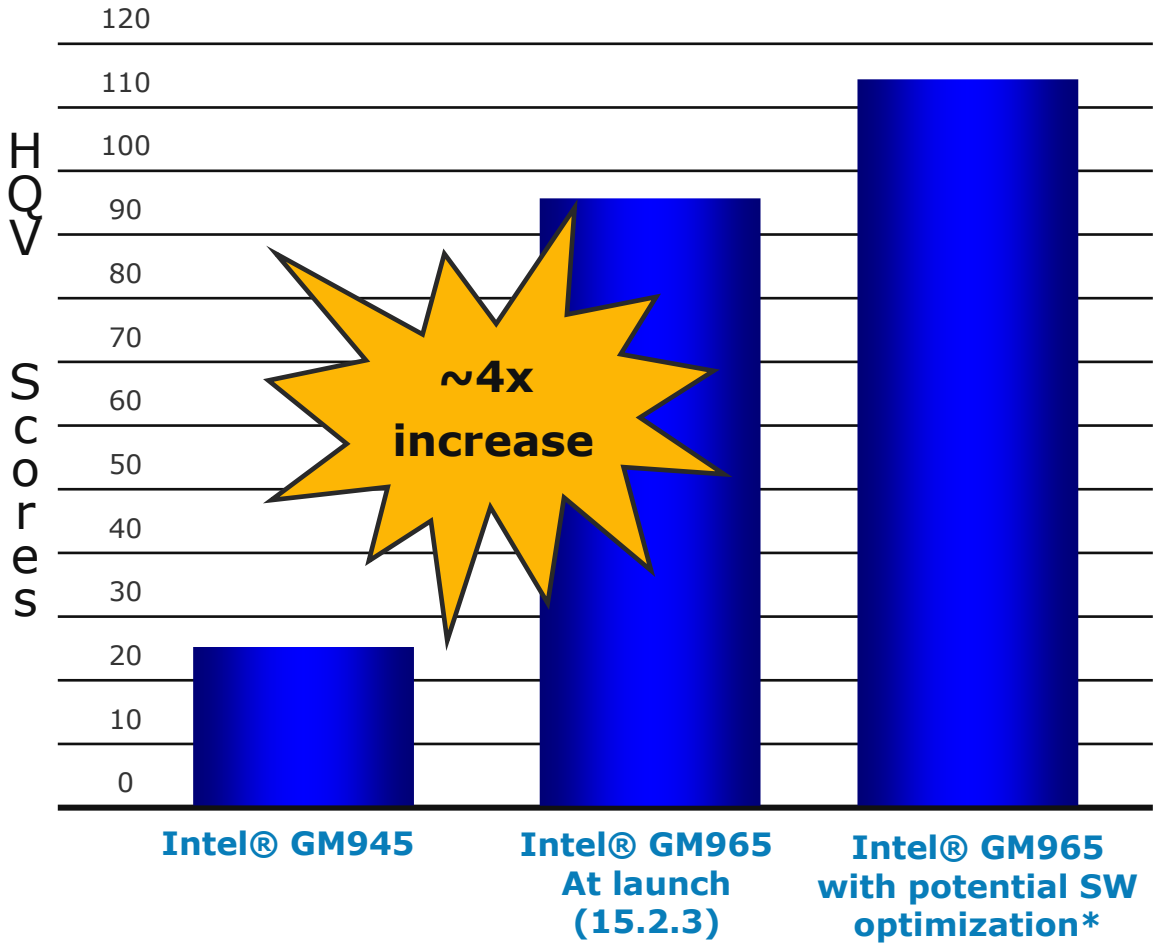
Hollywood Quality Video (HQV*)

What is it?

- **Current "De Facto" benchmark intended to evaluate video quality in the consumer electronics industry**
  - Created and published by Silicon Optix*
- **Subjectively scored**
  - Each test contains brief visual descriptions of potential video artifacts and scoring guidelines for the resulting image
- **10 different test patterns designed to test variety of scenarios**
  - De-interlacing
  - Detail Enhancement
  - Noise reduction
  - Film cadence detection

* Image copyright of Silicon Optix

Improving Video Quality



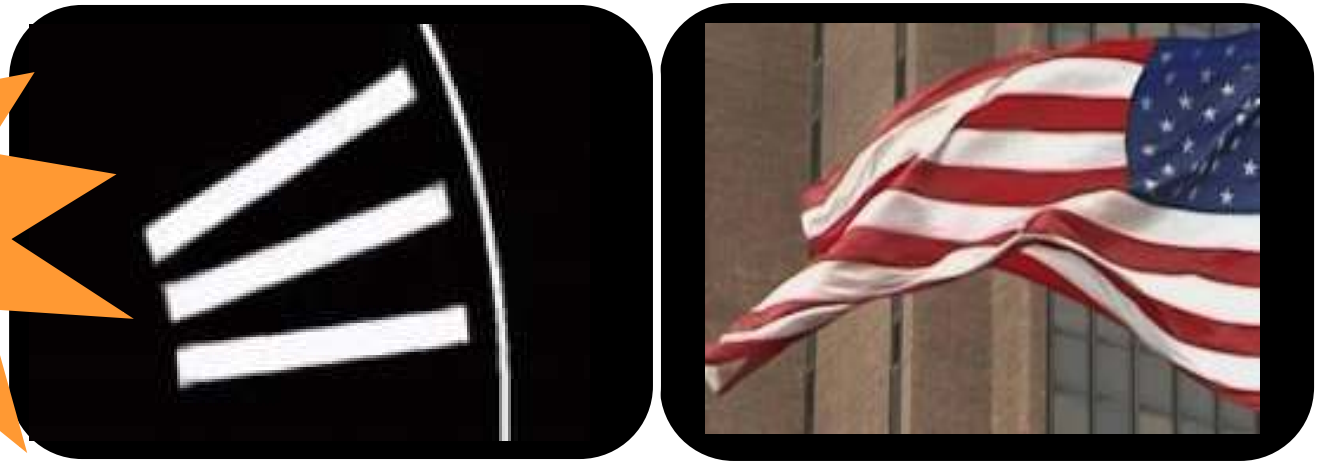
- Significant video quality enhancement from last generation chipsets
- Performance scalability provided through flexible graphics architecture

* Please see demos in the Mobility Zone

Advanced De-interlacing

Intel® GM945 without Intel® Clear Video Technology

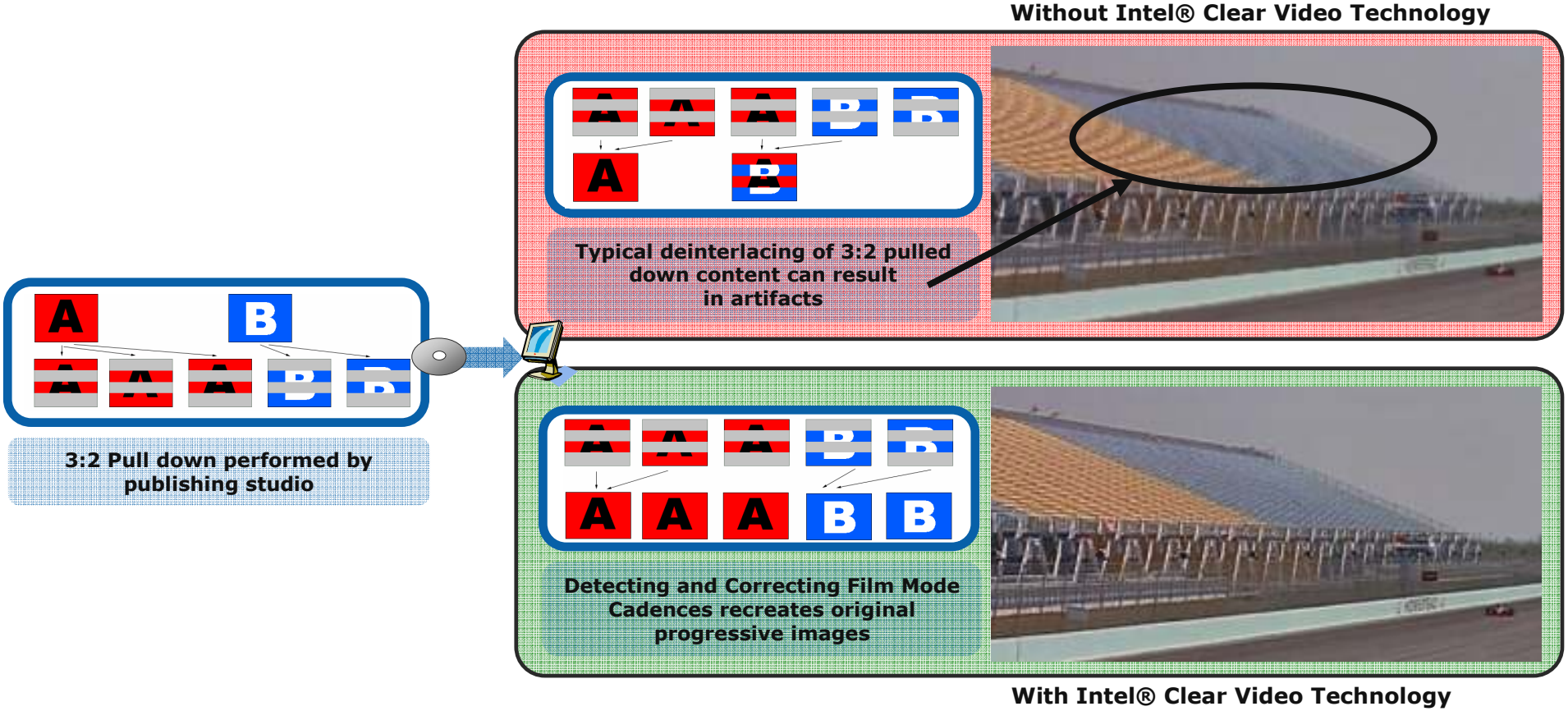
Intel® GM965 with Intel® Clear Video Technology



* Images obtained from Silicon Optix HQV benchmark

Film-Mode Detection & Reconstruction

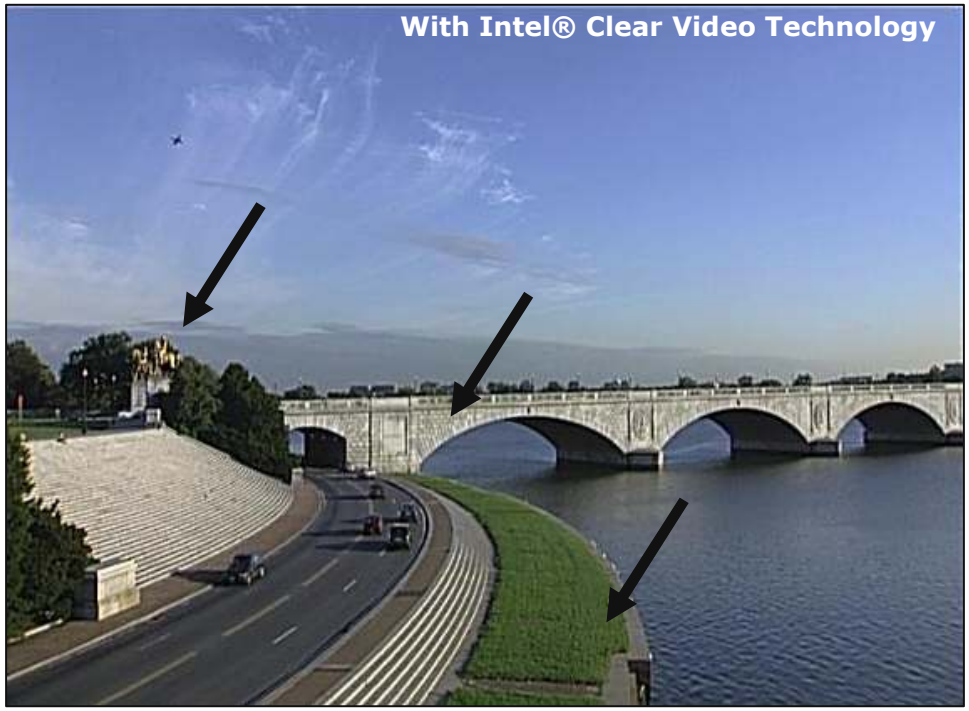
- Detects when progressive "film-mode" content is encoded as interlaced
- Intelligently combines fields to recreate original progressive frames
- Support for large number of cadences:
  - 3:2, 2:2, 2:2:2:4, 2:3:3:2, 3:2:3:2:2, 5:5, 6:4, 8:7



* Images obtained from Silicon Optix HQV benchmark

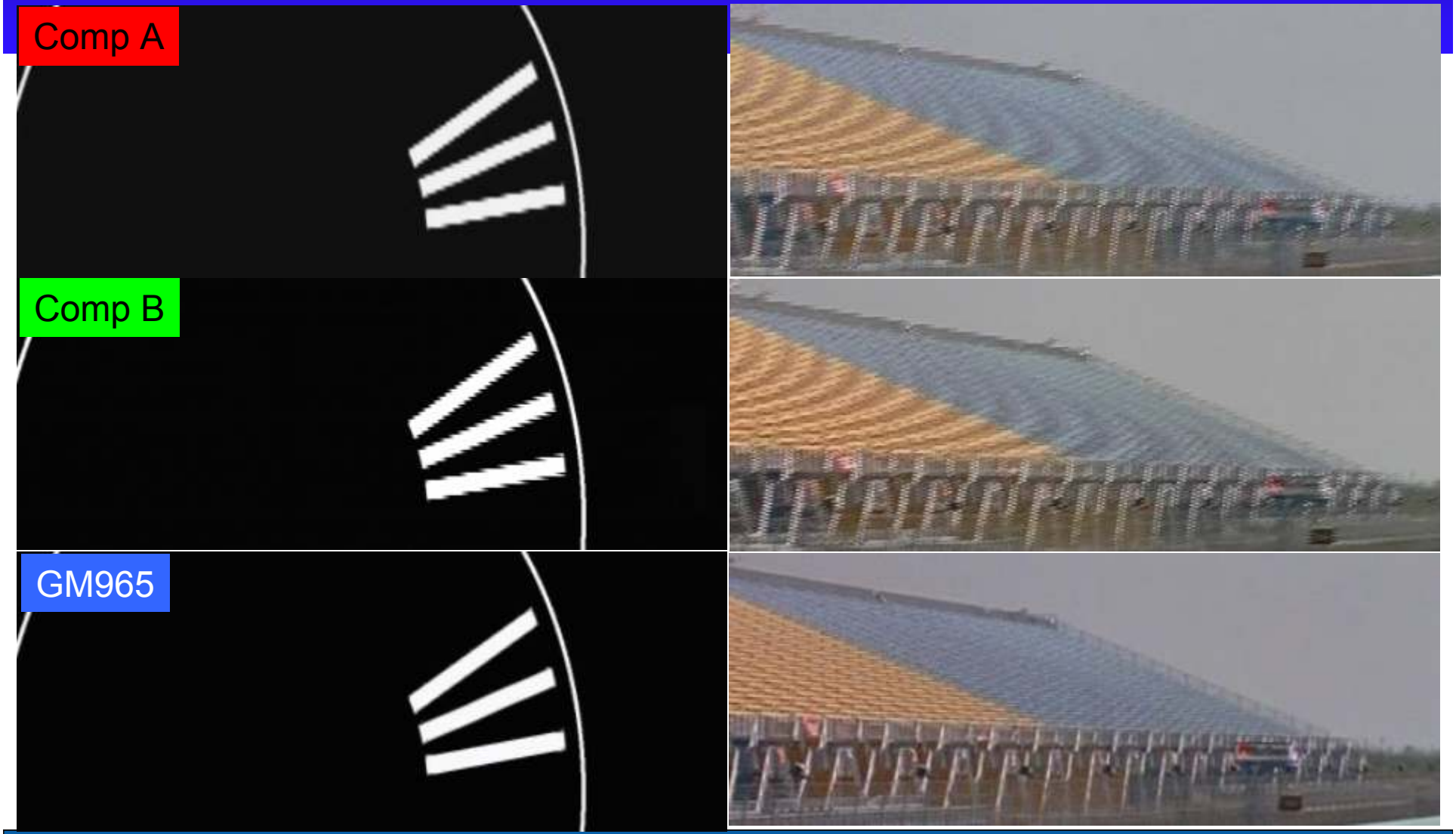
Detail Enhancement

- Detects and sharpens edges of image increasing visibility of scene detail
- Reduces perceived image softness
- Adaptive technology to sharpen image w/o emphasize noise



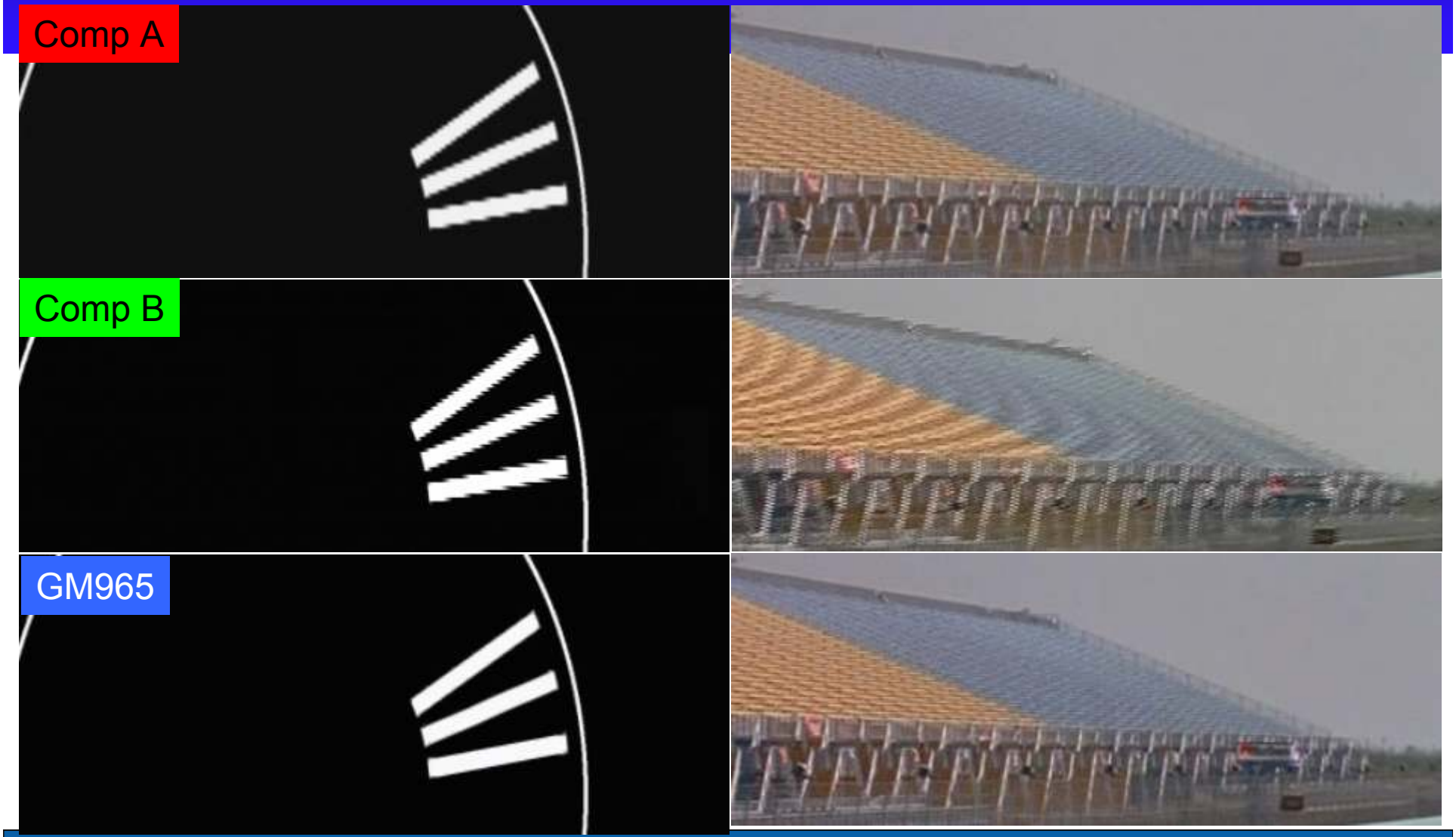
* Images obtained from Silicon Optix HQV benchmark

Example Comparison (Out-of-Box)



* Images obtained from Silicon Optix HQV benchmark

Example Comparison (Custom Player)



* Images obtained from Silicon Optix HQV benchmark

Transition from SD to HD…

6X Resolution:

from SD (720x480)
to HD (1920x1080)

>5X Codec complexity:

From 1-stream MPEG2 to
2-stream MPEG2/AVC/VC1

>4X Usage complexity:

From 2-plane non-interactive
to multi-plane interactive

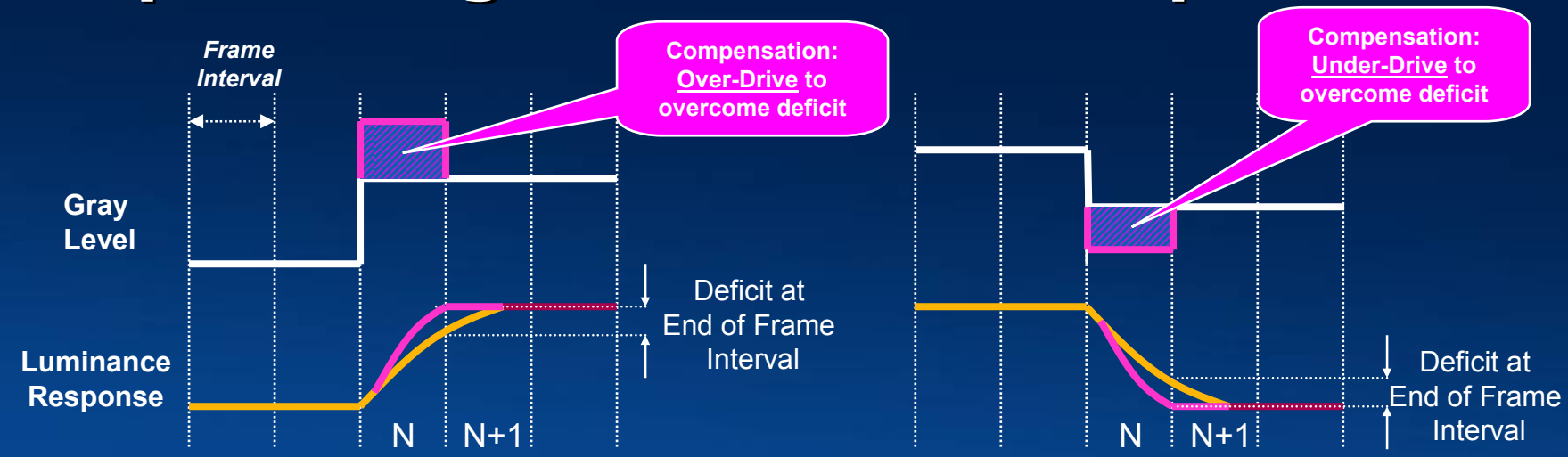
Graphics/Media Processor
with Media Hardware Assist

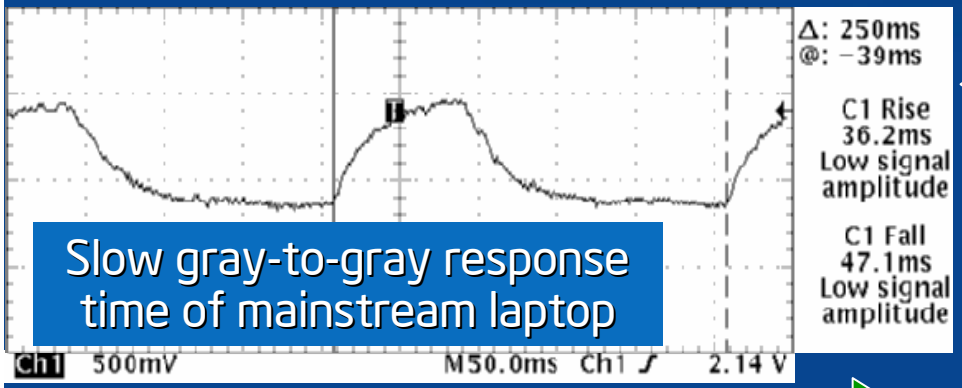
Video Codec Pipe

Future Graphics Generations

Intel will continue innovation to bring power efficient, high quality, HD media experience to mobile platforms

Compensating for LCD Slow Response Time

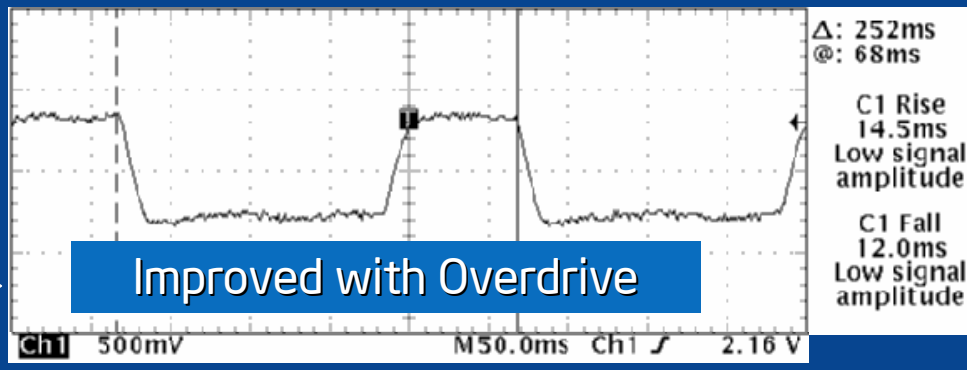




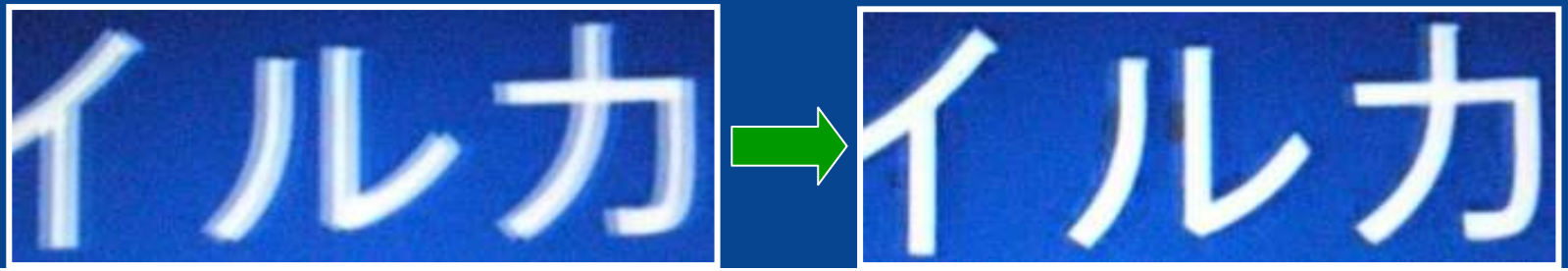
Slow gray-to-gray response time of mainstream laptop

w/o overdrive

w/ overdrive



Improved with Overdrive



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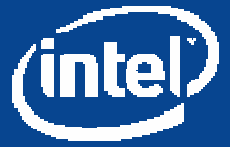
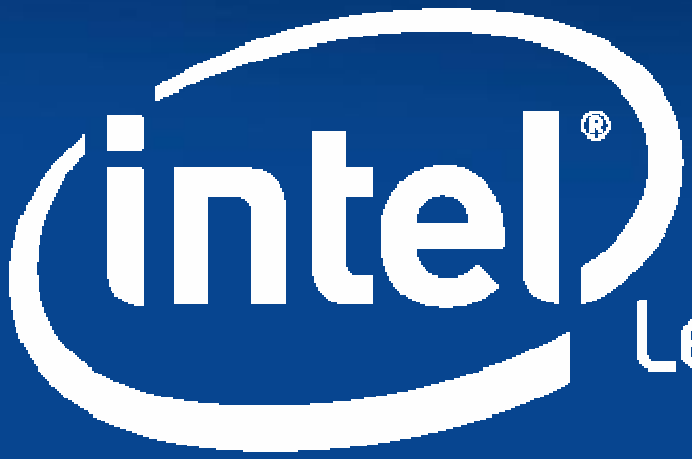
Summary

- Rapid growth continues in the mobile computing market, aided by exploding internet usage and technology advancements
- Intel is leading the mobility wave with power-performance optimized platforms
- Significant challenges and opportunities for the video & display technologies to continue enhancing the visual experience for the consumer
- We look forward to collaborative R&D with innovators in the academia

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