DisplaySearch FPD 2007 Conference

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Summary of Discussions about High Resolution Displays

Geoff Walker provides a selective report about resolution-related topics discussed at the DisplaySearch FPD 2007 conference.

FPD 2007 was typical of previous FPD conferences; attendance was around 375 people from 180 companies in 17 countries. There were 18 exhibitors and a total of 61 presentations spread over 12 sessions. Overlapping sessions are a fact of life in today's face-paced world. At FPD 2007, the TV Displays session competed with the Mobile Displays session; the FPD Equipment & Materials session competed with the HD Content session; and the Display Electronics session competed with the OLED & Reflective Displays session. As a result, a portion of this report was compiled from the slide decks rather than the actual presentations.

Mobile Handset Displays

The adjacent table details the 2006 worldwide display market revenue by application. From a pixels-per-inch (ppi) point of view, the most action is happening in mobile handset displays, so let's start there.

Display Application	2006 $B	Share %
TVs	$36.9	39%
Desktop Monitors	$20.6	22%
Mobile Handsets	$12.8	14%
Notebook PCs	$9.2	10%
Amusement	$2.2	2%
DSC/DVC/VFs	$2.0	2%
Automotive	$1.4	1%
PDAs & Portable GPS	$1.2	1%
Portable DVDs	$1.0	1%
MP3 Players	$1.0	1%
Public Displays	$0.8	1%
Printers	$0.4	0%
Other	$4.0	4%
TOTAL	**$93.4**	**100%**

2006 Worldwide Display Market Revenue by Application (including CRTs)
Source: DisplaySearch

Barry Young from DisplaySearch did a thorough job in detailing the status of the small-medium LCD market. Barry's forecast for mobile handset displays by technology share and by resolution is shown in the two tables below. Barry also presented the set of high-resolution products shown in Figure 1 on the next page as typical current entries in the small-medium area.

DisplaySearch believes that essentially all mobile handsets will use displays in the 2.0–2.5-inch range, limited by what you can comfortably hold in your hand. Strategy Analytics disagrees, forecasting that in 2010, 37% will be <2.5-inch, 46% will be 2.5–3.0-inch, and 17% will be >3.0-inches. They believe that the mobile TV application will cause the average display size to increase.

Technology	2007	2010
a-Si TFT LCD	39%	39%
LTPS TFT LCD	22%	27%
CSTN	25%	16%
LTPS TFT OLED	1%	9%
MSTN	13%	6%
PM-OLED	1%	2%
e-Ink	1%	1%

Mobile Handset Displays by Technology
Source: DisplaySearch

PPI	Q2'04	Q2'07	Q2'10
>225	0%	4%	6%
175-225	8%	22%	35%
120-175	38%	31%	31%
100-120	20%	22%	16%
<100	33%	20%	12%
Segment	0%	1%	1%

Mobile Handset Displays by Resolution
Source: DisplaySearch
(ppi estimations by VeV)

Note that in the first of the two mobile handset forecast tables, both LTPS shares are increasing. Barry predicted that by 2010, mobile handset displays will soak up 50% of the total existing LTPS manufacturing capacity in the world. Because almost all of the existing LTPS fabs will be fully depreciated by 2008, LTPS display prices may actually become 10–20% lower than a-Si prices. In the second table, the key factor that's driving the increase in the 175-225 ppi range is mobile TV.

5.0-inch	**2.8-inch**	**4.1-inch**	**1.8-inch**	**2.4-inch**
800x480	**320x240**	**800x480**	**320x240**	**320x240**
187 ppi	**144 ppi**	**228 ppi**	**222 ppi**	**167 ppi**

Figure 1: A selection of high-PPI mobile products -- presented by Barry Young from DisplaySearch

While Barry didn't say much about mobile TV, Nokia gave a detailed explanation of why they believe it is inevitable. In a nutshell, the reasons are (a) TV is the world's most popular entertainment medium, (b) mobile handsets are becoming focal point for all mobile voice, data and entertainment functions, and (c) DVB-H technology is fully ready to support it. Interestingly, there have been some pilot tests in the UK, France and Spain; the results were that three-quarters of the participants were satisfied with the service and two-thirds of them would pay $9 per month for a subscription. Nokia's assessment of the display requirements for Mobile TV is as follows:

- 240x320 to 480x800 resolution
- 2.4–3.5-inch screen size
- Low power consumption
- Fast response with smooth motion
- 80% to 100% color gamut
- Good contrast

By the way, Nokia agrees with Intel's assessment that 4.0-inch is the minimum display size for mobile Internet (more below). But, they also believe that 3.5-inch is the maximum size for "pocketability". Therefore their mobile TV application analysis doesn't include any significant amount of mobile Internet usage. Whether this is realistic or not remains to be seen.

While there's more to the small-medium display market than just mobile handsets, only about 8% of the revenue shown in the overall display market revenue table at the start of this article is attributable to other small-medium applications, so with a few exceptions, there wasn't much focus on any of the other application areas. One exception was Deutsche Bank, who in their industry analysis session, said they believe that one of the keys for survival in the small-medium LCD market is the ability to develop and supply higher resolution and performance in 4.0–10.0-inch panels for mobile applications. That was well-received by those of us who view higher resolution as one of the holy grails…

Another exception was CDT's presentation on their Total Matrix Addressing (TMA) technology. This new concept extends the size and resolution of PM-OLEDs by reducing the peak luminance through an innovative driving scheme that can drive multiple columns and rows simultaneously. The result is a display with half the power consumption of conventional PM-OLEDs. Compared with AM-OLEDs, PM-OLEDs made with TMA have no active-matrix backplane, much higher yields, half the cost – but similar performance. How high can PM-OLED resolution go with TMA? Possibly to 640x480 (TBD).

Last but not least in the small-medium display area, Anand Chandrasekher, an SVP from Intel responsible for the "Ultra Mobility Group", gave a very energetic pitch on the market potential of "pocketable personal Internet devices" (think: N[th] generation of the UMPC). Anand showed a video that imagined some highly idealized, very small devices with video conferencing, speech recognition and lots of other leading-edge capabilities. The author's immediate reaction was "maybe by 2015"; Anand said "starting in 2008", while also acknowledging that it will take most of the next decade for mobile Internet usage to become a mainstream application. One interesting detail from Anand's pitch is that Intel focus-group studies have concluded that the appropriate screen size range for such a device is 4.0–6.0-inches; smaller than 4.0-inch was considered to be unusable, while larger than 6.0-inch isn't portable enough. Although Anand didn't mention pixel density, a wide-aspect LCD with 1024x640 resolution (a realistic minimum for such a device) would be 302 ppi at 4.0-inches and 201 ppi at 6.0-inches.

Notebook PC Displays

John Jacobs from DisplaySearch provided his usual well-executed analysis of data and trends in the notebook PC market. Extracted below are two tables of interest. The first table details the Q4'06 worldwide notebook market share by size and resolution. Note the wide range of pixel densities (85 to 147) – there's something for everyone!

Unfortunately, the weighted average of all the displays is only 103 ppi, while the mean of all the pixel densities is 114. Note that just three display sizes account for 67% of all notebooks sold in Q4'06. The good news is that notebooks are becoming an increasingly large share of the total PC market; sales are forecasted at 97 million units in 2007 (67% at a wide aspect ratio) and 146 million in 2011 (80% at a wide aspect ratio). The crossover point (where notebooks sales exceed desktop sales) is in late 2009. Once notebooks are in the majority, it's possible that their wide range of pixel densities may have a positive effect on the stuck-in-the-mud desktop monitor market.

Size (inches)	Resolution	PPI	4Q06 Share
12.1	1024x768	106	3%
12.1	1280x800 (W)	125	3%
13.3	1280x800 (W)	113	6%
14.1	1024x768	91	6%
14.1	1400x1050	124	1%
14.1	1280x800 (W)	107	18%
14.1	1440x900 (W)	120	2%
15.0	1024x768	85	10%
15.0	1400x1050	117	1%
15.4	1280x800 (W)	98	39%
15.4	1440x900 (W)	110	1%
15.4	1680x1050 (W)	129	2%
15.4	1920x1200 (W)	147	1%
17.0	1440x900 (W)	100	6%
17.0	1920x1200 (W)	133	1%
Others			2%

Q4'06 Worldwide Notebook Market Share by Size and Resolution
Source: DisplaySearch (ppi column added by VeV)

The second table below on the right details DisplaySearch's notebook display forecast for 2007 and 2011. It's interesting to note that the weighted-average notebook-display size increases by less than 0.5-inch from 2007 through 2011; this could indicate that notebook displays have reached an appropriate balance between useable area and portability.

The forecasted changes by notebook category in 2011 are relatively small. The "ultraportable" category (13.3-inch and smaller) shrinks from 13% to 11%; the mainstream "thin and light" category (14.1-inch through 15.4-inch) shrinks from 80% to 75%, and the "desktop replacement" category (17.0-inch and up) grows from 7% to 13%. Although the growth of 13.3-inch wide-format LCDs may seem counter-intuitive, shipments are forecasted to increase because it is the most profitable size to manufacture on a Gen-5 fab (it replaces most of the 12.1-inch panels in the forecast). It's well-known that in the LCD industry, panel-manufacturer profit concerns are almost always more important than any market demand factors. Although it's not shown explicitly in the table, between 2007 and 2011, the average ppi increases slightly (4%) from 103 to 107. Most of this growth comes from the increasing share of higher-resolution 15.4-inch panels.

Size (inches)	2007	2011
>17	0%	2%
17	7%	11%
15.4	46%	50%
15.0	8%	0%
14.1	26%	25%
13.3	7%	10%
12.1	5%	1%
<12.1	1%	0%

Notebook Display Forecast by Size
Source: DisplaySearch

Desktop Monitor Displays

Chris Connery from DisplaySearch led an interesting session on the status of the desktop monitor market. The adjacent table contains Q4'06 monitor market data extracted from Chris' presentation.

Size (inches)	Resolution	PPI	Share
17.0	1280x1024	96	45%
19.0	1280x1024	86	24%
19.0	1440x900 (W)	88	13%
15.0	1024x768	85	9%
20.0	1680x1050 (W)	99	3%
22.0	1680x1050 (W)	90	2%
20.1	1600x1200	100	2%
24.0	1920x1200 (W)	94	1%
20.1	1400x1050	87	1%
21.3	1600x1200	94	0%
Others			1%

Q4'06 Monitor Market Share by Size and Resolution
Source: DisplaySearch (ppi column added by VeV)

Note the limited range of pixel densities (85–100 ppi) compared with that of notebooks (previous page). Why would someone with a 117+ ppi notebook (seven choices!) buy a monitor with less than 100 ppi? Because that's all that's available, that's why! The weighted average and the mean of all the displays in the table are both 92 ppi. It's worth pointing out that pixel density was never mentioned even once during the entire monitor session, including during presentations by DisplaySearch, HP, Dell, Samsung and TCO Development (a third-party display certification organization), and during an audience Q&A period. Now that's discouraging!

Wide-format monitors are of course growing rapidly; DisplaySearch forecasts overall penetration of 58% by 2010. (Corning is slightly more aggressive, forecasting 49% penetration by 2008.) In the consumer space, there's nothing to prevent rapid and widespread adoption of wide-format monitors. However, in the enterprise space, adoption is considered to be tied to Vista – and that's not going to be fast. DisplaySearch presented some interesting data on the forecasted Vista adoption rate, as shown in the table to the right.

Vista Adoption Time Frame	SMB	Large Enterprise
1H07	6%	8%
2H07	33%	16%
1H08	29%	18%
2H08	10%	9%
2009+	7%	5%
Unknown	15%	43%

The Vista Adoption Curve: Expected Date of Initial Deployment
Source: Cowen/CRN Vista Adoption Study, January 2007 Survey: 170 solution providers were surveyed for the SMB market (defined by CRN as companies with less than 1,000 employees). 238 companies were surveyed for the enterprise market (defined by Cowen as companies with more than $501M in 2006 sales).

Clare Hobby from TCO Development (mentioned above) reported the results of an interesting glossy-panel user study. The objective of the study was to perform a comparative visual evaluation of matt and glossy panel surfaces. The study population was age range 25-56; the test material was MS Word documents and images; and the measured parameters included disturbing reflections, contrast, brightness, color rendering and eye comfort. In subdued illumination (100 lux), there was no difference reported in disturbing reflections, while the other four parameters were seen as slightly better (around 7% on average) with a glossy panel. However, in office illumination (600 lux), all five parameters were seen as significantly better (around 50% on average) with a matt panel. The greatest difference was seen in disturbing reflections, with the matt panel receiving a subjective score of 5 while the glossy panel received a 1. These results are not exactly surprising, and they easily explain why enterprise is generally seen as resisting a move to glossy panels.

TV Displays

Panasonic reported that the Advanced PDP Development Center Corp. (APDC, http://www.advanced-pdp.jp), established by five PDP companies in 2003), has developed some new PDP prototypes that emit 10 lumens per watt; this is a substantial advance over today's 1.0-1.5 lumens-per-watt products. This will allow PDP to achieve 1080p at 32-inch (69 ppi) and 4Kx2K ("Quad Full HD") at 55-inch (80 ppi) – which is significant considering that PDP is struggling to achieve 1080p at 42-inch (52 ppi) today with higher costs and lower brightness. This technology, which also enables a substantial cost reduction while increasing brightness and contrast, is believed to be two years away from mass production.

Panasonic also reported that the APDC has proposed a method of measuring moving-picture resolution. The measurement involves scrolling a resolution chart for 5 seconds across the screen with the camera following at the same speed. Figure 2 below shows the result when comparing a PDP display against a 60 Hz LCD. The results are pretty much as expected, but the point isn't really the results as much as it is to prove the usefulness of the measurement technique.

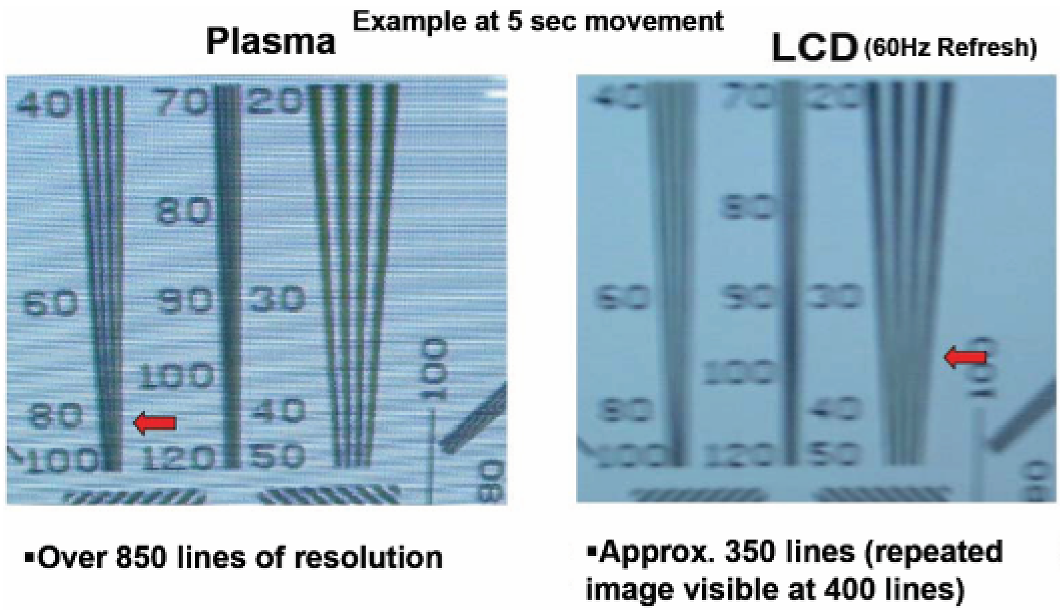

Figure 2: Result of APDC's Proposed Measurement of Moving-Picture Resolution

The topic of eliminating LCD motion blur and judder is always well-covered at FPD conferences. One of several Samsung presentations on the status of LCD technology improvements included a good illustration of the difference between 60 Hz frame-rate with repeated frames and 120 Hz frame-rate with interpolated-motion frames (see Figure 3 below; pay close attention to the stripe on the batter's pants). This illustration provides an interesting follow-on to Figure 2 above. Note that in the case of film, the original frame rate was typically 24 frames per second; going from film to 120 Hz therefore means that 80% of the displayed frames are calculated!

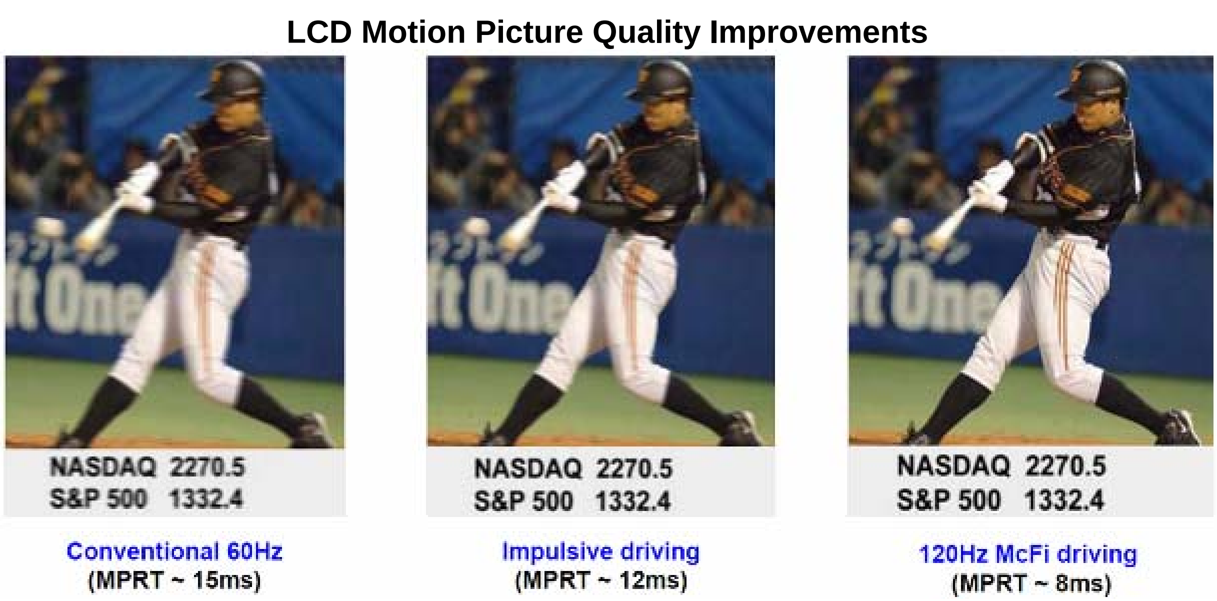

Figure 3: Result of Samsung's Method of using 120 Hz Frame-Rate with Interpolated-Motion Frames as a Means of Reducing Motion Blur

DisplaySearch's FPD conferences always include the latest news from the front lines in the LCD vs. PDP war. The table on the right shows DisplaySearch's current forecast for worldwide TV unit share by technology in 2010. The forecast shows LCD driving PDP largely out of the 40–44-inch space and into 50-inch and larger segment, with LCD and PDP together driving MD-RPTV out of everywhere except the >55-inch market.

In his introductory overview to the TV Display session, Ross Young of DisplaySearch provided some interesting data showing the current difference in manufacturing cost between standard HD and full HD on LCD and PDP displays, as follows:

Display	720p	1080p	Difference
40-inch LCD	$558	$631	113%
50-inch PDP	$787	$1,103	140%

Manufacturing Cost Premium for 1080p vs. 720p TV Displays
Source: DisplaySearch

The 13% difference for LCD is due mostly to increased components cost, mostly the driver ICs and the backlight. The 40% difference for PDP is due to both higher circuitry costs and significantly lower yield; the availability of single-scan electronics should reduce this difference, but it won't happen until Q3'08.

Size Range (inches)	Technology	2006	2010
40-44	LCD	40%	77%
	PDP	54%	23%
	RP-CRT	3%	0%
	MD-RPTV	3%	0%
45-49	LCD	81%	100%
	PDP	0%	0%
	RP-CRT	6%	0%
	MD-RPTV	13%	0%
50-54	LCD	3%	27%
	PDP	48%	72%
	RP-CRT	18%	0%
	MD-RPTV	32%	1%
>55	LCD	1%	13%
	PDP	15%	57%
	RP-CRT	11%	0%
	MD-RPTV	73%	30%

TV Display Market Share Forecast by Size Range and Technology
Source: DisplaySearch

Charles Annis, DisplaySearch's expert on LCD manufacturing equipment, materials and processes made an interesting forecast of LCD module cost: 42-inch could be as low as $277 in 2010 and $125 in 2015. Since materials account for 65-80% of LCD module costs, these reductions can be achieved by a combination of materials cost-down strategies and manufacturing technology innovations.

Conclusions

- Mobile handset displays (accounting for 14% of 2006 display revenues) continue to be the focal point for increasing pixel density. DisplaySearch forecasts that by Q2'10, 41% of mobile handset displays will be at or above 175 ppi.
- Notebook displays (accounting for 10% of 2006 display revenues) were available from 85 to 147 ppi at the end of 2006, with a weighted average of 103 ppi. DisplaySearch forecasts that the average will increase about 4% to 107 ppi by 2011, due mainly to the increasing share of higher-resolution 15.4-inch displays.
- Desktop monitor displays (accounting for 22% of 2006 display revenues) have been stuck in the 85-100 ppi range for a number of years, and there is no indication of any change in the future.
- TV displays (accounting for 39% of 2006 display revenues) continue to improve. The focus in PDPs is enabling 1080p at smaller sizes, while the focus in LCDs is on eliminating motion blur and judder.

Like the half-dozen previous DisplaySearch USA FPD conferences that the author has attended, FPD 2007 was definitely worthwhile. It provided a thorough review of a variety of marketing, business and high-level technology topics in the display industry, good networking, good food & facilities, and lots of information (131 MB) to take home for reference. While overlapping tracks are an understandable way of keeping the conference relatively short at 2.5 days, the author would still like to be able to clone himself and attend them all. FPD is that good!