has been experiencing. In the civilian avionics marketplace cost is always an issue as there are options. The cathode-ray tube (CRT) and classical servos, galvanometers and barometric instruments have dominated the flight deck and are not instantly replaced by something 10 times the price. At the single-engine, general-aviation end of the spectrum, one LCD-based digital avionics box can cost more than a rebuilt engine.

However the LCD is the key to flight deck evolution. LCD technology is the only solution known to completely couple the pilot to digital electronics images in all environmental situations. CRTs were the first displays in the digital glass cockpit and have performed admirably but with limitations – they are difficult to read in color in bright sunlight, are difficult to dim and have poor image quality in the corners and at low light levels. The other limitations of the CRT have been met by improved designs but with increased weight, power, volume and cost.

The good news

LCDs and CRTs use completely different technology. The performance and operation of the LCD is based on different materials, electronics, physics and optics. In its application to the flight deck it requires much less weight, power and volume, and is practically immune to shock, vibration, ambient pressure and illumination. It does have limits in temperature and humidity but things can be improved through ruggedization. The viewing angle, speed of response and temperature range of LCDs have always been less than that of CRTs, but these parameters have improved markedly and now are good enough for the cockpit environment. The new generation of commercial-off-the-shelf (COTS) LCDs now exceeds many of the performance parameters of custom-made avionics LCDs.

The new generation of commercial-off-the-shelf LCDs now exceeds many of the performance parameters of custom-made avionics LCDs

The bad news

Yet LCDs are not a slam-dunk due to lack of availability in the desired form factor and acceptable cost. Most primary flight instruments are square. For historical reasons most LCDs are rectangular with a 3:4 aspect ratio as required in the TV and computer markets. With an LCD production line costing over US$100 million and NRE tooling costing over US$1 million, factories cannot be engaged to make a few hundred LCDs of a custom size for aviation. Custom aviation LCDs have been made, for example, by American Corporation of Atlanta, Georgia, and the price is correspondingly high.

Custom LCDs are being manufactured, but only under special arrangements and in most cases as a sole source. There is a long and turbulent history in manufacturing custom LCDs for aerospace. Most custom display manufacturers have seen financial failure with aircraft deliveries delayed and avionics business plans destroyed. Most airframe manufacturers and avionics manufacturers say "No" to sole source of avionics components in general and LCDs in particular.

The good news

A new approach to sourcing LCDs has evolved – resizing COTS LCDs and ruggedizing them for the avionics environment. The ruggedization needed for resized COTS LCDs is the same as that needed for any custom or COTS LCD. Two entities that can resize COTS LCDs have evolved – Tannas Electronic Displays in California, with patents in the USA, and BAE Systems, in Scotland, with patents in the UK.

As reported in technical papers[1, 2], both entities describe the resizing process as straightforward, cost-effective and reliable. Resized COTS LCDs have been tested to aviation environmental requirements and have passed DO-160 temperature and humidity requirements. COTS LCDs are getting better and the new generation of COTS displays has, in several ways, better performance than custom avionics LCDs. In particular the viewing angles for many COTS products are ±70° in the horizontal axis, +15° and -35° in the vertical axis, and 80° in all axes for the larger COTS LCDs such as those needed to resize 8in x 8in D-size avionics.

There are two alternatives to custom LCDs. One is to use COTS displays, ruggedize them for avionics and change the panel as needed; the other is to resize (cut and reseal) an appropriate COTS LCD to the size desired to fit the panel. The first option is appropriate for new aircraft and the second is appropriate for a retrofit. Regardless of the size of custom, COTS or resized COTS LCDs, the LCD industry may stop manufacturing the selected size over the 20- or 30-year life of the aircraft. Therefore the solution is to make lifetime buys or consider resizing COTS LCDs – in whatever sizes are then available – to the desired size.

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Ruggedized for avionics

Custom, COTS and resized COTS LCDs need to be ruggedized, giving several areas of concern:

- Antireflective coating on the front surface;
- EMI filter on the front surface;
- Heating of the LCD and backlight for rapid start at low temperatures;
- Sealant to protect from humidity, the polarizers, silicon chips and anisotropic conductive adhesive.

The ruggedized sandwich is shown in Figure 1. Glass plates carry the performance enhancements and protective features and are laminated to the original LCD. The glass plates make a rugged package. The environmental issue of shock and vibration are a function of the mounting of the glass sandwich in the box. Shock, vibration and breakage are not such a problem in LCDs as they are in CRTs. The LCD sandwich is solid and there is nothing to implode. If breakage occurs the pieces are held in place by the sealants and polarizer laminants.

Display module

The avionics LCD is an assembly of two components – the backlight and