COTS GPU Selection Considerations for Mil-Aero Electronics

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Abstract

COTS graphics processors (GPUs) have become popular components in mil-aero display systems with high performance graphics processing requirements. This article provides several GPU selection considerations that can impact the success of a display system design and delivery schedule as well as total life cycle systems management costs.

Introduction

Over the past decade mil-aero equipment manufacturers have been pursuing initiatives to enable the acquisition, fusion, and timely communication of critical situational awareness data to improve safety and provide a tactical advantage during military operations. In the aerospace sector the desire for improved situational awareness has led to a technological revolution in the "glass cockpit." In these types of scenarios, the Human Machine Interface (HMI) is responsible for the presentation of large amounts of disparate information into formats that can be quickly presented, understood, and responded to by the human operator. These graphics-intensive applications often operate in resource constrained environments where power is limited, operating temperatures can vary to extremes, and regulatory certification of software and equipment is required. One key challenge for mil-aero display system manufacturers therefore, is to select a graphics processor (GPU) that uses as little power as possible while providing the enhanced graphics performance required, and which can be deployed cost-effectively in a mil-aero environment.

Where mil-spec FPGAs or other programmable ASICs can often address some of these requirements, graphics intensive applications that can be found in systems such as primary flight displays, 3D maps, and enhanced or synthetic vision systems often require more graphics processing capabilities than can be practically supported by these components.[1] Many system manufacturers are overcoming this limitation by deploying commercial off the shelf (COTS) GPUs that were originally designed for consumer markets into mil-aero platforms.[2]

A COTS GPU can provide high performance multi-channel graphics capabilities in an efficient package that includes both the processor and high speed memory. Key challenges to be considered when selecting a COTS GPU for mil-aero applications include operating temperature range, power consumption, and component obsolescence Equally important are the availability of GPU vendor support during product development, and the availability of compatible graphics drivers that are designed to support real time operating systems and are compliant with international safety critical certification standards such as FAA DO-178C and EASA ED-12C.

Power and Performance Management

When selecting a commercial GPU for resource constrained computing environments, system designers must perform the balancing act of finding a graphics processor that delivers the performance and functionality required, including the ability to accommodate potential increases in those requirements over time, while simultaneously respecting the resource constraints of the target environment. GPU manufacturers such as NVIDIA and AMD offer high performance "embedded GPUs" specifically designed to accommodate these competing priorities. System-on chip processors with dedicated graphics cores can be considered for low to mid-performance graphics applications, but for high performance 3D graphics and advanced video processing, nothing at this time can compete with today's high-end discrete embedded graphics processors.[3] Some embedded GPUs also offer programmable scaling of power and performance to reduce overall power consumption, which is an attractive feature for system designers looking for more direct control of the graphics processor's power management functions. Although reducing the graphics processor's clock speed also decreases performance, today's high performance COTS GPUs often exceed the performance requirements of even the most graphics-intensive mil-aero applications, making lowering clock rates a viable option for achieving target power-performance ratios. This approach can also have the additional benefit of extending component life and accommodating future legacy upgrades by simply increasing the GPU clock speed.

Extended Temperature Use

Ruggedization and environmental testing are critical to achieving mil-spec and industrial grade qualification. A GPU's extended temperature range is an important part of this screening process.

Embedded system manufacturers using COTS components generally perform temperature testing at the board level. Components used in industrial and mil-aero platforms must survive testing at temperature extremes that can vary from -40°C to over 105°C. This screening process can be very costly due to component failure and can significantly impact board production yield. Board level testing failure rates can be drastically reduced through the selection of COTS components that have previously undergone temperature screening. Since GPU vendors usually offer only commercial temperature tested versions of their GPUs, mil-aero board manufacturers generally look to electronic component vendors such as Core Avionics and Industrial (a Channel One company), who provide industrial temperature screened versions of commercial GPUs that meet or exceed the power and performance requirements of mil-aero applications.[4]

Obsolescence Management

Component obsolescence can significantly increase the total ownership cost (TOC) of aerospace and defense platforms, which is why many government agencies have mandated that an obsolescence management strategy be included as part of any technology procurement program.[5] A typical aerospace and defense platform can take as long as three to five years or longer to progress from the system design phase to product launch. In the aerospace sector, an aircraft's end-of life can span 15-20 years or longer. Conversely, the typical semiconductor's production life can span as little as two to five years. This problem is addressed by third party organizations such as Channel One, who provide obsolescence management programs and strategically align themselves with semiconductor manufacturers to ensure long-term component availability and storage of GPU components. Channel One also mitigates the mil-aero supplier's obsolescence management costs by allowing program managers to purchase relatively small quantities of components before their end-of-life (EOL) while reserving additional purchase options over the life of the program.[6] This approach reflects the process defined in the United States Defense Standardization Program Office as an efficient "Life-of-Type (LOT) buy, which it recommends as one of the most cost-effective procurement approaches to obsolescence management."[7]

Temperature-screened versions of AMD's ATI Radeon E4690 are available with 20-year supply programs from Core Avionics & Industrial (a Channel One Company).

Image courtesy of AMD.

Software Support, Integrity and Certification

The Airbus A380 cockpit display system employs AMD ATI Radeon GPUs, EASA ED-12B safety certified OpenGL and several COTS safety critical operating systems.

The vast majority of mil-aero display systems operate with real time operating systems (RTOSes), graphics drivers and software development tools that are not supported by the GPU manufacturer. Unlike drivers used in consumer markets, the graphics drivers used in high reliability environments must be rigorously designed in conformance with industry-recognized safety critical standards and include support for the target system's RTOS.

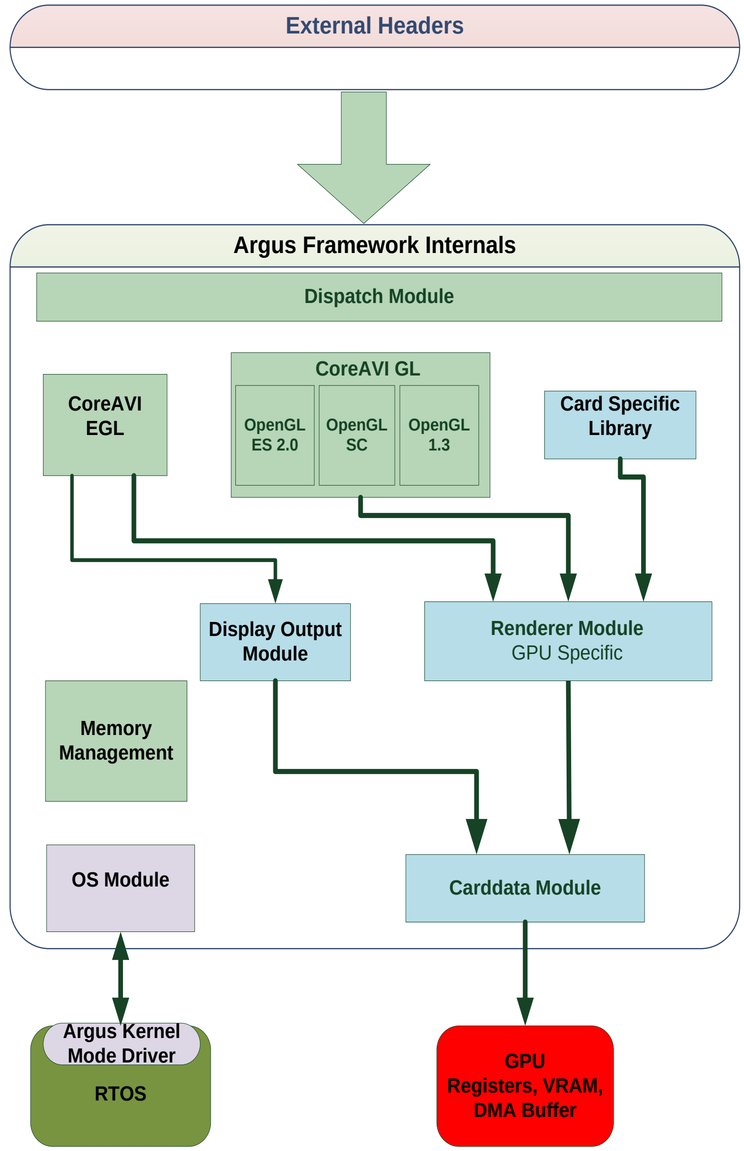
Software solutions can be found through an ecosystem of software vendors that serve mil-aero markets by providing COTS products specifically designed for integration and certification with each other in a target system. Core Avionics & Industrial (CoreAVI), for example, provides FAA approved DO-178C Level A certifiable graphics drivers for select GPUs that are deployed in avionics platforms. Human Machine Interface (HMI) tool vendors such as ENSCO IData Visual Systems, Esterel Technologies, and the DiSTI Corporation provide mil-aero HMI development tools that can be integrated with select GPUs, CoreAVI's graphics drivers, and popular safety-critical RTOSes such as Wind River VxWorks 6.6 cert, 653, DDC-I Deos, Green Hills Integrity-178B, and others.

Graphics drivers for high reliability systems must always perform in a deterministic manner (i.e. sequence of states consistently provide the same output given the same input) and should be written in conformance with the MISRA-C guideline for safety critical software.[8]

Another important consideration is the inclusion of run-time built-in test (BIT) functions that monitor interactions between the software and the GPU throughout the graphics pipeline in order to ensure functional integrity. In the event of a failure, built-in test modules can react by generating a fault log, rebooting the system, and at higher levels of safety criticality initiating failsafe back-up systems to prevent a catastrophic failure. Graphics drivers built using the safety critical OpenGL SC API meet the functional requirements of most mil-aero applications and also offer a small memory footprint that respects the resource constraints of an embedded system.[9]

GPU Manufacturer Support

GPU manufacturers provide widely varying levels of support to embedded device manufacturers in the mil-aero sector. This can range from providing direct support during the design and development process, to offering limited or even no support whatsoever. When selecting a particular GPU, it is important to understand the level of support the GPU manufacturer is willing to provide during the design & development phases of a project and to determine if their product roadmap includes consideration for aerospace and defense programs. Certain GPU vendors have product roadmaps that support mil-aero and/or have enabled third party partners to directly support their aerospace and defense customers. These manufacturers may also allocate resources dedicated to ensuring that mil-aero display system designers are making decisions that will yield optimal performance from the GPU.



An architectural diagram of CoreAVI' s safety critical OpenGL graphics drivers. In safety critical environments, BITs monitor system integrity and can initiate a response to address software or hardware failure conditions.

Conclusion

A new generation of “embedded GPUs” are available that often meet the requirements of high reliability computing device manufacturers in the industrial, medical, and aerospace and defense sectors. When selecting a suitable GPU for a mil-aero program, important considerations include not only the GPU’s ability to meet or exceed performance and operating environment requirements, but also the availability of component obsolescence management solutions, design support from the GPU vendor, and the availability of supporting software that meets the rigorous industry certification requirements of safety critical platforms. A well-selected GPU can keep program costs and delivery schedules within acceptable parameters while providing a clear software and hardware integration path that ensures the success of a project.

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