

Optimized Safety-Critical Embedded Display Development with OpenGL SC

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ABSTRACT

Historically, the majority of avionics display manufacturers have sought custom solutions to support the development of cockpit displays, head-up displays and other avionics on-board and ground displays, from specification through to target. This was however a decision borne out necessity rather than choice since the inherent wisdom of a 'commercial-off-the-shelf' (COTS) approach had been understood and demonstrated in other parallel domains for some time. So, with this in mind, why was a more costly custom approach selected?

TODAY: CUSTOM SOLUTIONS FOR EMBEDDED DISPLAYS

Avionics displays present a unique set of requirements in that the COTS techniques used to create high performance and high quality graphics in other domains cannot be used because they are inherently incompatible with the stringent requirements of DO-178B certification for safety-critical display applications. COTS solutions comprising design tools, code generators, graphics drivers and graphics processors that have been developed with DO-178B certification objectives in mind are a relatively new innovation.

Secondly, by creating a perfect match with the very specific needs of each display supplier, custom solutions are traditionally the only way to achieve the highest

performance available from a given platform. Such solutions encompass very local optimizations (e.g. use of a dedicated chip) through to fine tuning or harmonizing of each component of the system, possibly at each stage of the development of the display solution, and the use of restricted, very specific, subsets of graphical objects and primitives.

With such varied requirements, it is easy to see how a COTS approach was dismissed and a custom solution selected. Nevertheless, there are a number of universally recognized drawbacks with the development of bespoke tooling.

Part of the difficulty in determining the most appropriate approach lies in understanding the mid to long-term effects of the decision. Even if the investment for the creation of the first incarnation of the proprietary solution may seem to make sense when compared to the purchase of the COTS alternative, the longer term costs associated with the continuation soon and predictably obliterate any initial savings. General maintenance costs to support evolving technologies coupled with the cost of re-qualification for development and verification tools under DO-178B can quickly become a problem.

Custom solutions also imply long-term maintainability issues. Internal, proprietary solutions are prone to becoming entrenched in the mindset of the developer; creating the possibility of a process that day-by-day becomes less effective and more difficult to escape. The developers effectively become prisoners of their own

technology, with the cost of migrating to new, up-to-date, technologies enslaving them.

There is also the thought that avionics manufacturers should focus on what they do best; delivering airframes with innovative, reliable, and fully integrated embedded display systems. The very skilled and specific tasks of setting up graphics devices or drivers, or developing graphics design tools all require programming skills that defocus avionics manufacturers from their core activities.

So, while traditionally providing the only approach to attain certifiable, optimized quality and performance, the long term costs of maintaining a bespoke and ultimately restrictive design process were a necessary evil; that is until the advent of the industry standard OpenGL SC.

OPENGL SC IS CHANGING THE GAME

OpenGL (www.opengl.org), the “premier environment for developing portable, interactive 2D and 3D graphics applications”, was first introduced in 1992 by Silicon Graphics Inc. and has become the industry's most widely used and supported 2D and 3D graphics application programming interface (API).

Among the numerous advantages of OpenGL, the most important from the point of view of the avionics display manufacturers is the fact that it has become a standard in the displays industry. The once Silicon Graphics proprietary standard is now managed by an independent consortium, The OpenGL Architecture Review Board, which guides the on-going development of the OpenGL specification.

With broad industry support, OpenGL is the only open, vendor-neutral, multi-platform graphics standard. By working to the standard, graphics developers have at their disposal a wide variety of OpenGL compliant platforms that offer backward compatibility to existing developments, therefore ensuring the continued value of intellectual property investments.

Moreover, by carefully defining the granularity of the OpenGL API, the efficiency of OpenGL routines typically result in applications with fewer lines of code than those generated using other graphics libraries or packages and, by virtue of its portability, all OpenGL applications produce consistent visual display results on all OpenGL API-compliant hardware, regardless of operating or windowing system.

While this innovation empowered the developers of ‘desktop’ graphical applications, until recently the aerospace industry, which has to cope with the numerous constraints of DO-178B certification objectives for their display software applications, was unable to

leverage an otherwise widely adopted graphics standard due to the absence of safety objectives in its construction.

OpenGL SC, the Safety-Critical profile of OpenGL, was developed to expressly help those tasked with meeting certification objectives realize the benefits of OpenGL standardization, specifically:

- minimizing graphical code size and complexity to ease certification
- enabling the porting of legacy applications that may have already been certified

OpenGL SC can be considered to have provided unification of existing industry practice; in an effort to deal with the certification issues of the ‘desktop’ OpenGL, many avionic companies independently refined a subset of OpenGL that included only the features that they needed. While this allowed many applications to be created and certified, numerous OpenGL variants were also created, along with many consequential portability issues.

The OpenGL SC definition is based on the OpenGL ES profile, a further refinement of OpenGL for Embedded Systems that offers a cross-platform API for full-function 2D and 3D graphics on embedded systems – including consoles, phones, appliances and vehicles – and is maintained by the Khronos group (www.khronos.org).

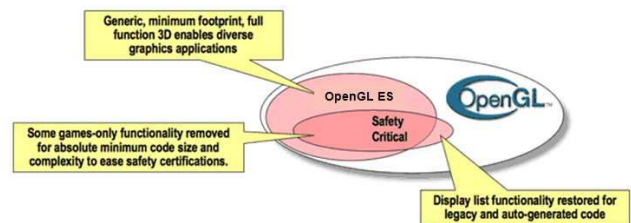


Fig. 1 – The Safety-Critical OpenGL Subset ^[2]

In an effort to strike a balance between functionality and certifiability, OpenGL SC subsets the functionality of OpenGL ES according to the following requirements:

- Meeting the functional requirements of avionic display applications
- Simplifying certification
 - Reducing complexity: certification tests have to be written in a way that they test every possible code path of the application or library that they test. The OpenGL SC API has been carefully chosen such that a combinatorial explosion of possible code paths is avoided, so making the writing and execution of certification tests possible. To reduce the burden of implementation and certification testing,