White Paper

Large LCD Displays for Collaboration and Situational Awareness in Military Environments

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ABSTRACT

Rugged large format LCD displays up to 80” will be required by all branches of the military. These displays will be used for collaboration, situational awareness, and information fusion in critical command and control situations. New challenges arise in adapting these larger LCDs to meet requirements for ruggedness and survivability.

TABLE OF CONTENTS

1 INTRODUCTION

Over the past 10 years, rugged COTS LCDs have displaced CRTs to become the dominant display technology in most every military system where size, power, weight, and survivability are of significant concern. Two key features that have driven the rapid evolution and adoption of LCDs are the scalability and the ubiquity of the technology in both military and commercial applications. LCDs from 4" ¼VGA hand-helds, to 30" WUXGA have proven suitable for a variety of rugged military applications from cockpit avionics to shipboard command and control. More recently, advancements in design and manufacturing technology have enabled LCD sizes and resolutions to increase rapidly. Commercial products are currently available up to 82" with resolutions of 1920 x 1080 and greater. This paper will discuss some of the unique challenges facing designers in ruggedizing and adapting these larger LCDs to military applications.

2 DEFINITIONS AND REQUIREMENTS

For the purpose of this discussion, we will focus on large LCDs with diagonal dimensions from 40" to 60" and resolutions of 1280 x 768 or greater. These large LCDs will require enhanced ruggedness for use on mobile platforms where environmental conditions (temperature, vibration, and shock) are significant considerations. While these large displays may not fill strict mission critical requirements, they must meet performance and environmental standards that typically exceed the specifications for commercial and industrial applications. In some cases, the displays may be used as simple monitors with direct video connections, or they may be networked to local and/or remote systems.

3 APPLICATIONS AND PLATFORMS

Rugged large format LCDs will be most often required in mobile command and control applications where strict environmental requirements are combined with the limited space in ships, aircraft and vehicles. Typical applications will be shipboard command information centers, airborne command and control, and ground mobile command and control. Large displays will typically serve as an adjunct to individual operator consoles. Critical real-time sensor data or information will be routed from the operator's station to a large display in a central location. Several persons will be able to simultaneously review images and data in a real-time collaborative environment. The large displays can also fuse multiple data sources in an integrated manner for improved situational awareness and decision making. In network-centric environments, commanders will be able to discuss and collaborate while processing information and sharing ideas, and attend virtual meetings without necessarily assembling in one place.

4 LARGE DISPLAY CHALLENGES

The rapidly growing commercial demand for LCDs in the 40-60" range, will provide a wide array of high-resolution panels that can be used as the basis for large rugged displays. As with smaller rugged COTS displays, the commercial LCD panels are only a building block for the design of the final rugged product. In some cases, the commercial electronics or backlights may be reused and repackaged in a rugged manner. In other instances, complete new subassemblies may be designed to meet specific requirements. Designers will need to tailor the large displays to specific applications with careful attention to the gamut of electrical, mechanical, optical, and environmental requirements.

While these design considerations are mostly similar to those for the smaller rugged displays already common in military applications, there are specific issues that become more challenging when applied to large format applications. The following provides some discussion around these issues and possible solutions.

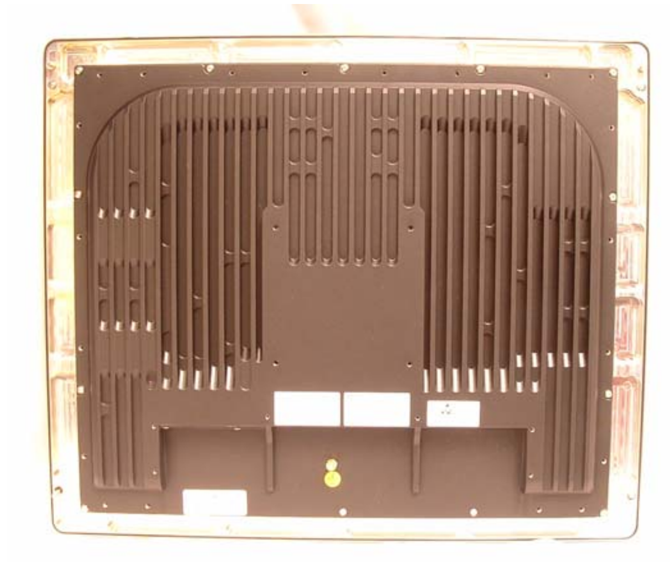
4.1 Daylight Readability

While most command and control environments will be sheltered with controlled illumination levels, in some cases it will be important for large rugged displays to be daylight readable. For instance, a mobile command vehicle may be open to direct sunlight, or may even have an application where the display is deployed outside when the vehicle is stationary. High brightness is a key consideration for daylight readability, with a minimum requirement of 500-700cd/m^2. Keep in mind, however, that luminance is a function of the surface area (cd/m^2), so for larger displays, significantly more power is required to maintain a set brightness level. For the largest displays, over 500 Watts are required to maintain a high brightness level. However, high brightness alone will not provide good daylight performance. The contrast ratio of the panel, the reflectance of the viewing surface, refraction, and the viewing angle of the user are equally significant considerations. It is very important to optimize the performance of the “front optical stack” in these regards to provided good daylight performance without resorting to higher brightness and the corresponding downsides of added heat and power consumption.

Front bonding of a rugged LCD display
for improved optical performance

4.2 Weight

While rugged COTS displays are based upon commercial LCD components, a significant part of the value added ruggedization is in the mechanical packaging that extends the equipment's tolerance for shock, vibration and temperature. While essential for the performance of the display, this rugged packaging typically incorporates high strength alloys and other structural materials that add significantly to the weight to the finished design. With large rugged displays, this added weight can become prohibitive, with the final product easily approaching 200 lbs. Clearly this is a concern for most mobile applications, but while it is important to keep weight low, little compromise can be allowed for mechanical and thermal requirements. One approach to minimizing weight is to use computer aided design to optimize (minimize) every structural element. In the same manner, heat exchangers must be designed to be highly efficient. The ideal condition is to design structural components to serve multiple functions. For example, the rear cover can be designed to serve as a structural element, and as a heat exchanger, and as an environmental enclosure.



Rugged LCD display with heat exchanger integrated into the rear cover assembly

4.3 Touch Screens

Conventional touch screen technologies (AR, IR, SAW, capacitive) are becoming available in larger sizes for commercial applications. While these legacy technologies have been used in rugged military environments, some scale more readily than others to large displays. Also, there have been issues with respect to reliability and durability that have held back success for all applications, regardless of size.

Ideally, touch technology for large displays will not adversely affect optical performance. It will be readily scalable to a range of sizes, with high resolution and accuracy. It will have a wide environmental range, and it will be reliable, durable, resistant to contaminants, and easily cleaned. Clearly this is a tall order, and the technology is not there yet.

However, emerging touch technologies, such as acoustic pulse recognition and optical recognition show promise and are particularly suitable for larger applications for all the reasons outlined above. Acoustic Pulse Recognition (APR), for example, works by identifying and locating the sound made when the operator touches the panel. APR uses a simple passive acoustic transducer and promises to meet the requirements outlined above for a range of large display sizes.

4.4 Shock 901D

Shock survivability is arguably one of the most difficult specifications to meet for rugged LCD displays, and even more so for larger variants. Shock requirements will vary significantly depending on the operational platform. Specifications for shipboard equipment, which are prescribed by MIL-S-901D, are particularly strenuous. There are two separate categories of 901D qualification. Grade A 901D certification is reserved for mission-critical display applications. This requires that the equipment is not degraded in any manner as a result of a series of calibrated shock pulses or explosive charges. Grade B certification is for non-essential items. Basically, a Grade B certification ensures that the displays will remain more or less intact, but not necessarily operational, after the same series of calibrated shock pulses.

For practical purposes, large displays will be mostly limited to Grade B service. Nonetheless, it will still be a challenge for engineers to design these larger and heavier displays to this specification. In mil-rugged environments, peak shock loads of 100Gs or more may be experienced. Significant mounting structures will be required, and heavier components will need to be well supported with direct mechanical coupling to these mountings. Tuned shock isolators may also be necessary at the mounting points. Considerable structural analysis and testing will be required for the entire display assembly. Protecting the LCD panel itself is a main concern. However, for Grade B certification the LCD needs to only remain contained by the front optical assembly. It will not be required to function after the test.

Mil-S-901D Heavyweight Shock Testing
with explosive charges

4.5 Vibration

Considerations for vibration will be similar to shock survivability, and much of the structural analysis performed for shock will convey. Some platforms, such as rotary winged aircraft and ground vehicles will have extremely high vibration profiles with specific frequency characteristics. Large rugged display designs will need to be evaluated and tested to ensure that they do not have any corresponding resonant frequencies.

4.6 Extended Operating Temperatures

Extending the operating temperature of rugged displays for both hot and cold climates has always been a challenge. Extended temperature capability is particularly important for ground vehicles and aircraft which are often idled for long periods in unsheltered conditions. At cold temperature (< 0°C) the response of the LCD becomes sluggish, and heaters are used to reduce the warm-up time. The requirements for quick start up will need to be balanced against already tight power budgets.

Under hot conditions (>40°C), the liquid crystal material becomes unstructured, and will fail to respond signal inputs. This phenomenon, referred to as “clearing”, is normally the limiting factor for high-temperature operation. Typical approaches to thermal management for rugged displays include conduction (heat sinks), as well as forced convection (fans). These approaches can be effectively applied to large rugged displays. However, it will be important to design light weight, highly efficient heat sinks to keep the overall display weight within limits. Conversely, fans can provide a lightweight solution, but they are often noisy, unreliable, and may require filters.

5 Summary and Conclustions

While LCDs had previously been limited in size, panels are now available up to 82” (and growing, with resolutions up to 1920 x 1080. These larger displays will be attractive to military users for collaboration, situational awareness, and information fusion in critical command and control applications. Rugged display designers will need to adapt these larger LCDs to meet the extreme requirements of military environments. While most of the rugged design techniques used for smaller displays will convey directly to larger applications, in many cases larger rugged displays will present unique challenges. Specifically, power, weight, readability, shock, vibration, and temperature will need to be addressed in new ways. Providers of large rugged displays will need to attach more value added engineering to their designs to make them suitable for the demands of military applications.

BARCO LC-47, 47" LCD Display