

Conquering SWaP Challenges in Soldier-Wearable Applications

Qseven Module Balances Custom and Off-the-Shelf Requirements

By Patrick Dietrich, hardware design engineer and project manager, Connect Tech, Inc.

Improved Battery Efficiency Needed for Mobile, Tactical Visual Computer

Designing high-performance embedded computing platforms for wearable and mobile battery-powered applications is tough on a good day. Add to that the requirement that the platform has to work in some of the most demanding and rugged environments in the world, and the challenge becomes exponentially more difficult.

That is exactly what the designers at Quantum3D (www.quantum3d.com) were faced with when they set out to upgrade their Thermite® TVC 2.0 TL line of tactical visual computers for mobile applications. The Thermite TL is designed for rugged environments with mobility, long battery life and real-time visualization capabilities in mind. This is achieved by combining embedded computing, 2D/3D graphics, extended-environment conduction cooling technologies, and support for open-architecture operating systems. Despite the many benefits, the Thermite TL had plenty of room for improved battery efficiency. Thus the designers set out on a quest to develop a better solution.

There are many mobile applications, some of them wearable, that have similar power requirements.

- Man-wearable computing applications such as control units for robotics and small unmanned vehicles
- Immersive, virtual-reality training applications such as man-wearable dismounted soldier training
- Control computer on unmanned aerial vehicle (UAV) and unmanned ground vehicle (UGV)
- Ground vehicles, aircraft, maritime and other manned or unmanned vehicles requiring graphics-processing capabilities in a compact format

These applications require many types of processing, including real-time signal processing for GPS location, radar, vision and inspection systems; embedded sensor signal processing for LIDAR/LADAR point cloud visualization; and embedded visual computing for digital map displays, heads-up/heads-down displays. Additional processing capacity is commonly needed for situational awareness, surveillance, target recognition and other

demanding processing capabilities. This processing is usually powered by batteries.



Challenges Include Power, Size, Weight and Heat

As with any embedded computing technology, there are challenges and design issues. Four of the most pressing for mobile, wearable platforms are power use, size, weight and heat dissipation. Quantum3D designers were primarily focused on the power use and efficiency of the next-generation design, aiming to achieve a 30 percent to 40 percent overall power reduction for improved battery life over the existing product. In addition, several enhancements were prioritized including improved scalability of the product for future upgrades and a performance boost to boot.

The new platform required:

- Rugged portability –contained within a lightweight, rugged and sealed alloy enclosure
- Power efficiency–performance with exceptionally long battery life
- Solid-state drives –shock-resistant solid-state drives for use in extreme environments
- Military connectors –mil-spec connectors for rugged reliable connection

- Video outputs – support for LVDS output to VGA, NTSC or PAL
- Standard computing platform – 100 percent PC-compatible to leverage existing software and programmer skills
- Performance –processing power and memory to handle applications
- Integrated graphics –high resolution for local displays

Power is Limiting Factor

Power is perhaps the most limiting factor in mobile technology. Wearable computing presents particular variations of this problem. The challenges faced when designing a product for military use are substantially different than the challenges when designing a consumer-market device. Power distribution is less of a concern for most wearable military applications because the computer unit provides power for display and I/O interfaces directly. In a consumer device, wearable computers are often part of the clothes; a user might wear a display in a pair of sunglasses, keep a computer on the back or have a keyboard

woven into a jacket. In target military applications, all components are powered from the embedded computer, i.e., HMD and keyboard power is provided directly by the computer platform.

If a system's battery life falls short of mission duration, its usefulness is significantly diminished. One solution is to use larger power supplies with chemical batteries, which are relatively long-lasting compared to rechargeable options. However, while rechargeable batteries are more environmentally friendly, they require maintenance to ensure performance when you need it, which can be a problem.

Alternatively, improving power efficiency increases how long a system can be used without having to worry about replacing or recharging batteries. In military applications, ensuring eight-plus hours is ideal.

Heat Dissipation Requires Careful Use of Resources

When specifying processors for wearable computers, MIPS per watt is a much more important parameter than raw



processing speed. Providing heat dissipation is a source of considerable expense. Designs must channel heat away from the processor, or else it will suffer thermal shutdown.

With a wearable computer, the user's thermal environment changes routinely. In the target Quantum3D application environments, the typical mounting is on the soldier's back. Here the challenges are about ambient temperature and the use of the system in hot desert environments, possibly in sunlight and also in cold tundra environments. A man-wearable system must deal with both effectively. Heat dissipation in hot environments – extracting heat from the inside to the outside where it can dissipate – is critical.

Careful use of resources helps avoid many heat-generation crises for a wearable computer. For example, developers could write applications for wearable computers with heat dissipation in mind. The computer can delay disk maintenance, downloads and batch jobs until it senses a cooler environment. Depending on perceived user need, a slower network connection might be appropriate to allow more time for heat dissipation. With such methods, performance is reserved for user interactions, and the effective average power consumption can be higher without causing uncomfortable spikes in heat generation.

Solution Integrates Internal Design and Commercial Modules

Fortunately, the designers at Quantum3D had several options available to meet design requirements: 1) design a computing platform from scratch; 2) use commercially available modules; or 3) work with a combination of the two. Designing from scratch is laden with risk; time-to-market, design expertise, life-cycle management and many other issues. While designing exactly what they needed was achievable, the time to do so would have taken more resources and more time than was available. To use off-the-shelf modules would eliminate many of those risks, but their particular design goals had requirements not typically found in commercial solutions. The unique requirements for mobility and I/O devices placed a lot of constraints on what could be used.

The best alternative integrated a combination of internal design and commercial modules. Quantum3D had design

teams dedicated to the development of the I/O, communications and human interfaces. Processing elements were best supplied by readily available commercial modules – all that was needed was a way to merge the two together.

To do that, Quantum3D engaged with Connect Tech (www.connecttech.com) for an exact-fit customized solution. Connect Tech leveraged its expertise of computer-on-module (COM) carrier board design based on standard and embedded form factors such as PC/104 and PCI Express, combined with a Qseven style processor module from congatec (www.congatec.com).

Computer on a Module – The Qseven Concept

The Qseven computer-on-module concept is an off-the-shelf, multi-vendor COM that integrates all the core components of a common PC and is mounted onto an application-specific carrier board. Qseven modules have a standardized form factor of 70mm x 70mm and have specified pin-outs utilizing a low-cost, high-speed MXM connector system with a standardized pin-out. A single ruggedized MXM connector provides the carrier board interface to carry all the I/O signals to and from the Qseven module.

The key advantages to Qseven modules are their small form factor, range

of current processor options and multi-vendor sources. Qseven COMs are some of the smallest, full-function COMs on the market, making them very attractive for many embedded mobile and ultra-mobile applications.

Connect Tech designers were able to utilize precisely the I/O interfaces required by Quantum3D. The carrier board provided all the interface connectors required to attach the system to the Quantum3D application-specific peripherals.

Benefits of the Combined Solution

The depth of choices is a critical criterion for many system designers. Often designers have constraints they cannot control or they may need the flexibility to make choices later in the design cycle to accommodate changing requirements during development. The combination of COM, carrier and custom I/O gives designers options that can benefit them throughout the entire design process.

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Scalability: Applications are scalable, which means once a product has been created there is the ability to diversify the product range with different performance class Qseven modules and I/O payloads through the carrier module. Simply unplug one module and replace it with another; no redesign is necessary.

Upgrades: Processor technology moves very quickly, with enhancements to existing processor families occurring two or three times a year. Compounding the problem are the numerous new processors introduced every year. Having the processing element, memory and supporting chipsets on a COM enables using the newest technology and then moving it into the product line at the right time. Because PCI Express is the common denominator, many cross-platform processor choices are available if needed. Instant upgrades to existing products can be offered and the product is never trapped in an obsolete design.

Cost: System cost can be reduced in lower unit volume applications by using high-volume components such as Qseven COMs. COM suppliers can increase unit volumes and reduce part numbers, generating savings that can be passed onto the integrators.

Battery Life Improved Without Giving Up Key Features

Quantum3D designers met the 40 percent improvement in battery life goal without giving up key features and performance needs. In addition, trade-offs were minimal with the combination selected by the Quantum3D design team. Connect Tech's Qseven carrier combined with the Congatec Qseven COM met all of the feature requirements. The Intel Atom processor met the low-power requirement, and the open-architecture, modular structure provided an upgrade path and scalability to add additional features now and in the future.

Patrick Dietrich is a hardware design engineer and project manager at Connect Tech, Inc. Patrick has many years of experience as a lead designer and project manager on numerous FPGA, PCI Express and embedded COM carrier products developed by Connect Tech. Patrick received a bachelor's of science degree in systems and computing engineering from the University of Guelph in Canada. He is an IEEE member, a Licensed Professional Engineer, and an active member of the PC/104 Consortium's Technical Committee.



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