Critical Embedded Systems Design Challenges

By Jerry Gipper, VITA Director of Marketing

VITA technologies such as VMEbus, VPX, PMC, FMC, VXS and many others are a favorite choice in what are termed “Critical Embedded Systems.” These are systems that are life-critical or safety-critical and whose failure or malfunction may result in death or serious injury to people, loss or severe damage to equipment or severe environmental harm. VITA technologies are further defined to be used in high performance, distributed computing systems that manage high bandwidth I/O, involve real-time processing and are environmentally constrained to space, weight and power (SWaP). This definition clearly separates VITA technology from that used in personal computing or data center servers.

The focus of VITA technologies on the needs of critical embedded systems means that most applications of the technology are in military/aerospace, communications, industrial and medical application markets. Applications within these markets that are life or safety critical benefit from the extra care that suppliers of VITA technologies put into their products. The performance bandwidth and packaging options defined in specifications such as VMEbus and VPX have attractive options for different requirements of demanding applications.

There are many challenges that designers face when developing critical embedded systems. As computing elements are added to new applications with each generation of product development, the issues become increasingly complex.

Fragmentation of markets

The very nature of embedded computing is forcing an ever-expanding fragmentation of the requirements. There is a wide range of usage models that make it very difficult to find a cost-effective, one-size-fits-all solution. It becomes difficult for suppliers to reach economies of scale that help to drive cost reductions enjoyed by high unit volume consumer devices. Some designers try to fit low-cost desktop technology into critical embedded systems only to find that the support costs far outweigh the material costs. Using a Windows and Intel Architecture solution is not always the best choice for critical applications. Evaluating commercially available real-time operating systems and other processor families is important when developing a critical embedded system because they can have features that are better suited to meet requirements. For instance: better security, event response times or processing elements.

Fortunately, some technology is ubiquitous and tends to evolve its usage model so that you can gain some cost savings without sacrificing performance and reliability. Examples of this include USB, Ethernet, PCI Express and Linux. While these are also not always a perfect fit, they have evolved over the years to make them suitable options in many cases. The respective ecosystems have roadmaps for the technology that make them suitable for the long product life cycles required by most critical embedded systems.

More “Standards” than ever

The fragmentation of the markets is leading to a rise in the number of standards that help to define next generations of technologies used in embedded computing. The next wave of standards is generally defined by the ecosystems that have the technology needs. One or two major contributors often team up to turn a proprietary specification into the next standard. The incentive is to help drive up the consumption and thus lower costs. The number of working groups that are defining the next generations of standards is increasing each year. VITA alone has over 30 active working groups gathering the “Voice of the Customer” inputs and converting the inputs into robust specifications. These working groups are working on everything from small form factor systems to backplane interconnect strategies to reliability guidelines. Standards driven through established organizations such as VITA ensure a well-developed and vetted specification.
SWaP is Critical
Size, weight and power are three limitations that nearly every critical embedded system is bounded to by some degree. All three become increasingly critical as devices become more mobile and integrated. SWaP applies across all levels of technology from chips to boards to systems. Finding the right combination and making the associated trade-offs is very challenging. Every application has its own guidelines and restrictions driving important design decisions. Standards that have made considerations for options help in the decision process. For example, the usage of the VPX family of specification is guided through the OpenVPX architectural framework that defines the operability levels of the numerous combinations of products that are available from the product suppliers.

Need for Speed
Many new applications arise because the performance levels are going off the charts with processing and interconnect capability and there does not appear to be any end to the need for speed anytime in the near future. Give an engineer more computing performance, and they will find a way to need even more.

Fortunately, there are small armies of engineers working on innovation to improve performance at all levels. Most important for a critical embedded system is interconnecting performance. In addition, most exciting and promising here is the work with optical interconnects. While still not practical for many applications, optical interconnects are making great inroads in performance and cost. The new VPX fiber optic interconnect specification (VITA 66) that defines a family of blind mate fiber optic interconnects for use with VPX backplanes and plug-in modules is one of the first backplane standards to emerge. The endgame is nowhere in clear sight, and you can expect a lot of new innovation as suppliers find ways to make optical interconnects practical and cost-effective. VITA has established the VITA Architectures for Optical study group to help push along efforts to create necessary standards.

Customization
Despite all the efforts to develop standards, there is also a conflicting and natural need to have the ability to customize the components and systems to solve the root problems of any application. Having the flexibility to customize eases the design process, but the levels of customization must not interfere with the time-to-market and cost models of the final product. Finding technologies that let you customize quickly and effectively are necessary. The use of FPGAs and system integration with board level modules is one of the most proven ways to address the requirement for fast and relatively easy customization. Most board suppliers offer custom products and design services to some degree, some more than others. Even higher levels of customization at the board level will happen in the future.

Summary
Designing critical embedded computing systems is no easy task. The challenges become more daunting with each passing generation of technology. Using standards and products based on the standards is one way to stay ahead of the game because you can reduce risk by leveraging the knowledge based on the developers of the standards and the related products. Visit VITA at www.vita.com to learn how VITA technologies can help you with your next project.

Jerry Gipper has held a variety of positions in systems engineering, sales, product marketing, business development and strategic planning. His technology and marketing experience spans embedded computing technologies from VMEbus, PMC, CompactPCI, AdvancedTCA, various embedded motherboard technologies, embedded microprocessors and SOCs, Embedded Windows, Linux and real-time operating systems.