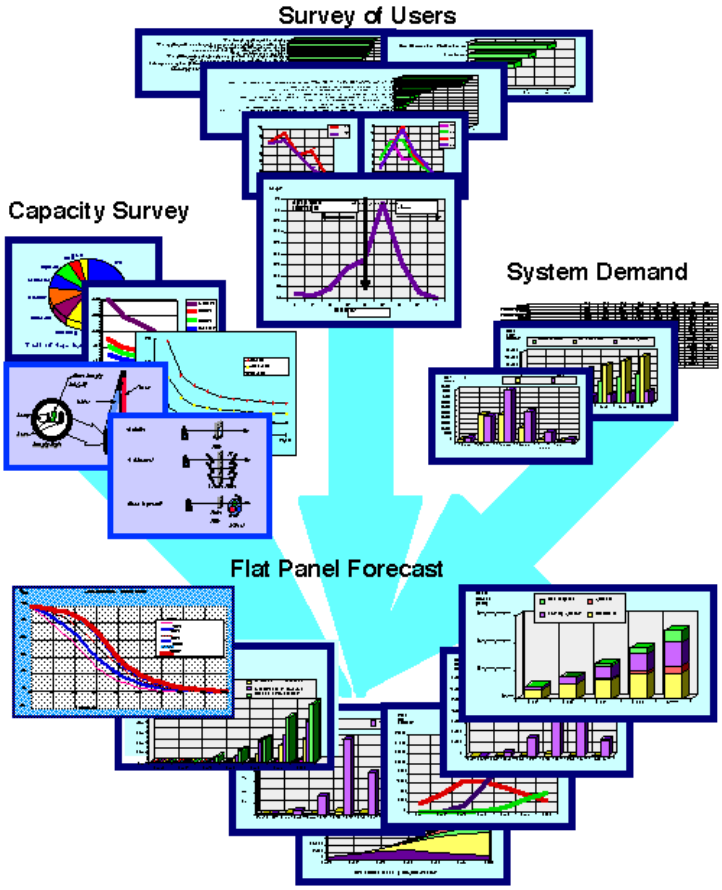
Flat Panel Displays
U.S. Manufacturing Infrastructure



March 1997
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Code 6024

NAVAL SEA SYSTEMS COMMAND
NSWC
Naval Surface Warfare Center
CRANE DIVISION

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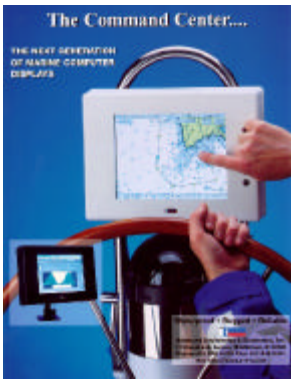
Introduction

The Flat Panel Display (FPD) industry is fairly new in the US. It is not quite established to where the basic user can find information easily. The FPD market is dominated by Japan. The US does have FPD manufacturing and this report will discuss many of these companies. To date most of the US FPD infrastructure in manufacturing is in research and development. There is some commercial production but most manufacturing is via captive lines, for internal use only, or government-funded projects. DARPA is a large funding source of the US FPD industry. Most of the companies listed in this report are funded in some way by DARPA. There are also other supporting agencies and groups (i.e., NIST, Virginia Tech, Harris, HP, and COMPAQ) and some joint projects. The companies listed in this report are not all those in the US FPD manufacturing infrastructure. They are though the majority of the FPD industry in the US. Some companies may have been left out by accident but this reinforces the idea of the instability that is in the US FPD infrastructure. This report is just a beginning to establish some control and relay some unbiased information about the US FPD manufacturing infrastructure.

U.S. FPD Companies



Advanced Engineering & Electronics Inc.
Advanced Engineering & Electronics provided engineering services to the Naval Undersea Warfare Center (NUWC) in Newport, Rhode Island. They designed and built computer systems installed on board SSN 688 and SSB 726 class submarines. They also develop products for commercial marine use. They design and manufacture waterproof active matrix computer displays and ruggedized computer systems.

Candescent Technologies - San Jose, CA
Candescent is supported by a five-year venture with Hewlett-Packard, Compaq, and DARPA. They manufacture Field Emission Displays (FED). There are two basic types of phosphors being used with FEDs today. The high voltage kind which Candescent uses are the traditional CRT type. This type phosphors perform better, are more efficient, and last longer. Their plan is to develop a core technology (FEDs), to compete with AMLCDs, and to manufacture high-volume domestically. Right now, Candescent is making 2.3" engineering prototypes. They're working closely with HP to manufacture a notebook computer product targeted for delivery in the 1999.

U.S. FPD Companies -continued

Colorado Microdisplay Inc. - Boulder, CO
CMD is bringing a new information display product, the Virtual Monitor. The monitor is a color, high resolution display in a package the size of a small cube of sugar. The monitor is designed for telephone headsets or products that are raised to the eyes.

dpi*X* - Palo Alto, CA
dpi*X* has produced active matrix LCDs (AMLCD) over an area the size of an 8.5" by 11" page. They were awarded a contract with DARPA, December 1996, to develop high resolution, reflective mode display technologies that can provide land warriors on the battlefield with digital maps, real-time video and other strategic and tactical information. They introduced, January 1997, the Eagle-5 cockpit avionics display, a high-resolution, AMLCD designed for Navy FA-18 Hornets, and Marine AV-8B Harriers. The display can produce color tactical data, full motion video and high resolution monochromatic forward looking infrared (FLIR) imagery, and its size is 5" by 5".

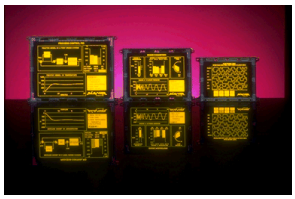
FED Corporation - Hopewell Junction, NY
FED Corp.'s product technology is FEDs. They've targeted the development of 3" to 8" custom direct view displays and 1" or smaller head mounted displays. FED Corp. is working with Harris Corporation in the area of military displays. They are shipping some panels of different sizes for the military helmet mounted display markets. By the year 2000, FED Corp. aims to be one of the leading manufacturers of custom high resolution high performance emissive FPDs.

Kopin Corporation - Taunton, MA
Kopin's product is AMLCDs . They plan to manufacture displays for workstations and larger applications. The company has developed a small pocket sized projector for home and office uses. They are also exploring the head mounted display markets. Kopin was mostly government funded by DARPA to develop a high resolution active matrix electrolumiscent display. This contract is coming to completion. They are presently emphasizing product for wireless telecommunications ahead of display products.

Motif
Motif will market AALCDs (active addressing LCD) that integrate the Motorola manufactured ASICs embodying the active addressing system with Motif's manufactured PMLCDs. They produce up to 8" diagonal displays. The applications are for use in respective projection and communication products.

NEC - Santa Clara, CA
NEC's display applications are for notebook computers, workstations, PC monitors, multimedia terminals, display terminals for control systems, monitors for process controllers, displays for measuring equipment, and for car navigation systems. NEC is an established Japanese company. They do have a manufacturing facility in the US.

Optical Imaging Systems (OIS) - Troy, MI
OIS product is active matrix LCDs. They're primarily for military and space applications. Applications in ground based, seaborne, and ruggedized systems also fall within their scope.

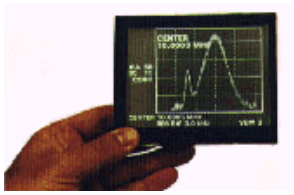


PixTech Inc. - Santa Clara, CA
PixTech product technology is FEDs. It's the only manufacture of FEDs commercially. The company targets test and measurement instrumentation, medical devices and vehicular displays, both military and commercial. They've produced a 10.5", 2.5mm thick FED display which uses no backlight, color filters or polarizer.

Photronics Imaging - Northwood, OH
Photronics produce plasma display panels (PDP). They are developing and manufacturing large area, monochrome (orange) PDPs suitable for applications as command control displays, and video confercencing monitors. They have developed full color plasma displays. Their displays are used mainly in military, business and industrial equipment where color is not critical. Photronics have developed a large area (30"), high resolution (1024x768), full color gray scale, video rate plasma display with DARPA support.

Planar Systems Inc. - Beaverton, OR
Planar manufactures both FPDs and CRT-BASED display products. Planar supplies commercial and military with its Electroluminescent displays (ELDs) and CRT technologies. They are sampling some new 1" active matrix electroluminescent panels for head mounted displays.

Plasmaco Inc. - Highland, NY
Plasmaco produces AC plasma display panels. They are marketing a 21.3" monochrome PDP, 1.5" deep, with a resolution of 1280x1024. Their displays are used on the stock exchange trading floors and on U.S. Navy surface ships and submarines. They have developed a full color PDP.



Standish Industries - San Jose, CA
Standish produces passive matrix LCDs (PMLCD) specializing in custom displays. Standish is the largest U.S. manufacturer of FPDs. One percent of production is for defense use. They are developing a 13", 6.3 million pixels, monochrome AMLCD with 3072x2048 resolution. They also have a contract with DARPA to develop a passive matrix and color filter manufacturing line.

Telegen Display Laboratories. - Redwood City, CA
TDL technology is high gain emissive display (HGED). They are working with Virginia Tech to develop this technology to manufacture. HGEDs are expected to be manufactured in sizes up to 40" or more. Their applications include large screen computer monitors, HDTV, and hang on the wall TVS.

Virtual I-O - Seattle, WA
Virtual I-O produces head mounted displays (HMD) for high end 2-D and 3-D applications. They use TFT AMLCD technology.

Conclusion

Since the early 1990's DARPA and other groups have been funding research and development of the Flat Panel Display industry in the US. Most all of the companies listed in this report were or have been funded largely by DARPA. Some of them have developed to a point of commercial production and have their own customer base. Probably each company is going for a certain niche market. That being avionics displays, head mounted displays (HMD), notebook computer displays, workstation displays or equipment displays. Some are ruggedized for harsh environments and others are for commercial game usage. The companies each seem to have a good base technology to work from (i.e., FED, AMLCD, PMLCD, HGED, etc.). They have all developed products or prototypes for specific usages. So we are certain they each can make a product and make it pretty good. One concern is can they each mass produce a product. Another concern is can they maintain in the market of their choice. They'll only be so many FED manufactures and so on. FEDs and PDPs are going to have a market as will some of the other technologies. When choosing a FED, PDP, or other technology type company try to have two or three backup choices. The backup is in case the initial choice stops manufacturing or has problems. These companies are to new to rely on one choice like maybe some AMLCD Japan companies are. There are some extremely interesting FPD products being made today. Most all these will improve greatly in quality and reduce in cost in short time. In addition, to the companies listed in this report other companies are working in the FPD market (i.e., Raytheon TI, Motorola, IBM, etc.). These companies are working on display products to improve there own products and information is hard to get from them. Many of the companies listed in this report have partners (i.e., HP, Compaq, military users, or commercial users). The FPD industry in the US is just beginning. There will be some technologies that compete with Japan in the near future. There also will be some FPD industry that will be an assembly only type industry for FPD technologies. This may be the industry best suited for the militaries many needs. Whatever, the future will bring FPD there will be many choices. So try not to choose "for military only" products or manufactures or one that says their product's rugged and militarily ready. Always try and use COTS and dual use products.